FEDERAL RESERVE BANK OF SAN FRANCISCO

WORKING PAPER SERIES

Temptation and Self-Control: Some Evidence and Applications

Kevin X.D. Huang,
Vanderbilt University

Zheng Liu,
Federal Reserve Bank of San Francisco

John Q. Zhu,
Fudan University School of Management

August 2013

Working Paper 2013-23
http://www.frbsf.org/publications/economics/papers/2013/wp2013-23.pdf

TEMPTATION AND SELF-CONTROL: SOME EVIDENCE AND APPLICATIONS

KEVIN X.D. HUANG, ZHENG LIU, AND JOHN Q. ZHU

Abstract. This paper studies the empirical relevance of temptation and self-control using household-level data from the Consumer Expenditure Survey. We construct an infinite-horizon consumption-savings model that allows, but does not require, temptation and self-control in preferences. In the presence of temptation, a wealth-consumption ratio, in addition to consumption growth, becomes a determinant of the asset-pricing kernel, and the importance of this additional pricing factor depends on the strength of temptation. To identify the presence of temptation, we exploit an implication of the theory that a more tempted individual should be more likely to hold commitment assets such as IRA or 401(k) accounts. Our estimation provides empirical support for temptation preferences. Based on our estimates, we explore some quantitative implications of this class of preferences for capital accumulation in a neoclassical growth model and the welfare cost of the business cycle.

For every man there exists a bait which he cannot resist swallowing.
–Friedrich Nietzsche

...we are often willing even to pay a price to precommit future actions (and to avoid temptation). –Robert H. Strotz (1956)

I. Introduction

John was on a diet. He planned to eat healthy and to exercise regularly. One day, John walked into *Ecopolitan*, a reputable neighborhood restaurant that was famed for healthy foods. When he browsed through the menu, John was delighted: the menu contained various

Date: August 27, 2013.

Key words and phrases. Temptation; Self-control; Limited participation; Consumption; Intertemporal Decision.

JEL classification: D91, E21.

Huang: Vanderbilt University; Email: Kevin.Huang@vanderbilt.edu. Liu: Federal Reserve Bank of San Francisco; Email: Zheng.Liu@sf.frb.org. Zhu: Fudan University School of Management; Email: John.QiZhu@gmail.com. We are grateful to Christopher Carroll, Narayana Kocherlakota, John Leahy, Luigi Pistaferri, and seminar participants at the Federal Reserve Bank of Atlanta, the Federal Reserve Bank of Minneapolis, Johns Hopkins University, Princeton University, the University of Minnesota for helpful comments. We thank the Editor and two anonymous referees for insightful comments and suggestions. The views expressed herein are those of the authors and do not necessarily reflect the views of the Federal Reserve Bank of San Francisco or the Federal Reserve System. John Qi Zhu acknowledges this research is supported in part by the National Science Foundation of China (#71001069).

salads and vegetarian meals. "This is exactly what I need," thought John. When he flipped to the last page of the menu, his eyes lit up as he saw pictures of some creamy, rich, and colorfully decorated deserts that appeared enticing. "Well, what am I going to do? Should I try some desert as well?" John started debating with himself and struggled a bit before he could make up his mind.

John is not alone. When planning for the long run, one intends to meet deadlines, exercise regularly, and eat healthy; but short-run behaviors are not always consistent with long-run plans. The availability of ex ante inferior, but ex post tempting alternatives often makes one worse off. Facing tempting alternatives, a decision maker may either end up succumbing to temptation (e.g., by eating unhealthy foods) or exert costly efforts to resist temptation. In either case, he is made worse off by the presence of tempting alternatives.

In a series of important contributions, Gul and Pesendorfer (2001, 2004a, henceforth GP) propose an axiomatic foundation for preferences that capture such behavioral observations. The GP-preference specification allows for temptation and self-control, which captures potential conflicts between an agent's ex ante long-run ranking of options and her ex post short-run urges in a rational and time-consistent framework. A typical agent faces temptation in each period of time, and she exercises costly self-control efforts to resist the temptation. Thus, she might be better off if facing a smaller opportunity set that excludes the ex ante inferior but ex post tempting alternatives. In other words, she has preferences for commitment, as commitment ex ante reduces costs of self-control ex post.

Preferences for commitment can be quantitatively important. To illustrate this point, consider a GP agent whose commitment ranking is represented by a standard CRRA utility function u, with a coefficient of relative risk aversion γ, and whose temptation utility is $v = \lambda u$. Here λ measures the strength of temptation. This is the setup we will employ in this paper (see, also, Krusell, Kuruşçu, and Smith 2010; Gul and Pesendorfer, 2004b). As we show below, as long as $\lambda > 0$, the agent is willing to pay a premium for an illiquid asset for its commitment value. To be specific, consider two N-period lived securities with an identical payoff at maturity, where $N \geq 2$. The two securities are both offered to the agent for purchase at time t. Security 1 can be traded in every period before the maturity date, with no trading frictions; while security 2 cannot be re-traded until the maturity date. As can be inferred from our analysis of equations (9) and (11) in the text below, under a mild assumption on short-sales restrictions, the ratio of the price of security 2 to that of security 1 that the agent is willing to pay is $\prod_{n=1}^{N-1}\{1 - [\lambda/(1+\lambda)](w_{t+n}/c_{t+n})^{-\gamma}\}^{-1} \geq 1$, where (w_{t+n}/c_{t+n}) denotes the ratio of liquid wealth (inclusive of income) to consumption at $t+n$. Evidently, the agent is willing to pay the same price for the two types of securities if and only if $\lambda = 0$. If $\lambda > 0$, then the illiquid security (security 2) commands a commitment premium that is strictly increasing in λ. To get a sense about the potential size of the

commitment premium, consider the case with $\gamma = 1$ (log-utility) and with $w/c = 4.84$, which corresponds to the average ratio of liquid wealth to consumption of nondurables and services in the U.S. data from 1952:Q1 to 2013:Q1.[1] Suppose that both securities mature in 30 years. Then, as λ rises from 0 to 0.1, the relative price of security 2 rises from 1 to 1.73. This calculation implies a cumulative commitment premium of 73% over 30 years, or an average annual premium of about 1.85%. While this is not a negligible number, the actual size of the commitment premium apparently depends on how large λ is in the data.

Indeed, conclusions from recent theoretical studies on the implications of GP preferences for a variety of economic issues hinge critically on the strength of temptation. These studies include Krusell, Kuruşçu, and Smith (2002) that applies the self-control theory to asset pricing, Krusell, Kuruşçu, and Smith (2010) to taxation, Esteban, Miyagiwa, and Shum (2003) to price discrimination, Ameriks et al. (2004) to survey designs, Gul and Pesendorfer (2004a, 2004b) to consumption-savings decisions and welfare, and Gul and Pesendorfer (2005b) to harmful addiction.[2] This growing literature suggests that incorporating temptation and self-control in preferences may shed new light on some important issues, especially those considered "puzzles" under standard preferences. Yet, assessing the quantitative importance of the GP preferences remains a challenge precisely because of the scarcity of empirical evidence on the strength of temptation, or the lack thereof.

The current paper intends to fill this gap by estimating the quantitative strength of temptation and self-control. We focus on temptation preferences instead of quasi-hyperbolic discounting preferences for both theoretical and empirical reasons. The two types of preferences both imply a desire for commitment (e.g., Strotz, 1956; Laibson, 1997; Harris and Laibson, 2001; Gul and Pesendofer, 2004b). However, temptation preferences are an appealing alternative to the quasi-hyperbolic discounting model since they do not rest heavily on the choice of the time period and are more suitable for welfare analysis (e.g., Attanasio and Weber, 2010). As we show in the text, temptation preferences give rise to a consumption Euler equation that represents a natural generalization of that under the standard utility function. In particular, under temptation preferences, the asset-pricing kernel is an explicit function of the consumption growth rate and the wealth-consumption ratio. With hyperbolic

[1]Our measure of wealth is the sum of household liquid net worth and disposable personal income, taken from the Flow of Funds tables from the Federal Reserve Board (Table B.100: Balance Sheets of Households and Nonprofit Organizations). The liquid net worth is defined as the difference between liquid assets and liquid liabilities, where liquid assets are total assets net of tangible assets (real estate, durable goods, and equipment and software owned by nonprofit organizations) and pension reserve funds; and liquid liabilities equal total liabilities net of home mortgages. Consumption is measured by personal consumption expenditures on nondurable goods and services, taken from the U.S. Bureau of Economic Analysis.

[2]Related theoretical and applied work also includes Benhabib and Bisin (2005) and Bernheim and Rangel (2002), among others.

discounting preferences, however, it is more difficult to estimate an Euler equation because the Euler equation involves the first derivative of consumption with respect to wealth; and to get an explicitly parameterized asset-pricing kernel requires knowledge of the policy function (e.g., Harris and Laibson, 2001).

To examine the empirical importance of temptation preferences, we estimate an intertemporal Euler equation based on an infinite-horizon consumption-savings model that allows for, but does not require, temptation and self-control using household-level data from the Consumer Expenditure Survey (CEX). The use of micro data is essential for two reasons. First, since the intertemporal Euler equation represents an interior optimizing decision, it is relevant only for those individuals who hold some form of financial assets. Thus, using aggregate data may lead to inconsistent estimates of the parameters of interest, whereas using micro data makes it possible to control for limited participation.[3] Second, and more importantly, using micro data allows us to capture individual differences in the strength of temptation and self-control. This level of heterogeneity is particularly useful for identifying the presence of temptation, since our model implies that an individual who is more susceptible to temptation would be more likely to hold commitment assets (such as individual retirement account (IRA)), because holding commitment assets helps reduce the cost of self control.[4]

Our work shares a similar goal with DeJong and Ripoll (2006), who estimate the strength of temptation based on a version of the Lucas (1978) model with a representative agent. Unlike DeJong and Ripoll (2006), who use aggregate time series data, we find significant presence of temptation. We argue that such difference arises mainly because our model takes into account limited asset-market participation and more importantly, our model allows for individual heterogeneity in the level of self-control, which helps identify the presence of temptation. From this perspective, our work is perhaps more closely related to that by Paserman (2004), Fang and Silverman (2004), and Laibson, Repetto, and Tobacman (2004), who all employ panel or field data in estimating the quantitative effects of self-control problems under preference specifications with hyperbolic discounting.

[3]For some studies that emphasize the importance of limited participation, see Mankiw and Zeldes, 1991; Brav, Constantinides, and Geczy (2002), Cogley (2002), Vissing-Jørgensen (2002), and Jacobs and Wang (2004). For a survey of this literature, see Constantinides (2002).

[4]The literature emphasizes other reasons for studying the cross-sectional variations in the level of self-control. Della Vigna and Paserman (2005) show that cross-sectional variations in self-control help predict cross-sectional variations in behaviors. Krusell, Kuruşçu, and Smith (2002) argue for the realism of differing degrees of temptation and self-control among consumers, and they demonstrate the potential significance of such heterogeneity in accounting for the high equity premium and low risk-free rate. See also Ameriks et al. (2004) for some evidence on the heterogeneity in the degree of temptation and self-control in a survey sample of TIAA-CREF participants.

In practice, we estimate jointly the elasticity of intertemporal substitution (EIS) and the temptation parameter using GMM in our baseline model. We parameterize the utility function to be consistent with balanced growth and recent evidence on the cointegrating relations between consumption, income, and wealth (e.g., Lettau and Ludvigson, 2001, 2004). We focus on estimating a log-linearized Euler equation, which is linear in parameters. We control the aggregation process to take into account limited asset market participation and to deal with potential measurement errors in the individual level data. This is fundamentally the same approach taken by Vissing-Jørgensen (2002), among others, under the standard preferences without temptation.

Because we allow for temptation and self-control, the wealth-consumption ratio, in addition to the consumption growth rate, becomes a determinant of the intertemporal marginal rate of substitution (i.e., the asset-pricing kernel), and the importance of this additional factor depends on the strength of temptation and self-control. The wealth-consumption ratio appears in the asset-pricing kernel because, if the individual agent succumbs to temptation, she would consume her entire income and accumulated (liquid) assets, which correspond to our definition of wealth (or "cash on hand", as in Deaton, 1991). In other words, wealth represents "temptation consumption."

To identify the presence of temptation, we exploit an implication of the theory that an individual who is more susceptible to temptation would be more likely to hold commitment assets, which are assets that cannot be easily re-traded or be used as a collateral for borrowing. Thus, we include in our estimation equation an interaction term between the wealth-consumption ratio and a dummy variable indicating the households' participation in IRAs or 401(k) retirement plans. The IRA dummy takes a value of one if the underlying individual holds any assets in these retirement accounts; and it takes a value of zero otherwise. Since early withdrawals from the IRA/401(k) accounts incur stiff tax penalties, contributions to IRAs or 401(k) retirement plans can be viewed as a form of commitment. If the GP theory is empirically relevant, then we should expect those individuals who participate in IRA/401(k) to have also a larger temptation parameter. Indeed, this is borne out by our estimation.

Our identification assumption is consistent with the findings by Laibson, Repetto, and Tobacman (1998), whose simulations show that defined contribution plans such as IRA and 401(k) accounts are effective for raising savings of individuals with self-control problems, since these agents value illiquid assets as a commitment device. However, individuals without self-control problems may also want to hold IRAs or 401(k) for other reasons (such as tax advantages). Further, more patient individuals are more likely to invest in long-term savings, and they may also want to hold defined contribution accounts because of patience.

To address these confounding issues in our identification, we control for the direct effects of these defined contribution plans on consumption growth by including the IRA dummy as a separate regressor in our empirical model. The coefficient on the IRA dummy captures the "level effects" of holding IRAs or 401(k) plans on consumption growth. The level effects include cross-sectional differences in patience, as well as potentially higher rates of returns on the illiquid assets in the defined contribution plans that are not captured in the returns on financial assets included in the regression. Controlling for the level effects of IRA contributions thus helps isolate the commitment value of these retirement accounts.

Our estimation provides statistical support for temptation and self-control preferences. With reasonable precisions, we obtain a significant estimate of the strength of present-biased temptation, and we reject the null hypothesis of no temptation at common confidence levels.

In our estimation, we also take advantage of our microeconomic data to separate self-control problems from other confounding factors such as liquidity constraints. We follow Hall's (2011) approach and define liquidity constrained households as those whose liquid asset holdings of checking and saving accounts are worth no more than two months of after-tax labor income. For the subsample with individuals who are not liquidity constrained, our estimation implies a greater and more precise value of the self-control parameter than in the full sample.

Our finding is consistent with a recent study by Bucciol (forthcoming), who reports evidence of a taste for commitment from the Survey of Consumer Finance (SCF) data using a structural estimation approach. While Bucciol (forthcoming) exploits the cross-sectional variations in the low-frequency SCF data (the SCF survey is conducted every three years), our estimation focuses on the time-series dimension with high-frequency data from the CEX survey (at monthly frequencies).

To illustrate the macroeconomic applications of the GP theory, we explore how the presence of temptation, with a reasonable magnitude as suggested by our estimates, can affect steady-state saving rate in an optimal growth model and calculations of the welfare cost of business cycles. We find that modest temptation implies large reductions in steady-state saving and income. With the temptation parameter calibrated based on our empirical estimation, restoring steady-state saving and income to levels obtained in an economy without temptation requires an investment subsidy rate of about 11% (financed by lump-sum taxes). In the context of welfare cost of business cycles, we also obtain some results that are somewhat surprising yet quite intuitive.

II. A Consumption-Savings Model with Dynamic Self-Control

In this section, we consider an infinite-horizon consumption-savings problem that allows the possibility of temptation and dynamic self-control in preferences, and we characterize the intertemporal Euler equation derived from the model.

II.1. **An Axiom-Based Representation for Self-Control Preferences.** Gul and Pesendorfer (2001, 2004a) consider decision problems by agents who are susceptible to temptations in the sense that ex ante inferior choice may tempt the decision maker ex post. They develop an axiom-based and time-consistent representation of self-control preferences that identifies the decision maker's commitment ranking, temptation ranking, and cost of self-control. According to their definition, "an agent has a preference for commitment if she strictly prefers a subset of alternatives to the set itself; she has self-control if she resists temptation and chooses an option with higher ex ante utility." They show that, to obtain a representation for the self-control preferences, it is necessary, in addition to the usual axioms (completeness, transitivity, continuity, and independence), to introduce a new axiom called "set betweenness," which states that $A \succeq B$ implies $A \succeq A \bigcup B \succeq B$ for any choice sets A and B. Under this axiom, an option that is not chosen ex post may affect the decision maker's utility at the time of decision because it presents temptation; and temptation is costly since an alternative that is not chosen cannot increase the decision maker's utility.

Under these axioms, GP (2001) show that a representation for the self-control preferences takes the form

$$W(A) = \max_{x \in A} u(x) + v(x) - \max_{y \in A} v(y), \tag{1}$$

where both u and v are von Neumann-Morgenstern utility functions over lotteries and $W(A)$ is the utility representation of self-control preferences over the choice set A. The functions u and v describe the agent's commitment ranking and temptation ranking, respectively. The term $\max_{y \in A} v(y) - v(x)$ is non-negative for all $x \in A$, and it represents the utility cost of self-control.

II.2. **An Infinite-Horizon Consumption-Savings Problem.** Consider now a consumption-savings problem in an infinite-horizon economy with a large number (H) of households. The households have access to an asset market, where they trade I types of assets, including a risk-free asset. Let c_t^h denote consumption by household h, e_t^h his endowment, and $\mathbf{b}_t^h = (b_t^{1h}, b_t^{2h}, \ldots, b_t^{Ih})'$ his asset-holding position at the beginning of period t, for $h \in \{1, 2, \ldots, H\}$. Let q_t^i and d_t^i denote the price and the dividend payoff of asset $i \in \{1, \ldots, I\}$ in period t. In each period t, a household's decision problem involves choosing current consumption and a continuation of decision problems (which is a function of new asset positions) to maximize his expected lifetime discounted utility, taking as given asset prices and dividends, his endowment, and current asset positions. In the decision problem, a household faces a temptation

to consume all his wealth that consists of current endowment and the market value of his current assets. He may exert costly efforts to resist such temptations.

As shown by GP (2004a), an infinite-horizon consumption planning problem, like the one described here, can be formulated in a recursive form. Denote by $z(\mathbf{b})$ the infinite-horizon planning problem when the current asset position is $\mathbf{b}$. The decision problem for a generic household is then described by the dynamic programming problem

$$W(z(\mathbf{b}^h)) = \max_{c^h, \tilde{\mathbf{b}}^h} \left\{ u(c^h) + v(c^h) + \delta \mathrm{E} W(z(\tilde{\mathbf{b}}^h)) - v(w^h) \right\}, \tag{2}$$

subject to the budget constraint

$$\sum_{i=1}^{I} q^i \tilde{b}^{ih} = e^h + \sum_{i=1}^{I} (q^i + d^i) b^{ih} - c^h, \tag{3}$$

and a short-sale constraint $\mathbf{b}^h \geq 0$. In these expressions, u and v are von Neumann-Morgenstern utility functions, $\delta \in (0,1)$ is a discount factor, E is an expectation operator, and the tilde terms denote variables in the next period. Given the borrowing constraint, the maximum level of consumption admissible for household h if the household succumbs to temptation is the sum of his current income and financial wealth, which is given by

$$w^h = e^h + \sum_{i=1}^{I} (q^i + d^i) b^{ih}. \tag{4}$$

Let $R^i_{t+1} = (q^i_{t+1} + d^i_{t+1})/q^i_t$ denote the gross return on asset i between period t and $t+1$. Then, for any asset $i \in \{1, \ldots, I\}$, the intertemporal Euler equation is given by

$$u'(c^h_t) + v'(c^h_t) = \delta \mathrm{E}_t [u'(c^h_{t+1}) + v'(c^h_{t+1}) - v'(w^h_{t+1})] R^i_{t+1}, \tag{5}$$

where $u'(\cdot)$ and $v'(\cdot)$ denote the marginal commitment utility and the marginal temptation utility, respectively, E_t is a conditional expectation operator. This Euler equation describes the household's intertemporal tradeoff in the face of temptation and costly self-control. The left hand side of the equation is the utility gain from a marginal increase in period-t consumption, which raises both the commitment utility and the temptation utility. The right hand side is the expected discounted utility from a marginal increase of period-t saving, which commands a gross return of R_{t+1} and raises both consumption and wealth in period $t+1$. The rise in consumption leads to utility gains, whereas the rise in wealth leads to utility losses because of costly self-control. At the margin, an optimizing household remains indifferent between consuming now or saving for future.[5]

[5]Krusell, Kuruşçu, and Smith (2010) derive Euler equations similar to our equation (5), but in a more general model that nests the quasi-geometric discounting preferences by Laibson (1997) and the temptation and self-control preferences by Gul and Pensendorfer (2004a).

More generally, the intertemporal Euler equation can be written as

$$1 = \mathrm{E}_t m^h_{t,t+1} R_{t+1}, \tag{6}$$

where, with a slight abuse of notation, R_{t+1} denotes the gross return on a generic asset, and $m^h_{t,t+1}$ denotes the household's intertemporal marginal rate of substitution (or SDF) between period t and $t+1$ given by

$$m^h_{t,t+1} = \frac{\delta[u'(c^h_{t+1}) + v'(c^h_{t+1}) - v'(w^h_{t+1})]}{u'(c^h_t) + v'(c^h_t)}. \tag{7}$$

Note that the SDF here is strictly positive if the temptation utility $v(\cdot)$ is concave.[6]

Our goal is to evaluate the empirical relevance of temptation and self-control in preferences. For this purpose, we follow Krusell, Kuruşçu, and Smith (2010) and restrict attention to a class of constant relative risk aversion (CRRA) utility functions that are consistent with balanced growth. In particular, we consider the commitment utility and the temptation utility functions

$$u(c) = \frac{c^{1-\gamma}}{1-\gamma}, \quad v(c) = \lambda u(c), \tag{8}$$

where γ is the coefficient of relative risk aversion and $\lambda \geq 0$ measures the strength of temptation. Under this specification, both the commitment utility u and the temptation utility v are concave, so that the household is risk-averse in consumption but risk-seeking in wealth (since $-v(w)$ is convex). In other words, the household exhibits more risk aversion when choosing among lotteries that promise immediate consumption rewards than when choosing among those that promise risky future returns. This pattern of risk attitudes is consistent with recent experimental evidence (e.g., Noussair and Wu, 2003). An immediate implication is that variations in consumption tend to make the household worse off, whereas variations in wealth (consisting of income and asset accumulations) tend to reduce the utility cost of resisting temptation and thus may be desirable for the household. This feature has important implications for calculations of the welfare cost of business cycles, as we show in Section 6.

With the utility functions so parameterized, the SDF defined in (7) is given by

$$m^h_{t,t+1} = \delta \left(\frac{c^h_{t+1}}{c^h_t}\right)^{-\gamma} \left[1 - \frac{\lambda}{1+\lambda}\left(\frac{w^h_{t+1}}{c^h_{t+1}}\right)^{-\gamma}\right]. \tag{9}$$

Clearly, without temptation, that is, with $\lambda = 0$, the SDF reduces to

$$m^h_{t,t+1} = \delta \left(\frac{c^h_{t+1}}{c^h_t}\right)^{-\gamma}. \tag{10}$$

We are thus testing the hypothesis that the SDF is characterized by (9) against the alternative that it is described by (10).

[6]To see this, under concavity, $v'(\cdot)$ is decreasing, implying that $v'(c^h) \geq v'(w^h)$ since $c \leq w$.

The one-period SDF can be used recursively to price liquid assets that are tradable in every period without friction prior to its maturity period. To price illiquid assets that can be traded only once every $N > 1$ periods, the appropriate pricing kernel is given by

$$m^h_{t,t+N} = \delta^N \left(\frac{c^h_{t+N}}{c^h_t}\right)^{-\gamma} \left[1 - \frac{\lambda}{1+\lambda}\left(\frac{w^h_{t+N}}{c^h_{t+N}}\right)^{-\gamma}\right]. \tag{11}$$

If $\lambda = 0$, then (11) is simply obtained by iterating (9) N periods forward. If $\lambda > 0$, then (11) is greater than the N-period iteration of (9), suggesting that a GP household is willing to pay a premium for an illiquid asset for its commitment value. This anti-liquidity (or desire for commitment) for GP households plays a key role in our empirical studies. Although due to data restriction we will mainly use (9) and returns on liquid assets in our empirical estimation and testing, we rely on information about illiquid assets, such as IRA or 401(k) assets, to help identify the presence of temptation.

Self-control preferences imply the presence of the wealth-consumption ratio in the SDF. This complicates direct estimation of the parameters of interest based on the (nonlinear) intertemporal Euler equation, especially if there are measurement errors. Under some conditions, however, one can still obtain consistent estimates of the elasticity of intertemporal substitution (EIS) and the temptation parameter even in the presence of measurement errors. Inspecting the expression for the SDF in (9), we see that a sufficient condition for obtaining consistent estimates for these parameters is that the measurement errors in individual consumption and in wealth are multiplicative and proportional to each other (with a constant proportionality), and that they are independent of the true levels of consumption and wealth, independent of asset returns and the instruments.[7] These conditions on the measurement errors appear quite stringent. For this consideration, we focus on estimating a log-linearized version of the Euler equation, which does not require strong assumptions about the stochastic processes of measurement errors.[8]

[7]For a similar argument in the context of estimating EIS alone (based on a CRRA utility function without temptation), see Attanasio and Weber (1995), Vissing-Jorgensen (2002), and Kocherlakota and Pistaferri (2005).

[8]The approach to estimating preference parameters based on log-linearized Euler equations is not without controversy. For a debate on some potential problems with and some main advantages of this approach, see the exchange between Carroll (2001) and Attanasio and Low (2004) (see also Ludvigson and Paxson, 2001). Despite its potential problems, the log-linear approach allows us to control the aggregation process, which is essential to capture the heterogeneity in individual preferences and to control for other aggregation biases and measurement errors. In the absence of a better approach to deal with aggregation biases and measurement errors, especially in a sample with a short time-series dimension of each individual household, as in the CEX survey, we view the log-linear approach as a useful compromise.

For the purpose of obtaining a log-linearized Euler equation, we assume that the consumption growth rate and the wealth-consumption ratio are both stationary.[9] A log-linear approximation to the SDF around the steady state is given by

$$\ln(m^h_{t,t+1}) = \ln(\delta) - \ln(1+\phi) - \gamma \ln\left(\frac{c^h_{t+1}}{c^h_t}\right) + \gamma\phi\left[\ln\left(\frac{w^h_{t+1}}{c^h_{t+1}}\right) - \ln\left(\frac{w}{c}\right)\right] + \kappa_{t+1}, \quad (12)$$

where the term κ_{t+1} includes the second or higher moments in consumption growth and the wealth-consumption ratio, and the parameter ϕ is given by

$$\phi = \frac{\lambda}{(1+\lambda)\chi^\gamma - \lambda}, \quad (13)$$

with $\chi = w/c$ denoting the steady-state ratio of wealth to consumption. Using (6) and (12), we obtain an empirical version of the consumption Euler equation in the presence of temptation:

$$\ln\left(\frac{c^h_{t+1}}{c^h_t}\right) = b_0 + \sigma \ln(R_{t+1}) + \phi \ln\left(\frac{w^h_{t+1}}{c^h_{t+1}}\right) + \nu_{t+1}, \quad (14)$$

where $\sigma = 1/\gamma$ is the EIS, the intercept term b_0 contains the constants and unconditional means of the second or higher moments of the variables, and the error term ν_{t+1} summarizes expectation errors, measurement errors, and approximation errors (i.e., deviations of second or higher moments of the relevant variables from their unconditional means).

In the restricted model without temptation, the SDF reduces to $\ln(m^h_{t,t+1}) = \ln(\delta) - \gamma \ln(c^h_{t+1}/c^h_t)$. An empirical version of the intertemporal Euler equation is then given by

$$\ln\left(\frac{c^h_{t+1}}{c^h_t}\right) = a_0 + \sigma \ln(R_{t+1}) + \varepsilon_{t+1}, \quad (15)$$

where the intercept term a_0 summarizes the constants and the unconditional mean of the second (or, in case of non-lognormal distributions, higher) moments of the variables, while the error term ε_{t+1} contains expectation errors, measurement errors, and approximation errors. This equation forms the basis for estimating the EIS in the literature (e.g., Attanasio and Weber, 1989; Vissing-Jorgensen, 2002).

To test the empirical presence of temptation is thus equivalent to testing the Euler equation (14) under GP preferences against its alternative (15) under CRRA utility. We implement this empirical task by first obtaining joint estimates of σ and λ using GMM, and then testing the null hypothesis that $\lambda = 0$. To implement the GMM estimation, we use the log-linearized Euler equations (14) and (15) for the two alternative specifications of preferences, which, under rational expectations, lead to the moment conditions $E_t(Z_t\varepsilon_{t+1}) = 0$ under

[9]The stationarity assumption that we make here is similar to Campbell (1993) and it is supported by empirical evidence (e.g., Lettau and Ludvigson, 2001, 2004). In a life-cycle model with finitely-lived consumers, however, the stationarity of the ratio of liquid wealth to consumption expenditures becomes a more subtle issue because a household typically saves at working ages and draws down from saving when retired. Bucciol (forthcoming) provides a nice treatment of this class of models with temptation preferences.

the standard CRRA utility and $E_t(Z_t\nu_{t+1}) = 0$ under the GP preferences, for any vector of variables Z_t that lie in the information set of period t.[10] Note that, to obtain an estimate for λ under GP preferences, we first estimate σ and ϕ from (14), and then compute the point estimate of λ from the relation

$$\hat{\lambda} = \frac{\hat{\phi}\chi^{1/\hat{\sigma}}}{1 - \hat{\phi}(\chi^{1/\hat{\sigma}} - 1)}, \tag{16}$$

where a hatted variable denotes its point estimate. One can then obtain a 95 percent confidence interval for the estimate of λ using the delta method. Clearly, the null hypothesis that $\lambda = 0$ is equivalent to $\phi = 0$.

III. Data Selection and Aggregation

We now describe the data that we use for estimating the intertemporal Euler equations. The household-level data are taken from the Consumer Expenditure Survey (CEX) provided by the Bureau of Labor Statistics (BLS). The CEX survey has been conducted in every quarter since 1980, with a representative sample of the universe of U.S. households. In each quarter, the BLS chooses about 5,000 households randomly according to the stratification criteria determined by the U.S. Census. Because of their broad coverage of consumption expenditures, CEX data have been widely used for studying a variety of issues, such as inequality (e.g., Deaton and Paxson, 1994), consumption smoothing (e.g., Attanasio and Weber, 1995; Attanasio and Davis, 1996; Kruger and Fernandez-Vilaverde, 2004), and asset pricing (e.g., Vissing-Jorgensen, 2002; Brav, Constantinides, and Geczy, 2002; Cogley, 2002; Jacobs and Wang, 2004).

In this section, we focus on describing our sample selection criteria and aggregation approaches. We provide further details about the CEX data and discuss some measurement issues in the Appendix.

III.1. **Limited Participation and Sample Selection Criteria.** Our empirical approach relies on estimating the intertemporal Euler equation derived from the agent's interior optimizing decisions. In the data, however, not all households hold financial assets. To stay consistent with theory, we focus on the subset of households that are classified as "asset

[10]Potential serial correlations in the deviations of the conditional second and higher moments in the Euler equations from their unconditional means might complicate the use of lagged variables as instruments for estimating Euler equations. Attanasio and Low (2004) show that, when utility is isoelastic and a sample covering a long time period is available, estimates from log-linearized Euler equations with varying interest rates are not systematically biased. A related issue is the control of measurement errors in the process of aggregation. When there are large enough cross-sectional observations, measurement errors in the linear terms tend to cancel out in the aggregation process, but those in the second or higher order terms contained in ν_{t+1} may not cancel, and may become even worse.

holders" based on a similar set of criteria used by Cogley (2002) and Jacobs and Wang (2004).

Specifically, for a household's Euler equation between period t and $t+1$ to hold, the household must hold financial assets at the beginning of period t, which corresponds to the beginning of the household's first interview period. We include two categories of asset holders in our sample.

The first category of asset holders includes households that report positive holdings of "stocks, bonds, mutual funds, and other such securities" or "U.S. savings bonds" at the beginning of the first interview. This is the category of asset holders used by Vissing-Jorgensen (2002) in the context of estimating the EIS. As in Vissing-Jorgensen (2002), we use two pieces of information in the CEX survey to construct this category of asset holders. First, a typical household reports whether its holdings of the asset category have remained the same, increased, or decreased, compared to a year ago; second, a typical household reports the difference in the estimated market value of the asset category held by the household in the previous month with that held a year before. Thus, we infer that the household has a positive value of holdings of the asset category at the beginning of period t if the household holds a positive amount of assets at the time of the interview and the asset value has either remained the same or decreased in the past year. If the household reports an increase in the asset value and the amount of the increase does not exceed the holdings at the time of the interview, we also infer that the household has a positive holding of the asset category at the beginning of period t.

The second category of asset holders are those households who report positive contributions to "an individual retirement plan, such as IRA or Keogh" and those who report receipts of positive dividend income or interest income during the first interview period.

The two categories of asset holders that we select account for about 42% of households in the CEX sample. This number is comparable to that in Cogley (2002) (40%) and in Haliassos and Bertaut (1995) (36.8%), but somewhat larger than that in Jacobs and Wang (2004) (31%) and in Mankiw and Zeldes (1991) (27.6%), who all use a similar selection criterion but with a shorter sample in the time-series dimension.

III.2. **Variable Construction and Aggregation.** The Euler equation (14) that we estimate contains three variables: (1) the consumption growth rate, (2) the wealth-consumption ratio, and (3) the asset returns. We construct the first two variables from the household-level data in the CEX survey, restricting our sample to those households who hold financial assets for reasons discussed in the section above.

We measure consumption for each household by the sum of expenditures on nondurable goods and services that are consistent with the NIPA definition. We leave out expenditures

on durable goods, and therefore implicitly assuming that the utility function is separable in durable and non-durable consumption. We deflate nominal quarterly consumption expenditures by the consumer price index (CPI) for nondurables, with a base period of 1982–1984.

To measure wealth, we utilize the theory's implication that the decision-relevant wealth measure should be that which enables the household to consume in the event that the household succumbs to temptation. Thus, we focus on liquid wealth, which is defined as the sum of the household's labor income, dividend income, and the beginning-of-period market value of liquid financial assets, all deflated by the CPI. The liquid financial assets that we consider include "checking accounts, brokerage accounts, and other similar accounts," "saving accounts," "U.S. savings bonds," and "stocks, bonds, mutual funds, and other such securities."[11]

Conditional on asset market participation, we have observations on household-level consumption expenditures and liquid wealth in each month. This represents a (pseudo) panel of data, based on which we construct the variables to be used for estimating the Euler equation. A well-known issue with using pseudo-panel data is that OLS estimates can be asymptotically inconsistent if the average number of households included in each period (i.e., the average cell size) is small (e.g., Deaton, 1985). A similar issue exists for instrumental variable (IV) estimation such as the Generalized Methods of Moments (GMM). To mitigate potential issues related to small cell sizes, we follow Attanasio and Weber (1993) and construct a broad year-of-birth cohort of prime-aged households. The cohort includes households with household heads born between 1939 and 1959 (and thus aged 25 to 45 in 1984 and 42 to 62 at the beginning of 2002).

Denote by cg_{t+1} the aggregate consumption growth rate between period t and $t+1$, which is the average of the consumption growth rates across all households. That is,

$$cg_{t+1} = \frac{1}{H_t} \sum_{h=1}^{H_t} \ln \left(\frac{c_{t+1}^h}{c_t^h} \right), \tag{17}$$

where c_t^h denotes consumption of household h and H_t is the total number of households in period t.

This equation reveals that aggregate consumption growth, which is the average of the logs of consumption growth across households, is also the difference between the averages of the log-levels of consumption expenditures between periods t and $t+1$. This seemingly

[11]The CEX survey provides information on a household's asset holdings only for the final interview, at which the household reports both the current stock of assets and the flows during the previous 12 months. The timing of the model implies that, for estimating the Euler equation, we need data of the beginning-of-period wealth, which are not directly observed in the survey. We thus impute the household' beginning-of-period wealth by subtracting the flow value of assets between the first and the final interview periods from the asset stocks reported at the final interview.

obvious relation is useful because it suggests that we do not need individual consumption growth data to construct aggregate consumption growth; instead, we can obtain aggregate consumption growth by first averaging the log-levels of consumption across households, and then take the time difference of the averages of log-consumption. Thus, our approach does not require to have a balanced panel of data. This helps us substantially expand the coverage of households and thereby enlarging the average cell size, despite missing observations for some households in some months of interviews.

Similarly, we construct the aggregate wealth-consumption ratio in the beginning of period $t+1$ (denoted by χ_{t+1}) based on the definition

$$\chi_{t+1} = \frac{1}{H_t} \sum_{h=1}^{H_t} \ln \left(\frac{w_{t+1}^h}{c_{t+1}^h} \right), \tag{18}$$

where w_{t+1}^h denotes the wealth of household h, which is the maximum resources available for the household to spend on consumption if she succumbs to temptation. The wealth data that we examine include labor income, dividend income, and liquid financial asset holdings. We impute the value for w_{t+1}^h based on a "buy-and-hold" assumption.[12] To obtain aggregate wealth-consumption ratio, we first average the logs of wealth and of consumption across households; we then subtract the average of log-consumption from the average of log-wealth. Again, an important advantage of this approach is that it does not require a balanced panel and thus helps us obtain a relatively large average cell size.

III.3. **Asset Returns.** We use monthly NYSE value-weighted returns as a measure of nominal returns on risky assets and monthly 30-day Treasury bill returns as a measure of nominal returns on risk-free assets, both of which are deflated by the CPI. To match the time series of quarterly consumption growth at monthly frequency, we construct quarterly asset returns by staggering the corresponding monthly returns, assuming household's consumption-saving decisions are always made at the beginning of each three-month period.

To illustrate the timing issue for constructing the asset returns series, denote by R_{m+1} the asset returns between months m and $m+1$. If the quarterly decision period for consumption and saving is between month m and $m+3$, then the appropriate asset returns should be a compounded return during the same period. In particular, the asset return that we use in this particular case is $R_{m+1}R_{m+2}R_{m+3}$.

Since the asset holders in our sample can hold a broad range of assets, we also measure the asset returns in our estimation by an average between the real value-weighted NYSE returns and the real 30-day Treasury bill returns (i.e., joint returns).

[12]We provide some details of the imputation of the wealth data in the Appendix.

IV. Estimation

We estimate a log-linearized conditional Euler equation derived from our model using the generalized method of moments (GMM). We test the statistical significance of the temptation parameter by also estimating a restricted version of the model that does not allow for self-control preferences and thereby constructing a Wald test statistic. In what follows, we describe the equations to be estimated, the instrumental variables to be used, the estimation procedure, and the estimation results.

IV.1. **Estimation Equations.** We estimate the log-linearized intertemporal Euler equation (14) augmented by a factor that controls for changes in family size and by 12 monthly dummies that adjust for seasonality. In particular, the estimation equation is specified as

$$cg_{t+1} = \sigma \ln(R_{t+1}) + \phi\chi_{t+1} + \alpha\frac{1}{H_t}\sum_{h=1}^{H_t}\Delta \ln F_{t+1}^{h} + \sum_{m=1}^{12}\delta_m D_m + \mu_{t+1}, \tag{19}$$

where σ is the EIS, the D's are monthly dummies, and $\Delta \ln F_{t+1}^{h}$ is the the cross-sectional average of log changes in family size. The variables cg_{t+1} and χ_{t+1}, to reiterate, are respectively the consumption growth rate and the wealth-consumption ratio. The coefficients in front of the monthly dummies (i.e., the δ's) are functions of the subjective discount factor, the unconditional mean of the wealth-consumption ratio, and the conditional second or higher moments of the log asset returns, log consumption growth, and log wealth-consumption ratio. The error term μ_{t+1} consists of expectation errors in the Euler equation and measurement errors in log consumption growth and log wealth-consumption ratio. It is also possible that the conditional second or higher moments contained in the δ's are not constant, in which case, the δ terms capture the unconditional means of the second or higher moment terms, and the error term μ_{t+1} contains the deviations of these higher moments from their unconditional means.

IV.2. **Instrumental Variables.** An appropriate instrumental variable should be correlated with the explanatory variables including asset returns and the wealth-consumption ratio, but uncorrelated with the error term μ_{t+1}. There are three types of errors in μ_{t+1}, including expectation errors, approximation errors, and measurement errors. Under rational expectations, the expectation errors in μ_{t+1} are uncorrelated with variables in the information set of period t. For simplicity, we assume that the second or higher moment terms of the relevant variables in the estimation equation (19) are either constant or uncorrelated with variables in the information set of period t. Under these assumptions and in the absence of measurement errors, any variable dated t or earlier can serve as an appropriate instrument.

However, time aggregation introduces potential serial correlations in the error term. We need to take into account time aggregation issues when selecting instruments and the number

of lags (e.g., Hall, 1988). In our model, a decision period corresponds to one quarter of a year. Accordingly, we construct quarterly data by staggering the monthly series in the CEX sample. This time aggregation approach implies that two adjacent data points contain two overlapping months and thus overlapping errors. As a consequence, the error term in our model contains an MA(2) component, which we take into account in selecting the lag length for the instrumental variables.

The instruments that we use for the asset returns include (i) a log dividend-price ratio measured by the ratio of dividends paid during the previous 12 months to the current-period S&P 500 index price, (ii) lagged, log real value-weighted NYSE returns, and (iii) lagged, log real 30-day Treasury bill returns. To ensure that the instruments are uncorrelated with the error term (which is potentially autocorrelated, as discussed above), we use the compounded return $R_{m-2}R_{m-1}R_m$ as the lagged asset returns in our set of instrumental variables. These instrumental variables for asset returns are similar to those used by Vissing-Jørgensen (2002).

The instrumental variables that we use for the wealth-consumption ratio in month $t+1$ include the wealth-income ratio lagged by 3 months (i.e., $\ln \frac{w_{t-2}}{y_{t-2}}$), consumption growth rates lagged by 3 months and 6 months (i.e., $\ln \frac{c_{t-2}}{c_{t-3}}$ and $\ln \frac{c_{t-5}}{c_{t-6}}$), as well as measures of asset returns with appropriate lags. Since our measure for wealth w_{t+1} is constructed under a "buy-and-hold" assumption, it should be correlated with lagged wealth w_{t-2}. We use the lagged wealth-income ratio instead of the lagged wealth-consumption ratio as an instrument, since the latter could be correlated with measurement errors in the left-hand-side variable (i.e., the consumption growth rate).

Table 1 reports the first-stage regression of the wealth-consumption ratio and its interaction with an IRA dummy (described in more details in Section IV.4.3) on the instrumental variables. The table reveals that most of the instrumental variables are significantly correlated with the wealth-consumption ratio.

IV.3. **Estimation Procedure.** We estimate the EIS and the temptation parameter using GMM with an optimal weighting matrix. We compute the Newey-West robust standard errors that take into account heteroskedasticity and autocorrelations in the error terms.

To examine the statistical significance of temptation preferences, we follow two steps. First, we estimate the unrestricted model described by (19). Second, we estimate a restricted model by imposing $\phi = 0$. Under this restriction, we are estimating a standard Euler equation with CRRA utility. We test the null hypothesis that $\phi = 0$ using a Wald statistic obtained as the ratio of the minimized quadratic objective in the restricted model to that in the unrestricted model, adjusted by the sample size and the degree of freedom. The test statistic has a χ^2 distribution with a degree of freedom equal to the number of restrictions.

IV.4. **Estimation Results.** The GMM estimation results of the log-linearized Euler equation (19) are shown in Table 2. The first three columns show the estimation results based on the real value-weighted NYSE returns (stock returns) and the next three columns show the results based on an average of the stock returns and the real 30-day Treasury bill rates (joint returns). In both cases, we find evidence of significant presence of temptation and self control preferences.

IV.4.1. *The restricted model without temptation.* We first describe the estimation results in the restricted model with no temptation (i.e., with $\phi = 0$ imposed). In this case, the model reduces to the standard Euler-equation model, with the elasticity of intertemporal substitution (EIS) as the only parameter to be estimated. This restricted model is similar to that studied by Vissing-Jørgensen (2002), who also uses CEX data and takes into account limited asset-market participation but with a slightly different aggregate approach (e.g., she constructs semi-annual consumption growth while our aggregation approach leads to quarterly consumption growth).

Table 2 shows that, when asset returns are measured by real stock returns (Column (1)), the estimated EIS is $\hat{\sigma} = 0.203$, which is statistically significant at the 99 percent level. When asset returns are measured by the average of real stock returns and real 30-day Treasury bills rates (Column (4)), the EIS estimate becomes greater (0.407) and remains statistically significant. The estimated values of the EIS in the restricted model are comparable to those obtained by Vissing-Jørgensen (2002) (which is about 0.3 for stock holders).[13]

IV.4.2. *The benchmark model with temptation.* We now discuss the estimation of the Euler equation in the benchmark model with temptation. Columns (2) and (5) in Table 2 show the estimation results. Similar to the restricted model without temptation, we obtain a larger EIS estimate when asset returns are measured by joint returns than by stock returns (0.496 vs. 0.274). The estimated value of the temptation parameter is about 0.012 using stock returns and 0.01 using joint returns, both statistically significant at the 95 percent level.

In the model restriction test, the Wald statistic and the associated p value reject the null hypothesis that $\phi = 0$. Thus, the wealth-consumption ratio is a statistically important component in the pricing kernel. This result is consistent with temptation preferences.

IV.4.3. *Desires for commitment.* An important implication of the dynamic self-control theory is that a GP agent has a desire for commitment, since ex ante commitment helps reduce ex post costs of self control. The desire for commitment helps distinguish self-control preferences from other preference specifications such as habit formation (e.g., Constantinides,

[13]Our EIS estimate lies within the estimated range obtained by Hall (1988), who uses aggregate consumption time-series data, which include consumption expenditures of all households, not just those who have positive asset holdings.

1990; Campbell and Cochrane, 1999), non-expected utility (e.g., Epstein and Zin, 1989, 1991), and the spirit of capitalism (e.g., Bakshi and Chen, 1996). Each of these alternative preference specifications introduces an additional element in the pricing kernel (in addition to consumption growth), as does the GP preference specification. It is important to disentangle the GP preferences from these alternative specifications because the additional component in the pricing kernel under these alternative specifications can be correlated with the wealth-consumption ratio.

We now exploit this theoretical implication of the GP theory in our empirical study. If the GP theory is correct, then an individual who is more susceptible to temptation should have a stronger incentive to hold commitment assets, that is, assets that cannot be easily re-traded or used as a collateral for borrowing. One form of such assets is contributions to IRA or 401(k) retirement plans because early withdrawals from these accounts are subject to substantial tax penalties.

To capture the preference for commitment, and thereby to disentangle self-control preferences from other preference specifications, we generalize the empirical model in equation (19) by including an interaction term between the wealth-consumption ratio and an IRA dummy. This dummy variable takes a value of one if the household has positive holdings of IRA or 401(k) assets; otherwise, it takes a value of zero.

While IRA and 401(k) accounts may be held as commitment devices for individuals with self-control problems (Laibson, et al., 1998), these assets may also be held for tax reasons or because an individual is more patient. To control for these confounding factors, we include in the empirical model the IRA dummy as a separate regressor. The return-driven portfolio decisions apply to all individuals—with or without self-control problems. More importantly, return-driven portfolio decision theory does not explain why those individuals who hold IRAs or 401(k) accounts should also have a greater slope coefficient on the wealth-consumption ratio in the Euler equation. The GP theory, however, implies that those who have a greater self-control problem should have a larger coefficient for the wealth-consumption ratio in the Euler equation.

Thus, the intercept term (i.e., the IRA dummy itself) in the empirical model may capture the effects of individual differences in patience and the rate-of-return considerations. The slope coefficient on the wealth-consumption ratio then captures the degree of temptation.

Specifically, we consider the generalized empirical model

$$\begin{aligned} cg_{t+1} &= \sigma \ln(R_{t+1}) + \phi_0 \chi_{t+1} + \phi_1 \frac{1}{H_t} \sum_{h=1}^{H_t} \left[IRA^h \times \ln\left(\frac{w_{t+1}^h}{c_{t+1}^h} \right) \right] \\ &+ \delta \frac{1}{H_t} \sum_{h=1}^{H_t} IRA^h + \alpha \frac{1}{H_t} \sum_{h=1}^{H_t} \Delta \ln F_{t+1}^h + \sum_{m=1}^{12} \delta_m D_m + \mu_{t+1}, \end{aligned} \tag{20}$$

where the coefficient δ on the IRA dummy captures patience factors or rate-of-return considerations. The magnitude of the self-control problems for those individuals who hold IRAs or 401(k) accounts is measured by $\phi_0 + \phi_1$; for those who don't hold these illiquid assets, it is measured by ϕ_0.

Columns (3) and (6) in Table 2 report the estimation results from the generalized empirical model in equation (20). The estimated EIS is similar to the benchmark model without the IRA dummy and remains statistically significant at the 99 percent level. More importantly, the point estimate for the temptation parameter in the subgroup of households who hold positive IRA/401(k) assets is twice as large as its population counterpart. Using stock returns, the point estimate for the temptation parameter is doubled to 0.024 ($\phi_0 + \phi_1 = 0.069 - 0.037 = 0.024$) from 0.012 in the benchmark model. The Wald statistics rejects the null hypothesis that $\phi_0 + \phi_1 \leq 0$, with a p-value of 0.03. We obtain similar results when we use joint asset returns (Column (6)).

Our finding that the temptation parameter is larger for individuals who hold IRA/401(k) assets lends empirical support to the GP theory.

IV.5. **Temptation preferences or liquidity constraints?** The finding that changes in the expected wealth-consumption ratio have a significant impact on expected consumption growth is consistent with the GP theory. However, this finding may also be consistent with the presence of liquidity constraints. For an individual who does not have self-control problems but is nonetheless liquidity constrained, changes in expected wealth may also affect her consumption growth. We now offer a theoretical argument and some supporting evidence that help disentangle self-control problems from liquidity constraints.

If an individual faces a binding liquidity constraint and the borrowing limit is exogenously fixed, then an increase in future wealth helps raise future consumption. But the increase in future wealth should have no effects on current consumption because the borrowing limit is fixed. Therefore, expected consumption growth rate should increase with expected wealth. If this were true in our data, then the estimated positive coefficient ϕ in our Euler equation (19) would reflect the effects of liquidity constraints and may not stem from temptation preferences.

In our data sample, however, exogenous credit limits are likely not important because, by construction, all households in our sample are asset-market participants. The households in our data sample are more likely to face some form of credit constraints, similar to those commonly studied in the macroeconomics literature (e.g., Kiyotaki and Moore, 1997; Bernanke, et al., 1999; Iacoviello, 2005; Liu, et al., 2013). Under this type of credit constraints, credit limits depend on the agent's expected wealth (or collateral value) that represents the agent's future repayment capability. Thus, an increase in expected wealth

helps relax the *current-period* liquidity constraint and raise current consumption. In future periods, the agent needs to repay the debt by reducing consumption. As a consequence, an increase in expected wealth *lowers* the expected consumption growth rate. In contrast, a central implication of the GP theory is that an increase in expected wealth-consumption ratio should *raise* expected consumption growth.

Our finding of a significantly positive coefficient for the wealth-consumption ratio in the estimated Euler equation (19) is thus inconsistent with the presence of liquidity constraints with an endogenous credit limit.

Nonetheless, it is important to control for liquidity constraints in our estimation because the presence of liquidity constraints (with an endogenous credit limit) would cause a downward bias for the estimated strength of the temptation parameter (i.e., the value of ϕ). Absent any self-control problems, the estimated response of consumption growth rate to changes in the wealth-consumption ratio (i.e., the value of ϕ) would be negative for liquidity constrained households. With self-control problems, the estimated value of ϕ would be reduced relative to that for the households who do not face binding liquidity constraints.

To correct the downward bias in our estimation caused by liquidity constraints, we split the sample of households into two groups—those who are liquidity constrained and those who are not. We follow the literature and define liquidity-constrained households as those with a net liquid asset value less than 2 months of labor income (e.g., Hall, 2011).[14] We then estimate the Euler equation in (20) for each subsample of households (liquidity constrained and unconstrained). Again, we use the interaction term between the wealth-consumption ratio and the IRA dummy to capture the desire for commitment.

Table 3 reports the estimation results. Consistent with our theoretical argument, the presence of liquidity constraints reduces the estimated coefficient for the wealth-consumption ratio in the Euler equation. In particular, for the subsample with liquidity constrained households, the estimated value of the temptation parameter using the stock returns is about 0.02 (i.e., $\phi_0 + \phi_1 = -0.021 + 0.041 = 0.02$), which, although statistically significant, is slightly smaller than that in the full sample (where we obtain a value of 0.024). For the subsample of households who are not liquidity constrained, however, we obtain greater values of the temptation parameter than in the full sample. Specifically, for this subsample of households, the estimated value of the temptation parameter is about 0.034, which is statistically significant. Thus, correcting the bias caused by liquidity constraints leads to a greater value of estimated temptation parameter.

[14]Following Hall (2011), we define net liquid assets as the difference between holdings in checking and savings accounts and the alike and borrowings from credit cards and other unsecured debt. In our sample, about 70% of the households are liquidity constrained. This is very similar to Hall's (2011) finding that 74% of households in the Survey of Consumer Finance are liquidity constrained.

IV.6. **Further corroborating evidence.** We have argued that defined contribution retirement plans such as IRAs help identify self-control preferences because their illiquidity provides commitment values for individuals with self-control problems. There are other illiquid assets (such as housing) that a GP agent might use as a commitment device. How do holdings of these alternative illiquid assets affect our estimation? We now examine this issue by focusing on the implications of home ownership.

In our sample, the homeownership rate is about 85% conditional on asset-market participation (in the general CEX sample, it is about 62%). We estimate the model specified in equation (20) using the subsample of home owners. Table 4 reports the estimation results and compares these estimates with those in the benchmark model estimated using the full sample of asset-market participants. The table reveals that the estimated strength of temptation is stronger for home owners than for the general population. For example, when we measure asset returns using real stock returns, the estimated strength of temptation is $\phi_0+\phi_1 = 0.026$, which is slightly larger than that obtained for the general population that includes also non-homeowners. The Wald statistic rejects the null hypothesis that $\phi_0+\phi_1 \leq 0$, with a p-value less than 0.01. This finding is consistent with the view that an individual with self-control preferences has a desire for commitment. The individual not only holds IRAs or 401(k) accounts, but also holds housing as devices for commitment.

V. Some Applications

Our evidence provides statistical support for the presence of temptation and self-control in preferences. We now discuss some quantitative applications of the GP theory based on our estimated strength of temptation. The first application studies the effects of temptation on wealth accumulation in a neoclassical growth model, and the second application revisits the welfare cost of the business cycle in the presence of temptation.

V.1. **Temptation and Wealth Accumulation.** Temptation and costly self-control typically reduce saving and therefore lower steady-state income and wealth. To examine the quantitative importance of temptation on wealth accumulation, we consider a neoclassical growth model in which the representative household faces temptation and costly self-control.

Specifically, we consider an economy with a representative household who has a logarithm commitment utility in consumption (i.e., $u(c) = \log(c)$) and who supplies her time endowment (normalized to unity) inelastically to firms for production. The production function is given by $y = k^\alpha$, where y and k denote output and capital stock, both expressed as per effective unit of labor. Capital stock depreciates completely within one period so that the law of motion for capital stock is given by $gk' = k^\alpha - c$, where g is an exogenous growth rate of the effective units of labor and k' denotes the next-period capital stock. As in our baseline model, we assume that the temptation utility is given by $v(c) = \lambda u(c)$. With complete

capital depreciation, the maximum consumption attainable is current-period output. That is, the temptation point is $w = k^\alpha$. The planner solves the dynamic programming problem

$$W(k) = \max_{0 \le k' < k^\alpha/g} \{(1+\lambda)\log(k^\alpha - gk') + \beta W(k') - \lambda \log(k^\alpha)\}. \tag{21}$$

Under these model specifications, we obtain closed form solutions given by

$$k^* = \left(\frac{s^*}{g}\right)^{\frac{1}{1-\alpha}}, \quad y^* = k^{*\alpha}, \quad \text{where } s^* = \frac{\alpha\beta}{1+\lambda(1-\alpha\beta)}. \tag{22}$$

The term s^* here denotes the saving rate. The standard model without temptation corresponds to the case with $\lambda = 0$, so that the saving rate is given by $\bar{s} = \alpha\beta > s^*$, and the steady-state capital ($\bar{k}$) and income ($\bar{y}$) are given by analogous expressions as those in (22).

One way to gauge the importance of temptation on saving and wealth accumulation is to compare the saving rate and the steady-state levels of capital and income in the two economies, one with temptation and the other without. Our closed-form solutions imply that the gaps in the saving rate, the capital stock, and the income level in the baseline economy (relative to the economy without temptation) are given by

$$\frac{\bar{s}}{s^*} = 1 + \lambda(1-\alpha\beta), \quad \frac{\bar{k}}{k^*} = \left(\frac{\bar{s}}{s^*}\right)^{\frac{1}{1-\alpha}}, \quad \frac{\bar{y}}{y^*} = \left(\frac{\bar{s}}{s^*}\right)^{\frac{\alpha}{1-\alpha}}. \tag{23}$$

The levels of, and the gaps in the saving rates, wealth, and income depend on 3 parameters: the income share of capital α, the subjective discount factor β, and the temptation parameter λ. Holding α and β constant, a higher cost of self-control (measured by λ) lowers the saving rate and long-run wealth and income. Holding α and λ constant, a higher level of patience (measured by β) leads to more saving and closes part of the saving gap between the two economies. Holding β and λ constant, a higher income share of capital (measured by α) raises the saving rate and wealth accumulation, reduces the gap in the saving rate, although it has ambiguous effects on the wealth gap and the income gap.

To see the quantitative effects of temptation on wealth accumulation, we calibrate the parameters α, β, and λ. Following the literature, we set $\alpha = 0.3$ and $\beta = 0.9$. To calibrate the value of λ, we use the relation $\lambda = \frac{\phi(w/c)^\gamma}{1+\phi(1-(w/c)^\gamma)}$ (see Equation (16)), where we set $\phi = 0.02$ based on our estimates, $\gamma = 1$ (corresponding to log utility), and $w/c = 4.84$ based on the wealth-consumption ratio in the NIPA data (see Footnote 1 for a description of the data). It follows that λ is about 0.10.

With the parameters so calibrated, we obtain $\bar{s}/s^* = 1.07$, $\bar{k}/k^* = 1.11$, and $\bar{y}/y^* = 1.03$. Thus, moving from an economy with temptation to one without entails a 7% increase in the saving rate, an 11% increase in the steady-state level of capital, and a 3% increase in steady-state income.

Figure 1 plots the gaps in the saving rate, the capital stock, and the income level for λ varying between 0 and 1. Evidently, the presence in temptation can lead to significant reductions in savings and long-run income and wealth.[15]

It is possible to restore the steady-state levels of income and capital stock to those in the counterfactual economy without self-control problems. For example, one could use investment subsidies (financed by lump-sum taxes) to raise the steady-state level of capital stock.[16] Our calculations based on the estimated temptation parameter suggests that the required investment subsidy rate is about 11%, which is economically significant.

V.2. **Temptation and Welfare.** We now examine the quantitative implications of temptation preferences on the welfare cost of business cycles based on our estimated strength of temptation. Following Lucas (1987), we focus on a representative-agent economy, and we do not attempt to model the driving forces of the business cycle properties of consumption and wealth; instead, we assume that these variables follow the same stochastic processes as observed in U.S. data.[17] We imagine the existence of a (black-box) model that is capable of generating exactly the same business cycle properties of consumption and wealth as in the data. In practice, we assume that the logarithm of the level of real consumption per capita follows a trend-stationary process,

$$c_t = c + \mu t - \frac{1}{2}\sigma_z^2 + z_t, \tag{24}$$

where z_t is an i.i.d. white-noise process with mean 0 and standard deviation σ_z. We also make an assumption that the log-level of real wealth per capita follows a trend-stationary process,

$$w_t = w + \mu t - \frac{1}{2}\sigma_u^2 + u_t, \tag{25}$$

where u_t is an i.i.d. white-noise process with mean 0 and standard deviation σ_u. To help exposition, we assume that u_t and z_t are independent processes.[18] The assumption that consumption and wealth share a common trend is motivated by empirical evidence on the existence of a cointegration relation between the two variables in U.S. data (e.g., Lettau and

[15]With incomplete capital depreciation, the negative effects of temptation on saving and wealth accumulation are likely larger because undepreciated capital becomes part of the liquid wealth and thereby providing an additional source of temptation.

[16]We do not claim such a policy is necessarily optimal because the social planner could also face self-control problems that individual agents face.

[17]One should view the analysis here as a first pass to a more ambitious investigation that takes into account potential effects of household heterogeneity and market incompleteness, among other frictions. For a survey of this literature, see, for example, Barlevy (2004).

[18]Allowing for cross correlations between these processes does not change the qualitative results. A more ambitious exercise should consider general equilibrium interactions between consumption and wealth, which we leave for future research.

Ludvigson, 2001, 2004). The terms $\sigma_z^2/2$ and $\sigma_u^2/2$ are subtracted from the log of consumption and the log of wealth to ensure that changes in the variances of the innovation terms are mean-preserving spreads on the corresponding levels.

In the spirit of Lucas (1987), we ask the following question: What would be the maximum welfare gains if all uncertainties in consumption and wealth were eliminated? To answer this question, we measure the welfare gains by the percentage increase in consumption that the representative household needs to be compensated in the economy with uncertainties specified in (24) and (25), so that the household would be indifferent between living in the stochastic economy and living in a hypothetical benchmark economy without uncertainties. We call this measure of welfare the "compensation consumption equivalence" (CCE). With some algebra, we can show that the CCE is given by

$$\mathrm{CCE}_1 = \exp\left(\frac{1}{2}\sigma_z^2 - \frac{\lambda}{2(1+\lambda)}\sigma_u^2\right) - 1, \tag{26}$$

for the case with $\gamma = 1$ (i.e., the log utility), and by

$$\mathrm{CCE}_2 = \exp\left(\frac{\gamma}{2}\sigma_z^2\right)\left\{1 + \frac{\lambda}{1+\lambda}\left(\frac{W}{C}\right)^{1-\gamma}\left[\exp\left(-\frac{\gamma(1-\gamma)}{2}\sigma_u^2\right) - 1\right]\right\}^{\frac{1}{1-\gamma}} - 1, \tag{27}$$

for the general case with $\gamma \neq 1$.

Evidently, the welfare cost of business cycle fluctuations increases with consumption volatility (i.e., σ_z^2) and, if $\lambda > 0$, decreases with wealth volatility (i.e., σ_u^2). Lucas's original calculation based on standard preferences without temptation suggests that the welfare costs of business cycles are likely small. Our calculation here suggests that, in the presence of temptation (i.e., $\lambda > 0$), the costs would be even smaller. Further, depending on the volatility of wealth relative to that of consumption and on the strength of temptation, the welfare costs of fluctuations can even be negative!

It is clear that risk-averse individuals dislike fluctuations in consumption, so that an increase in consumption volatility raises the welfare cost of fluctuations. It is less transparent why the welfare cost decreases with wealth volatility in the presence of temptation. To understand this result, it helps to inspect the utility function (2). There, it is clear that, as wealth increases, the household needs to exert more effort to resist the temptation of overconsumption, although it enables the household to afford more. Since the temptation utility with respect to wealth is concave, larger volatilities in wealth fluctuations tend to lower the expected temptation utility, and thus to reduce the effort needed to resist temptation. In this sense, fluctuations in wealth provide some commitment value that increases welfare. This is why an increase in the variance of wealth tends to reduce the welfare costs, as revealed by the expressions in (26) and (27). These expressions also reveal that, as the strength

of temptation measured by λ increases, the welfare cost declines for given volatilities in consumption and wealth, as illustrated by Figure 2.[19]

A natural question is then: What is the quantitative size of the welfare costs of business cycle fluctuations in the U.S. economy? To answer this question, we need to calibrate the volatilities σ_z and σ_u, the parameters γ and λ, and the wealth-consumption ratio W/C. For the purpose of illustration, we calibrate the volatilities and the wealth-consumption ratio using two alternative sources of data. One source is the aggregate time series of consumption, income, and asset holdings constructed by Lettau and Ludvigson (2001) based on the NIPA data; and the other is the CEX data. The trends in the data are removed by applying the Hodrick-Prescott filter (for the CEX data, we also make seasonal adjustments before applying the HP filter). From the NIPA data, we obtain $\sigma_z = 0.0086$, $\sigma_u = 0.0354$, and $W/C = 4.838$. From CEX data, we obtain $\sigma_z = 0.0716$, $\sigma_u = 0.0946$, and $W/C = 9.995$.

Given the average wealth-consumption ratio in our samples, we then calibrate the parameters γ and λ using our estimates for the EIS parameter σ and the temptation parameter ϕ, as well as the relation in (16). In light of our estimates, we set $\gamma = 1$ and $\phi = 0.02$ as a baseline. Given these values of γ and ϕ, we obtain $\lambda = 0.10$ for the NIPA data and $\lambda = 0.24$ for the CEX data. These parameter values imply that $CCE = -0.002$ percent for the NIPA data and $CCE = 0.167$ percent for the CEX data. These results suggest that the welfare costs of business cycle fluctuations are not only small but can even be negative with our estimated strength of temptation in preferences.

What does this finding say about stabilization policies? Lucas (1987) concludes from his welfare exercises that stabilization policies may improve social welfare, but they are far less important than policies that promote economic growth. Our results lend support to his view. Further, our results suggest that stabilization policies, especially those aiming at smoothing income and therefore wealth fluctuations, can be counterproductive, since fluctuations in income and wealth serve to reduce the efforts needed for individuals to resist temptation. In this sense, though fluctuation in consumption may reduce welfare, some fluctuations in income and wealth can be socially desirable and might not deserve to be targets of stabilization policies.

VI. Conclusion

In a series of important contributions, Gul and Pesendorfer (2001, 2004a) have laid down a theoretical, axiomatic foundation for the representation of preferences that allows for temptation and self-control. One of the main attractions of the axiomatic approach is that

[19]The welfare costs in Figure 2 are calculated based on the assumption of log utility, with the average wealth-consumption ratios and the volatilities of consumption and wealth calibrated to NIPA data and CEX data, respectively, as we describe below.

such preference representation is time-consistent, and is thus suitable for studying optimal policies. Temptation and self-control preferences have many important implications on macroeconomic issues, such as social security reform, income tax reform, and a variety of asset-pricing issues. To assess with confidence the quantitative importance of GP preferences for these prominent issues, one needs to get a sense about whether or not the presence of temptation and self-control in preferences is supported by data.

This paper represents a first attempt at estimating the strength of temptation and self-control using household-level data. We have presented a simple infinite-horizon consumption-savings model that allows, but does not require, temptation and self-control in preferences. We have shown that, in the presence of temptation and self-control, the asset-pricing kernel is a function of not only consumption growth, as in standard models with CRRA utility, but also the wealth-consumption ratio, a feature unique to the model with temptation and self-control preferences. Using individual household-level data on consumption and wealth from the U.S. Consumer Expenditure Survey, we have obtained statistically significant joint estimates of the elasticity of intertemporal substitution and the parameter measuring the strength of temptation and self-control. The use of household-level data allows us to take into account limited participation in asset market transactions. More importantly, introducing household-level heterogeneity enables us to identify the presence of temptation and self-control based on a unique property of the GP preferences, that is, the desire for commitment. Our empirical results lend support to the presence of temptation and self-control in individuals' preferences. Based on our estimates, we find that GP preferences have quantitatively important implications for understanding capital accumulation in an optimal growth model and for calculating the welfare cost of the business cycle.

Our findings have potential implications for some asset-pricing issues. In the presence of temptation, the wealth-consumption ratio and the consumption growth rate for asset holders jointly determine the asset-pricing kernel. Thus, looking into this class of preferences may also help build a theoretical underpinning for empirical work that aims at forecasting future asset returns and for explaining the cross-sectional variations of asset returns based on the wealth-consumption ratio for asset holders. The GP preferences are also potentially important for understanding some public finance issues, such as the optimal design of social security and taxation systems. Quantitative assessment of these issues are promising, as they have important implications for public policy. Doing so would certainly require reliable empirical estimates of the strength of temptation and self-control, and our work represents a first step in this direction.

Appendix

Overview of the CEX. The CEX survey is a rotating panel of about 5,000 households as a representative sample of the U.S. civilian noninstitutionalized population. Each household is interviewed every three months and participates in the survey for five consecutive quarters, including one training quarter with no data recorded and four "regular" quarters. The 5,000 interviews are organized into monthly rotating groups and split more or less evenly over the three months of the quarter. Each quarter, roughly one-fifth of the sample is new and one-fifth is completing its fifth and final interview. Expenditure, income, and demographic information is recorded in the second to fifth quarter. Financial information is gathered only in the last interview, in which households report both the current stock of financial assets and changes in the market value of assets in the prior 12 months. The survey accounts for about 95 percent of all household expenditures in each consumption category from a highly disaggregated list of consumption goods and services. Our sample was drawn from CEX data files corresponding to the period 1984:Q3 through 2002:Q1.

Sample selection. To minimize the influence of measurement errors and other problems caused by poor quality of the data in our estimation, we apply some restrictions to our sample. First, we drop from our sample households who report non-positive real quarterly consumption. Second, as in Zeldes (1989) and Vissing-Jorgensen (2002), we drop observations with outliers in consumption growth. Third, we drop non-urban households and those residing in student housing. Finally, we exclude from our sample households that report a change in the age of the household head between any two interviews by more than one year or less than zero. We do this to rule out the possibility of drastic changes in consumption behavior due to changes in household heads.

Consumption measure. We derive our measure of consumption from the detailed CEX expenditure files and construct the variable corresponding as closely as possible to Personal Consumption Expenditure (PCE) in the U.S. National Income and Product Accounts. A typical consumption basket includes food, alcoholic beverages, tobacco, apparel and services, gasoline and auto oil, household operations, utilities, public transportation, personal care, entertainment, and miscellaneous expenditures.

Labor income measure. Our measure of labor income was based on the household's after-tax labor income for the past 12 months, taken from the CEX family files for each interview. We then divide the reported annual income by four to obtain the quarterly measure of labor income.

Financial asset measure. The CEX survey provides information on a household's asset holdings only for the last interview, at which the household reports both the current stock

of assets and the change in market value of assets during the previous 12 months. What is relevant for the interpemporal Euler equation is the wealth-consumption ratio at the beginning of household's each decision period. For this purpose, we retrieve household's asset holdings at the beginning of its second interview period by subtracting the asset flows during the entire interview period from the end-of-interview asset stocks. Assuming that the households follow a "buy-and-hold" strategy between their two adjacent decision periods, we can further impute the market value of financial assets for each household at the beginning of the third, fourth, and fifth decision period (quarter) by multiplying the last period asset holdings with the corresponding asset returns of various asset categories. The asset categories are already summarized in Section (III.2). We assume zero net return on the checking accounts, use returns on the 30-day Treasury bills for the savings accounts and saving bonds, and finally use the New York Stock Exchange (NYSE) value-weighted returns for the last asset category of "stocks, bonds, mutual funds, and other such securities".

References

Altug, Sumru, and Robert A. Miller, 1990. Household Choices in Equilibrium. *Econometrica* 58(3), 543–570.

Ameriks, John, Andrew Caplin, John Leahy, and Tom Tyler, 2004. Measuring Self-Control. NBER Working Paper No. W10514.

Attanasio, Orazio P., 1999. Consumption. Chapter 11 of *Handbook of Macroeconomics*, Vol 1, J.B. Taylor and M. Woodford (ed), Elsevier Science B.V. 1999.

Attanasio, Orazio P., and Steven J. Davis, 1996. Relative Wage Movements and the Distribution of Consumption. *Journal of Political Economy* 104(6), 1227–1262.

Attanasio, Orazio P., and Hamish Low, 2004. Estimating Euler Equations. *Review of Economic Dynamics* 7(2), 406–435.

Attanasio, Orazio P., and Guglielmo Weber, 1989. Intertemporal Substitution, Risk Aversion and the Euler Equation for Consumption. *Economic Journal* 99(395), Supplement: Conference Papers 59–73.

Attanasio, Orasio P., and Guglielmo Weber, 1993. Consumption Growth, the Interest Rate and Aggregation. *Review of Economic Studies* 60(204), 631–649.

Attanasio, Orazio P., and Guglielmo Weber, 1995. Is Consumption Growth Consistent with Intertemporal Optimization? Evidence from the Consumer Expenditure Survey. *Journal of Political Economy* 103(6), 1121–1157.

Attanasio, Orazio P., and Guglielmo Weber, 2010. Consumption and Saving: Models of Intertemporal Allocation and Their Implications for Public Policy. *Journal of Economic Literature* 48, 693-751.

Bakshi, Gurdip S., and Zhiwu Chen, 1996. The Spirit of Capitalism and Stock-Market Prices. *American Economic Review* 86(1), 133–157.

Barlevy, Gadi, 2004. The Cost of Business Cycles and the Benefits of Stabilization: A Survey. NBER Working Paper No. 10926.

Benhabib, Jess, and Alberto Bisin, 2005. Modelling Internal Commitment Mechanisms and Self-Control: A Neuroeconomic Approach to Consumption-Saving Decisions. *Games and Economic Behavior* 52(2), 460–492.

Bernanke, Ben, Mark Gertler, and Simon Gilchrist, 1999. The Financial Accelerator in a Quantitative Business Cycle Framework. In John B. Taylor and Michael Woodford (eds.), *The Handbook of Macroeconomics*, vol. 1, chap. 21, pp. 13411393. Amsterdam: Elsevier Science.

Bernheim, B. Douglas, and Antonio Rangel, 2002. Addiction and Cue-Conditioned Cognitive Processes. NBER Working Paper No. 9329.

Brav, Alon, George Constantinides, and Christopher Geczy, 2002, Asset Pricing with Heterogeneous Consumers and Limited Participation: Empirical Evidence. *Journal of Political Economy* 110(4), 793–824.

Browning, Martin, Angus Deaton, and Margaret Irish, 1985, A Profitable Approach to Labor Supply and Commodity Demands over the Life-Cycle. *Econometrica* 53(3), 503–543.

Bucciol, Alessandro, (forthcoming), Measuring Self-Control Problems: A Structural Estimation. *Journal of the European Economic Association.*

Campbell, John Y., 1993. Intertemporal Asset Pricing without Consumption Data. *American Economic Review* 83, 487-512.

Campbell, John Y., and John H. Cochrane, 1999. By Force of Habit: A Consumption-Based Explanation of Aggregate Stock Market Behavior. *Journal of Political Economy* 107(2), 205-251.

Carroll, Christopher D., 2001. Death to the Log-Linearized Consumption Euler Equation! (And Very Poor Health to the Second-Order Approximation), *Advances in Macroeconomics* 1(1), Article 6, http://www.econ.jhu.edu/people/ccarroll/death.pdf.

Cochrane, John H., 1991. A Simple Test of Consumption Insurance. *Journal of Political Economy* 99(5), 957–976.

Cochrane, John H., 2005. *Asset Pricing.* Princeton, NJ: Princeton University Press.

Cogley, Timothy, 2002. Idiosyncratic Risk and the Equity Premium: Evidence from the Consumer Expenditure Survey. *Journal of Monetary Economics* 49(2), 309–334.

Constantinides, George M., 1990. Habit Formation: A Resolution of the Equity Premium Puzzle. *Journal of Political Economy* 98(3), 519-543.

Constantinides, George M., 2002. Rational Asset Prices. *Journal of Finance* 57(4), 1567–1591.

Deaton, Angus, 1985. Panel Data from Time Series of Cross-Sections. *Journal of Econometrics* 30(1–2), 109–126.

Deaton, Angus, 1991. Saving and Liquidity Constraints. *Econometrica* 59(5), 1221–48.

Deaton, Angus, and Christina Paxson, 1994. Intertemporal Choice and Inequality. *Journal of Political Economy* 102(3), 437–467.

DeJong, David, and Marla Ripoll, 2003. Self-Control Preferences and the Volatility of Stock Prices. Working Paper, University of Pittsburgh.

Della Vigna, Stefano, and M. Daniele Paserman, 2005. Job Search and Impatience. *Journal of Labor Economics* 23(3), 527–588.

Epstein, Larry G., and Stanley E. Zin, 1989. Substitution, Risk Aversion, and the Temporal Behavior of Consumption and Asset Returns: A Theoretical Framework. *Econometrica* 57(4), 937–969.

Epstein, Larry G., and Stanley E. Zin, 1991. Substitution, Risk Aversion, and the Temporal Behavior of Consumption and Asset Returns: An Empirical Analysis. *Journal of Political Economy* 99(2), 263–286.

Fang, Hanming, and Dan Silverman, 2004. Time Inconsistency and Welfare Program Participation: Evidence from the NLSY. Cowles Foundation Discussion Paper No. 1465, Yale University.

Gul, Faruk, and Wolfgang Pesendorfer, 2001. Temptation and Self-Control. *Econometrica* 69(6), 1403–1435.

Gul, Faruk, and Wolfgang Pesendorfer, 2004a. Self-Control and the Theory of Consumption. *Econometrica* 72(1), 119–158.

Gul, Faruk, and Wolfgang Pesendorfer, 2004b. Self-Control, Revealed Preference and Consumption Choice. *Review of Economic Dynamics* 7(2), 243–264.

Gul, Faruk, and Wolfgang Pesendorfer, 2005a. The Revealed Preference Theory of Changing Tastes. *Review of Economic Studies* 72(2), 429–448.

Gul, Faruk, and Wolfgang Pesendorfer, 2005b. Harmful Addiction. *Review of Economic Studies* (forthcoming).

Haliassos, Michael, and Carol C. Bertaut, 1995. Why Do So Few Hold Stocks? *Economic Journal* 105(432), 1110–1129.

Hall, E. Robert, 1988. Intertemporal Substitution in Consumption. *Journal of Political Economy* 96(2), 339–357.

Hall, Robert E. 2011. The Long Slump. *American Economic Review* 101(2), 431-69.

Hall, E. Robert, and Frederic Mishkin, 1982. The Sensitivity of Consumption to Transitory Income: Estimates from Panel Data on Households. *Econometrica* 50(2), 461–481.

Harris, Christopher, and David Laibson, 2001. Dynamic Choices of Hyperbolic Consumers. *Econometrica* 69(4), 935–957.

Heckman, James.J., and Richard Robb, 1985. Alternative Methods for Evaluating the Impact of Interventions. In James J. Heckman and Burton Singer (eds.), *Longitudinal Analysis of Labor Market Data*. Cambridge: Cambridge University Press.

Iacoviello, Matteo, 2005. House Prices, Borrowing Constraints, and Monetary Policy in the Business Cycle. *American Economic Review* 95(3), 739-764.

Jacobs, Kris, 1999. Incomplete Markets and Security Prices: Do Asset-Pricing Puzzles Result from Aggregation Problems? *Journal of Finance* 54(1), 123–164.

Jacobs, Kris, and Kevin Q. Wang, 2004. Idiosyncratic Consumption Risk and the Cross Section of Asset Returns. *Journal of Finance* 59(5), 2211–2252.

Kiyotaki, Nobuhiro, and John Moore, 1997. Credit Cycles. *Journal of Political Economy* 105(2), 211248.

Kocherlakota, Narayana R., 2001. Looking for Evidence of Time-Inconsistent Preferences in Asset Market Data. *Federal Reserve Bank of Minneapolis Quarterly Review* 25(3), 13–24.

Kocherlakota, Narayana R., and Luigi Pistaferri, 2005. Asset Pricing Implications of Pareto Optimality with Private Information. Mimeo, Stanford University.

Krueger, Dirk, and Jesus Fernandez-Villaverde, 2004. Consumption over the Life Cycle: Facts from Consumer Expenditure Survey Data. Working Paper, University of Pennsylvania.

Krusell, Per, and Anthony A. Smith, Jr., 2003. Consumption-Savings Decisions with Quasi-Geometric Discounting. *Econometrica* 71(1), 365–375.

Krusell, Per, Burhanettin Kuruşçu, and Anthony A. Smith, Jr., 2002. Time Orientation and Asset Prices. *Journal of Monetary Economics* 49(1), 107–135.

Krusell, Per, Burhanettin Kuruşçu, and Anthony A. Smith, Jr., 2010. Temptation and Taxation. *Econometrica* 78(6), 2063-2084.

Laibson, David, 1997. Golden Eggs and Hyperbolic Discounting. *Quarterly Journal of Economics* 112(2), 443–477.

Laibson, David I., Andrea Repetto, and Jeremy Tobacman, 1998. Self-Control and Saving for Retirement. *Brookings Papers on Economic Activity* 1, 91–172.

Laibson, David I., Andrea Repetto, and Jeremy Tobacman, 2004. Estimating Discount Functions from Lifecycle Consumption Choices. Working Paper, Harvard University.

Laitner, John, and Dan Silverman, 2004. Estimating Life-Cycle Parameters from the Retirement-Consumption Puzzle. Working Paper, University of Michigan.

Lettau, Martin, and Sydney Ludvigson, 2001. Consumption, Aggregate Wealth, and Expected Stock Returns. *Journal of Finance* 56(3), 815–849.

Lettau, Martin, and Sydney Ludvigson, 2004. Understanding Trend and Cycle in Asset Values: Reevaluating the Wealth Effect on Consumption. *American Economic Review* 94(1), 276–299.

Liu, Zheng, Pengfei Wang, and Tao Zha, 2013. Land-Price Dynamics and Macroeconomic Fluctuations. *Econometrica* 81(3), 1147-1184.

Loewenstein, George, 1996. Out of Control: Visceral Influences on Behavior. *Organizational Behavior and Human Decision Processes* 65(3), 272–292.

Lucas, Robert J., 1978. Asset Prices in an Exchange Economy. *Econometrica* 46(6), 1429–1445.

Lucas, Robert J., 1987, *Models of Business Cycles*. Oxford: Basil Blackwell.

Ludvigson, Sydney, and Christina H. Paxson, 2001. Approximation Bias in Linearized Euler Equations. *Review of Economics and Statistics* 83(2), 242–256.

Mankiw, N. Gregory, and Stephen P. Zeldes, 1991. The Consumption of Stockholders and Nonstockholders. *Journal of Financial Economics* 29(1), 97–112.

Noussair, Charles, and Ping Wu, 2003. Risk Tolerance in the Present and the Future: An Experimental Study. *Managerial and Decision Economics* (forthcoming).

Paserman, Daniele, 2004. Job Search and Hyperbolic Discounting: Structural Estimation and Policy Evaluation. Working Paper, Hebrew University.

Peleg, Bezalel, and Manahem E. Yaari, 1973. On the Existence of a Consistent Course of Action when Tastes are Changing. *Review of Economic Studies* 40(3), 391–401.

Rabin, Matthew, 1998. Psychology and economics. *Journal of Economic Literature* 36(1), 11–36.

Rubinstein, Ariel, 2003. "Economics and Psychology"? The Case of Hyperbolic Discounting. *International Economic Review* 44(4), 1207–1216.

Strotz, R.H., 1956. Myopia and Inconsistency in Dynamic Utility Maximization. *Review of Economic Studies* 23(3), 165–180.

Vissing-Jorgensen, Annette, 2002. Limited Asset Market Participation and the Elasticity of Intertemporal Substitution. *Journal of Political Economy* 110(4), 825–853.

Zeldes, Stephen P., 1989. Consumption and Liquidity Constraints: An Empirical Investigation. *Journal of Political Economy* 97(2), 305–346.

TABLE 1. First Stage Instrumental Variable Regressions

	Dependent variable	
Instruments	$\ln \frac{w_{t+1}}{c_{t+1}}$	IRA$\times \ln \frac{w_{t+1}}{c_{t+1}}$
$\ln \frac{w_{t-2}}{y_{t-2}}$	1.076***	-0.284***
	(0.089)	(0.114)
IRA$\times \ln \frac{w_{t-2}}{y_{t-2}}$		1.676***
		(0.170)
$\Delta \ln c_{t-2}$	-0.643***	-0.442***
	(0.176)	(0.147)
$\Delta \ln c_{t-5}$	-0.347*	-0.357**
	(0.179)	(0.158)
Δln(*family size*)	-0.028	0.127
	(0.280)	(0.229)
Lagged Dividend-Price ratio	-1.251**	-1.292***
	(0.597)	(0.457)
Lagged stock returns	-0.998*	-1.278***
	(0.600)	(0.487)
Lagged bond returns	2.837	7.948**
	(4.402)	(3.559)
R^2	0.87	0.88
F test	96.13***	199.26***

Note: This table presents results from the first stage regression of log wealth-consumption ratio and its interaction with the IRA dummy. In addition to the instrumental variables listed in this table, the set of instruments also include monthly dummies (not shown here). The data are monthly frequencies from January 1984 to March 2002. The F-statistics at the bottom of the table test the overall significance of the regression. Standard errors in parenthesis are robust to heteroskedasticty and autocorrelation, with *, **, and *** denoting two-tailed significance at 10%, 5%, and 1% level, respectively.

TABLE 2. GMM Estimation of Euler Equation with Self-Control Preferences

	Stock Returns			Joint Returns		
	(1)	(2)	(3)	(4)	(5)	(6)
$\hat{\sigma}$	0.203***	0.274***	0.215***	0.407***	0.496***	0.443***
	(0.048)	(0.050)	(0.080)	(0.087)	(0.099)	(0.149)
$\hat{\phi}_0$		0.012**	-0.039		0.010**	-0.031
		(0.005)	(0.025)		(0.005)	(0.024)
$\hat{\phi}_1$			0.063*			0.052*
			(0.032)			(0.030)
$\hat{\delta}$			-0.111			-0.080
			(0.122)			(0.114)
Hansen's J	8.80	8.84	16.02	9.10	8.78	15.24
P-value	1.00	1.00	0.85	1.00	1.00	0.89
Model Restriction Test:						
Null Hypothesis:		$\phi_0 = 0$	$\phi_0 + \phi_1 \leq 0$		$\phi_0 = 0$	$\phi_0 + \phi_1 \leq 0$
Wald Stat (χ^2)		7.05	4.83		4.45	4.70
P-value		< 0.01	0.03		0.04	0.03
Obs (T)	200	200	200	200	200	200
Average Cell Size	182.07	182.07	182.07	182.07	182.07	182.07

Note: This table presents the second-stage GMM estimation results. Columns (1) and (4) show the estimates in the standard model with no self-control preferences. Columns (2) and (5) show the estimates in the model with self-control preferences, as specified in equation (19). Columns (3) and (6) show the estimates in the model with self-control preferences identified by holdings of IRA or 401(k) accounts, as specified in equation (20). The null hypothesis for the model restriction test is that $\phi_0 = 0$ in column (2) and (5); and $\phi_0 + \phi_1 \leq 0$ in column (3) and (6). Standard errors shown in the parentheses are robust to heteroskedasticty and autocorrelation. *, **, and *** indicate two-tailed significance at the 10%, 5%, and 1% level, respectively.

TABLE 3. GMM Estimation of Euler Equation with Self-Control Preferences: Liquidity Constrained vs. Unconstrained Households

	Unconstrained		Constrained		Benchmark	
	Stock return	Joint return	Stock return	Joint return	Stock return	Joint return
	(1)	(2)	(3)	(4)	(5)	(6)
$\hat{\sigma}$	0.305***	0.585***	0.104*	0.212**	0.215***	0.443***
	(0.077)	(0.156)	(0.056)	(0.107)	(0.080)	(0.149)
$\hat{\phi}_0$	0.004	0.005	-0.021	-0.020	-0.039	-0.031
	(0.013)	(0.013)	(0.021)	(0.021)	(0.025)	(0.024)
$\hat{\phi}_1$	0.031**	0.030*	0.041*	0.039	0.063*	0.052*
	(0.016)	(0.016)	(0.024)	(0.024)	(0.032)	(0.030)
$\hat{\delta}$	-0.117***	-0.114***	-0.023	-0.022	-0.111	-0.080
	(0.025)	(0.027)	(0.034)	(0.034)	(0.122)	(0.114)
Hansen's J	9.45	10.28	8.92	8.91	16.02	15.24
P-value	1.00	1.00	1.00	1.00	0.85	0.89
Model Restriction Test: $\phi_0 + \phi_1 \leq 0$						
Wald Stat (χ^2)	11.20	10.45	4.88	4.80	5.10	4.83
P-value	< 0.01	< 0.01	0.03	0.03	0.03	0.03
Obs (T)	200	200	200	200	200	200
Average Cell Size	55.64	55.64	126.43	126.43	182.07	182.07

Note: This table presents second-stage GMM estimation results for the sub-samples of liquidity constrained and unconstrained households. Following Hall(2011), we define a household as *liquidity constrained* if its net liquid asset holdings in checking and saving accounts combined are less than two months of its after-tax labor income. The fraction of *constrained* households is about 70% in our benchmark sample that includes the prime-age, broad birth-year cohort who are active market participants. The null hypothesis for the model restriction test is $\phi_0 + \phi_1 \leq 0$. Standard errors in parenthesis are robust to heteroskedasticty and autocorrelation. *, **, and *** denote two-tailed significance at the 10%, 5%, and 1% level, respectively.

TABLE 4. GMM Estimation of Euler Equation with Self-Control Preferences: Homeowners vs. General Population

	Homeowners		Benchmark	
	Stock return	Joint return	Stock return	Joint return
	(1)	(2)	(3)	(4)
$\hat{\sigma}$	0.119**	0.234**	0.215***	0.443***
	(0.049)	(0.95)	(0.080)	(0.149)
$\hat{\phi}_0$	-0.038	-0.036	-0.039	-0.031
	(0.031)	(0.031)	(0.025)	(0.024)
$\hat{\phi}_1$	0.064***	0.061***	0.063*	0.052*
	(0.016)	(0.016)	(0.032)	(0.030)
$\hat{\delta}$	-0.191***	-0.186***	-0.111	-0.080
	(0.071)	(0.070)	(0.122)	(0.114)
Hansen's J	8.80	8.79	16.02	15.24
P-value	1.00	1.00	0.85	0.89
Model Restriction Test: $\phi_0 + \phi_1 \leq 0$				
Wald Stat (χ^2)	14.28	13.95	4.83	4.70
P-value	< 0.01	< 0.01	0.028	0.030
Obs (T)	200	200	200	200
Average Cell Size	154.89	154.89	182.07	182.07

Note: This table presents second-stage GMM estimation results for the sub-sample of homeowners and compares them with the full-sample estimation. We define households as homeowners if they self-reported their housing tenure as "owned with/without mortgage" in the CEX survey. The fraction of *homeowners* is 85% in our benchmark sample that includes the prime-age, broad birth-year cohort who are active market participants. The null hypothesis for the model restriction test is $\phi_0 + \phi_1 \leq 0$. Standard errors in parenthesis are robust to heteroskedasticty and autocorrelation. *, **, and *** denote two-tailed significance at the 10%, 5%, and 1% level, respectively.

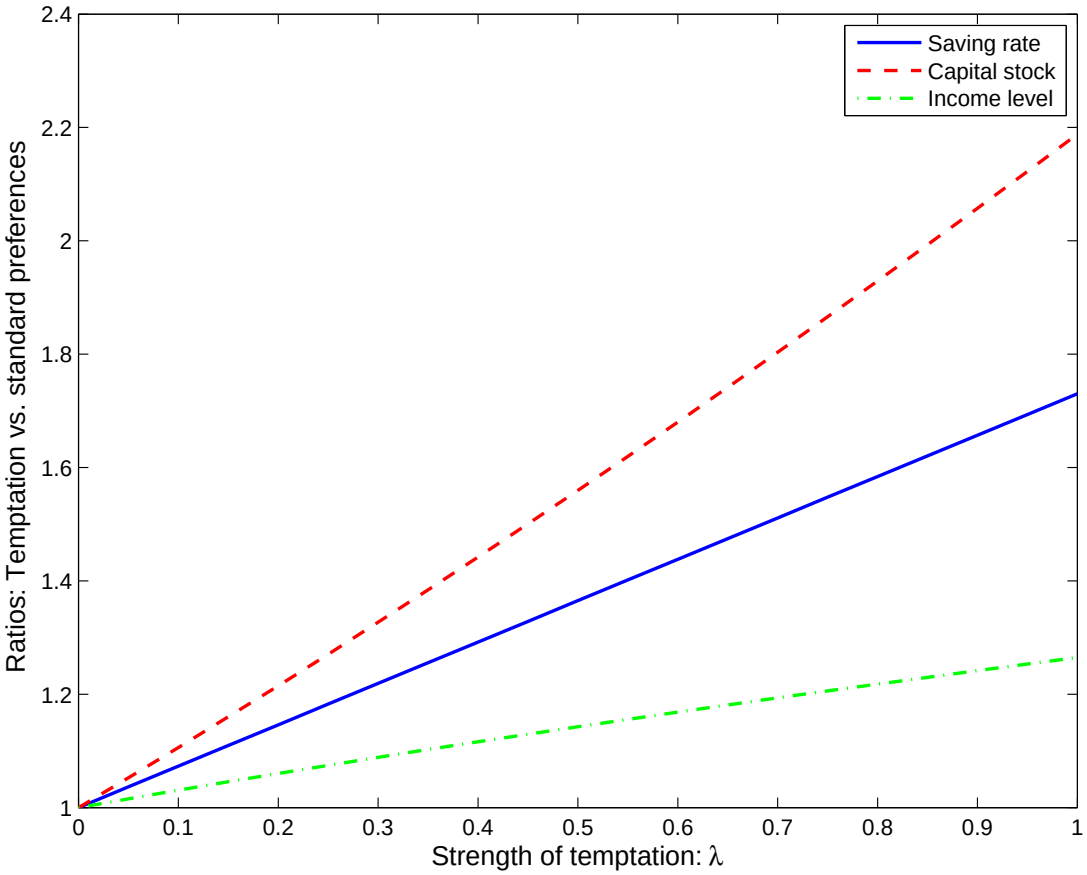

FIGURE 1. Temptation and wealth accumulation.

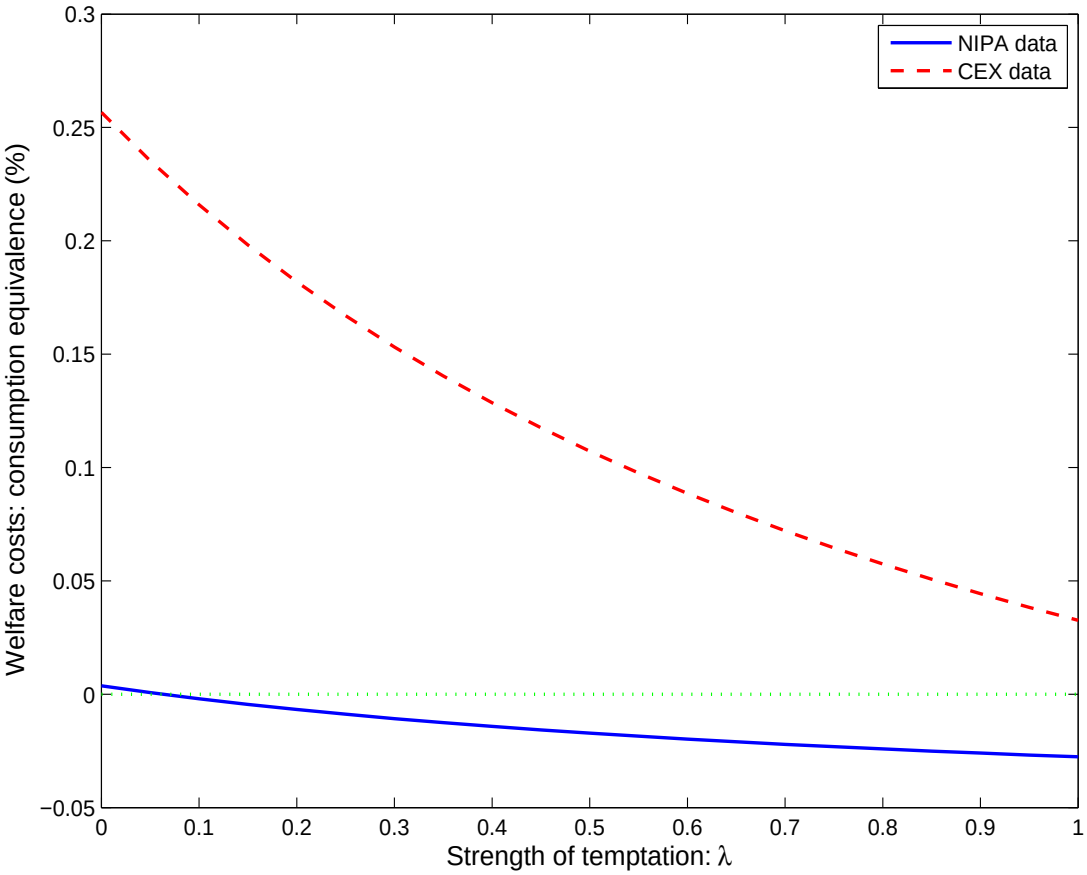

FIGURE 2. Temptation and welfare costs of business cycles.

VANDERBILT UNIVERSITY, FEDERAL RESERVE BANK OF SAN FRANCISCO, FUDAN UNIVERSITY SCHOOL OF MANAGEMENT