TEMPTATION AND SELF-CONTROL: SOME EVIDENCE AND APPLICATIONS

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Temptation and Self-Control: Some Evidence and Applications*

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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. To distinguish temptation preferences from others, we exploit individual-level heterogeneities in our data set, and we rely on an implication of the theory that a more tempted individual should be more likely to hold commitment assets. In the presence of temptation, the cross-sectional distribution of the wealth-consumption ratio, in addition to that of consumption growth, becomes a determinant of the asset-pricing kernel, and the importance of this additional pricing factor depends on the strength of temptation. The empirical estimates that we obtain provide statistical evidence supporting the presence of temptation. 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.

JEL classification: D91, E21, G12

Key Words: Temptation; Self-control; Limited participation; Growth; Welfare.

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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)

1 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 its super-healthy food. When he browsed through the menu, John was happy about what he saw: the menu contained various 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 the short-run behavior is not always consistent with the long-run plan. 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 captures 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 the cost 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 and

Smith, 2003; 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 once bought cannot be re-traded but liquidated only on the maturity date. As can be inferred from our analysis of (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 consumer's wealth-consumption ratio 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 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 $w/c = 7.7$, which corresponds to the average ratio of aggregate wealth (inclusive of income) to aggregate consumption in the U.S. data at annual frequency.[1] Suppose that both securities mature in 30 years. Then, as λ rises from 0 to 0.1, the relative price of security 2 to 1 rises from 1 to 1.41. Thus, for $\lambda = 0.1$, the cumulative commitment premium is about 41% for the 30 year period, corresponding to an average premium of about 1.16% per year. 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 (2003) 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 rapidly growing literature suggests that incorporating temptation and self-control in preferences may shed new lights on some important issues, especially those considered "puzzles" under standard preferences. Yet, assessing the quantitative importance of the GP preferences

[1]Our measure of wealth here is the sum of household networth and disposable personal income, and consumption is personal consumption expenditure on nondurables and services. The networth data are taken from Flow of Funds from the Federal Reserve Board (Table B.100: Balance Sheet of Household and Nonprofit Organizations), and the income and consumption data are both 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.

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. For this purpose, we construct an infinite-horizon consumption-savings model that allows for, but does not require, temptation and self-control in preferences. Since our model nests the standard consumption-savings model without temptation as a special case, testing the statistical presence of temptation boils down to a model-restriction test. We implement this test by first estimating an unrestricted model that allows for temptation using the generalized method of moments (GMM), and then estimating a restricted model that corresponds to the standard model without temptation. We then construct a Wald statistic to test the null hypothesis of the absence of temptation and self-control.

An innovation of this paper is that we use micro, household-level data from the Consumer Expenditure Survey (CEX) to estimate the strength of temptation. The use of micro data is essential for several reasons. First, it 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, as holding commitment assets helps reduce the cost of self control.[3] Second, allowing for preference heterogeneity and idiosyncratic risks is essential, especially in the absence of a complete insurance market. Without complete insurance, estimating intertemporal Euler equations based on aggregate data would be problematic, since agents would be exposed to uninsurable idiosyncratic risks. Third, as intertemporal Euler equations hold only for those individuals who participate in asset market transactions, using aggregate data may lead to inconsistent estimates of the parameters of interest as the limited-participation aspect would be ignored in the process of aggregation.[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. A main difference is that we use household-level pseudo-panel data constructed using the synthetic-cohort

[3]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.

[4]For some recent studies that emphasize the importance of idiosyncratic risks and limited participation, see Brav, Constantinides, and Geczy (2002), Cogley (2002), Vissing-Jorgensen (2002), and Jacobs and Wang (2004). For a survey of this literature, see Constantinides (2002).

approach and we find significant presence of temptation, whereas DeJong and Ripoll (2006) rely on aggregate time series data and they find a small level of self-control. We argue that such difference arises mainly because our model takes into account idiosyncratic risks and 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.

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, based on pseudo-panel data constructed using the synthetic cohort approach. We control the aggregation process and deal with potential measurement errors in the individual level data. This is fundamentally the same approach taken by Vissing-Jorgensen (2002), among others, under the standard preferences without temptation.

As we allow for temptation and self-control, the cross-sectional distribution of wealth-consumption ratios, in addition to the cross-sectional distribution of consumption growth rates, becomes a determinant of the intertemporal marginal rate of substitution (IMRS) (also known as the asset-pricing kernel or the stochastic discount factor), 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. In other words, wealth is the "temptation consumption."

The estimates that we obtain provide statistical evidence supporting the presence of temptation and self-control in 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.

To distinguish self-control preferences from other classes of preferences such as habit formation (e.g., Constantinides, 1990; Campbell and Cochrane, 1999) or non-expected utility (e.g., Epstein and Zin, 1989, 1991), we exploit an implication of self-control preferences 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.[5] To implement this idea, we include in our estimation equation an interaction term between the wealth-consumption ratio and an education dummy. The education dummy takes a value of one if the underlying individual has received 16 or more years of schooling, and zero otherwise. Since education can be viewed as a form of commitment asset (e.g., Kocherlakota, 2001), we should expect those individuals with higher levels of education to have also a larger temptation parameter. Indeed, this is borne out by our estimation.

Of course, there may be other reasons for education to be correlated with temptation. To isolate the commitment value of education, we need to control for a few other covariates. For this purpose, we use the Survey of Consumer Finance (SCF) data to examine cross-sectional correlations between pension participation and education, controlling for a set of demographic variables (such as age, assets, marital status, etc.). Since pension is arguably a form of commitment asset (especially in light of the tax penalties for early withdrawals), if the GP theory is correct, then we should expect that an individual with a higher level of education, holding other demographic characteristics fixed, should be more willing to participate in pension plans. Our SCF evidence provides strong support for this implication. The GP theory also implies that an individual with a greater degree of temptation, while more likely to hold commitment assets, should also be more likely to incur credit-card debt. Holding commitment assets ex ante helps reduce the cost of self-control ex post; but if the ex post self-control cost is sufficiently high, then the individual will choose to succumb to temptation. One way to give in is to borrow from credit cards. Our SCF evidence again lends support to this implication: individuals who have higher levels of education are more likely to hold credit-card debt, so are those who participate in pension plans.

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. It is possible to restore steady-state saving and income to levels obtained in an economy without temptation. It requires an investment subsidy rate of about 16% (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.

[5]Time-inconsistent preferences featuring hyperbolic discounting may also imply desire for commitment (e.g., Strotz, 1956; Laibson, 1997; Harris and Laibson, 2001). This class of preferences shares many other similar implications with GP preferences, although some subtle differences do exist (e.g., Gul and Pesendofer, 2004b). We emphasize that the current paper focuses on studying the empirical relevance of GP preferences (since it's easier to implement), and does *not* intend to distinguish between GP preferences and time-inconsistent preferences.

2 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 stochastic discount factor (SDF) in the model.

2.1 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.

2.2 An Infinite-Horizon Consumption-Savings Problem

Consider now a consumption-savings problem in an infinite-horizon economy with a large number (H) of households, who face idiosyncratic risks and incomplete insurance. 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.

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 and Smith (2003) and restrict attention to a class of constant relative risk aversion (CRRA) utility functions, with the commitment utility and the temptation utility functions given by

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

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 is thus 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

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

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

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).

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, preferences 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 education and pension, to help identify the presence of temptation.

Presence of temptation gives rise to 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 recent 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

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

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

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

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

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:

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

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

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

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).

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.

[9]Lettau and Ludvigson (2001, 2004) provide evidence that wealth and consumption are cointegrated in aggregate U.S. data. Zhu (2007) shows that the cointegrating relation between consumption and wealth is also present in the CEX data.

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 (15) and (14) 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 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

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

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 $\phi = 0$.

3 Data

In this section, we describe the data that we use to estimate the intertemporal Euler equations. The household-level data are taken from the Consumer Expenditure Survey (CEX) provided by the Bureau of Labor Statistics (BLS). In what follows, we present a general overview of CEX data (Section 3.1), discuss our procedure to construct a pseudo panel with synthetic birth-year cohorts of households (Section 3.2), describe our sample selection criteria (Section 3.3), and explain how to construct measures of consumption growth (Section 3.4), wealth-consumption ratio (Section 3.5), and asset returns (Section 3.6).

3.1 Overview

The CEX survey has been conducted on an ongoing basis by the BLS in every quarter since 1980. It is a representative sample of the universe of U.S. households. In each quarter, the BLS chooses

[10] One cannot rule out the possibility that deviations of the conditional second or higher moments in the Euler equations from their unconditional means might be highly persistent. This may make the use of lagged variables as instruments problematic in 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.

about 5,000 households randomly according to the stratification criteria determined by the U.S. Census. The households are asked to report how much they have spent on a variety of goods and services in the previous three months. The 5,000 interviews are split more or less evenly over the three months of the quarter. Each household participates in the survey for five consecutive quarters, including one training quarter with no data recorded and four "regular" quarters, during which expenditure, income, and demographic information are recorded. Financial information is gathered only in the last interview, in which households report both the current stock of their assets and the flows over the previous 12 months. In each quarter, roughly one-fifth of the participating households are replaced by new households. Thus, CEX data are a rotating panel, which covers a relatively long time period and contains a considerable amount of demographic information.

The survey accounts for about 95 percent of all quarterly household expenditures in each consumption category from a highly disaggregated list of consumption goods and services. This gives CEX data a main advantage over other micro-panel data, such as the Panel Studies of Income Dynamics (PSID), which reports consumption expenditures for food only.[11] CEX data would be particularly useful if preferences are nonseparable among different types of consumption goods and services in the theoretical model (e.g., Hall and Mishkin, 1982; Zeldes, 1989; Altug and Miller, 1990; Cochrane, 1991; Mankiw and Zeldes. 1991; Jacobs, 1999). Because of their broad coverage of consumption expenditures, CEX data have been widely used in the literature as an attractive alternative to aggregate macro data such as those in the National Income and Product Accounts (NIPA). For instance, CEX data have been used for the studies of 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).

3.2 Synthetic Cohorts

The short panel dimension of CEX data makes the use of direct panel techniques problematic. Since each individual household is interviewed only five times (including a training period), one would be seriously constrained by the time-series dimension in estimating Euler equations if individual household data were to be used. For this reason, we do not rely on individual household data. We follow instead a pseudo-panel approach proposed by Attanasio and Weber (1989, 1993,

[11] Attanasio and Weber (1995) argue that food consumption is a poor measure of total consumption expenditures for investigating issues related to intertemporal substitution or asset pricing.

1995), which exploits the repeated nature of the CEX surveys, and which takes its original root in Browning, Deaton, and Irish (1985), Deaton (1985), and Heckman and Robb (1985). As new households from a randomly selected large sample of the U.S. population keep entering the survey, consumption by the sampled households contains information about the mean consumption of the group to which they belong. Thus, a relatively long time series can be constructed for each synthetic cohort, that is, a typical group defined by observable and relatively fixed characteristics.

The characteristic that we use to construct our synthetic cohorts is the birth years of household heads, as in Attanasio and Weber (1995). We define a birth-year cohort as a group of individuals who were born within a given five-year interval. We follow the households in each cohort through the entire sample period to generate a balanced panel. We exclude households whose heads were born after 1963 (younger than 21 in 1984) or before 1898 (older than 86 in 1984). The remaining households are assigned to 13 cohorts (i.e., 13 five-year intervals) based on their ages in 1984. We further narrow down our sample by excluding households whose heads are younger than 30 years or older than 55 years in 1984. We exclude those younger than 30 years because these households may not have had a chance to accumulate sufficient wealth, thus are likely to be liquidity constrained and, as a result, the Euler equations may not hold. We exclude those older than 55 years because these households are likely to retire before the end of our sample (the beginning of 2002), and households at retirement ages typically experience a discrete jump in consumption expenditures, and it is not clear whether or not the jump is consistent with the Euler equations.[12] With these restrictions, we end up with five birth-year cohorts in our sample, with the ages of the household heads lying between 31 and 55 years in 1984 and between 48 and 72 years at the end of the sample.

We also report results based on a simple cohort technique, an approach used, for example, by Vissing-Jorgensen (2002). Under this approach, we pool the five birth-year cohorts into a single cohort, and compute the resulting cohort's consumption growth and wealth-consumption ratio by taking cross-sectional averages for each time period. This procedure results in a single time series.

3.3 Limited Participation and Sample Selection Criteria

The intertemporal Euler equation holds only for those households that participate in asset market transactions. But not all households participate. The importance of limited participation has

[12]For a survey of the literature that documents the jump in consumption at retirement age and attempts to explain it, see, for example, Attanasio (1999). See Laitner and Silverman (2004) for a more recent explanation.

been widely recognized in the literature (e.g., Mankiw and Zeldes, 1991; Brav, Constantinides, and Geczy, 2002; Cogley, 2002; and Vissing-Jorgensen, 2002, among others).

To recognize the importance of limited participation, we select a subsample of households who are classified as "asset holders" based on a similar set of criteria used by Cogley (2002) and Jacobs and Wang (2004). 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. Our 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.[13] Our second category of asset holders includes households that report positive contributions to "an individual retirement plan, such as IRA or Keogh" during the first two interview quarters (i.e, during period t). Our final category includes households that report receipts of positive dividend income or interest income during the first two interviews. Based on these criteria, we categorize 42% of households as asset holders. 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.

To minimize the influence of measurement errors and other problems caused by poor quality of the data in our estimation, we apply some further restrictions to our sample in constructing the consumption growth data. 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 outliers in the data for consumption growth rates, since these data may reflect reporting or coding errors. Third, we drop the households with any missing interviews, since we cannot compute the semiannual consumption growth rate for these households. Fourth, we drop non-urban households, those residing in student housing, and those with incomplete income reports. Finally, we exclude from our sample households that report a change in the age of the household head between any

[13] 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.

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. In addition, starting in the first quarter of 1986, the BLS changed its household identification numbering system, leaving no information about the correspondence between the household identification numbers in 1985:Q4 and 1986:Q1. We had to drop some observations (seven monthly observations) because of this mismatching problem. A similar problem also occurred in 1996, and we had to drop four additional monthly observations.

3.4 Consumption Growth Rate

We measure consumption by the sum of expenditures on nondurable goods and services. We construct a consumption basket for each household in the CEX survey based on the definition of nondurables and services in the NIPA. 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.[14] We deflate nominal consumption expenditures by the consumer price index for nondurables (unadjusted for seasonality), with a base period of 1982–1984.

To construct data for our estimation, we focus on semiannual frequencies, for two reasons. First, using lower frequency data helps mitigate problems caused by measurement errors, as argued by Vissing-Jorgensen (2002). Second, unique to our model with temptation, we need to construct wealth data for our estimation, and there is only one observation of wealth for each household in the CEX survey. Given the semiannual data that we construct, each household faces two decision periods: t and $t+1$, which correspond to the first and the second half of the year during which the household is interviewed.

The semiannual consumption growth rate is defined as

$$\frac{c^h_{t+1}}{c^h_t} = \frac{c^h_{m+6} + c^h_{m+7} + c^h_{m+8} + c^h_{m+9} + c^h_{m+10} + c^h_{m+11}}{c^h_m + c^h_{m+1} + c^h_{m+2} + c^h_{m+3} + c^h_{m+4} + c^h_{m+5}}, \tag{17}$$

where m refers to the first month that a household makes its consumption decision. Thus, $m+3$ is the month when the first interview is conducted, at which the household reports expenditures incurred during the previous three months (i.e., c^h_m, c^h_{m+1}, and c^h_{m+2}), $m+6$ is the month for the second interview, at which the household reports consumption expenditures incurred during $m+3$, $m+4$, and $m+5$, and so on. For each household that has four complete interviews recorded, we obtain one observation of semiannual consumption growth rate. Given the rotating-panel feature

[14] By leaving out expenditures on durable goods, we implicitly assume that the utility function is separable in consumption of durables and of nondurables and services.

of the CEX survey, we can construct a cohort-specific semiannual consumption growth rate for each month, which is the cross-sectional average of the consumption growth rates for households in the same cohort. The average consumption growth rate for a specific cohort j is given by

$$cg_{t+1}^{j} = \frac{1}{H_t^j} \sum_{h=1}^{H_t^j} \ln \left(\frac{c_{t+1}^{jh}}{c_t^{jh}} \right), \tag{18}$$

where H_t^j denotes the number of households in cohort j in period t, and c_t^{jh} denotes the period t consumption of household h in cohort j. Note that, if complete insurance against idiosyncratic risks were available, then all households would have identical consumption growth, and the average consumption growth rate would be identical to the growth rate of aggregate consumption per capita (aggregated in the spirit of NIPA). In general, if there are uninsurable idiosyncratic risks, consumption growth would not be identical across households, so that our measure of consumption growth rate as described in (18) would be more appropriate than the one obtained from aggregate data.

Table 1 presents some summary statistics of our measure of semiannual consumption growth, sorted by asset holder status and cohort groups. The table reveals a high degree of heterogeneity in consumption growth rates across households, suggesting the existence of important uninsurable consumption risks.[15]

3.5 Wealth-Consumption Ratio

We now describe how we construct a theory-consistent measure of the wealth-consumption ratio.

In our model, a household's wealth w_t is the maximum amount of resources available at the beginning of period t for consumption if the household succumbs to temptation. It equals the sum of period t income, including labor income and dividend income, and the market value of liquid financial assets available at t.

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 flows during the previous 12 months. We retrieve asset holdings at the beginning of period t by subtracting

[15] Each time series has 199 monthly observations, covering the sample period from October 1983 to March 2001, where 11 monthly observations are missing because of the mismatching problem in the identification numbering system in 1986 and 1996. Note that the earliest interview period is the first quarter of 1984, when the households report consumption expenditures in the past three months, so that the time series of cohort-specific consumption growth rates starts in October 1983. The last interview period in our sample is the first quarter of 2002. Since a household's intertemporal consumption-savings decision shifts consumption between the first half year and the second half during the interview period, we need a whole year's consumption data to construct a consumption growth rate for a given household, so that the available consumption growth observations end by March 2001.

the asset flows during the entire interview period from the end-of-interview asset stocks. This information helps pin down $\sum_{i=1}^{I} q_t^i b_t^{ih}$. But what is relevant for the intertemporal Euler equation is the wealth-consumption ratio at the beginning of period $t+1$. Thus, we need to calculate the value of w_{t+1}^h. For this purpose, we assume that the households follow a "buy-and-hold" strategy between their decision periods t and $t+1$, so that the wealth at the beginning of period $t+1$ can be imputed based on reported income for $t+1$, the market value of the household's assets at the beginning of t, and the market return between t and $t+1$. Specifically, we have

$$w_{t+1}^h = y_{t+1}^h + \sum_{i=1}^{I} R_{t+1}^i q_t^i b_t^{ih}, \tag{19}$$

where $y_{t+1}^h = e_{t+1}^h + \sum_{i=1}^{I} d_{t+1}^i b_{t+1}^{ih}$ is the flow of reported income, consisting of labor income (i.e., endowment) and dividend income.

The asset categories that we use in constructing the wealth data include liquid asset holdings in the household's "checking accounts, brokerage accounts, and other similar accounts," "saving accounts," "U.S. savings bonds," and "stocks, bonds, mutual funds, and other such securities."[16] To compute the total value of holdings of different types of assets, we assume a zero net return on the first category of assets (i.e., checking accounts, etc.); we use returns on the 30-day Treasury bills for the second and the third category of assets (i.e., savings and savings bonds); and finally, we use the New York Stock Exchange (NYSE) value-weighted returns for the last asset category (i.e., "stocks, bonds, mutual funds, and other such securities").[17]

In addition to the value of financial assets, we need to have income data to construct our imputed wealth measure in (19). The CEX survey reports, for each interview, the "amount of total income after tax by household in the past 12 months." To calculate a household's semiannual income y_t^h (i.e., income earned during the first half-year of the household's interview period), we first divide the reported annual income at the time of each interview by four, and then add up the resulting quarterly incomes for the first and the second quarters in the interview period. Similarly, the income earned during the second half-year of the household's interview period (i.e., y_{t+1}^h) is the sum of the household's average quarterly incomes for the third and the fourth interview quarters.

[16]We include here only liquid assets because the wealth in our model corresponds to the maximum amount of consumption if the household succumbs to temptation. The assets must have sufficient liquidity so that they can serve as "temptation." We have also examined a broader definition of asset holdings by including property values (mainly housing), and obtained very similar results (not reported).

[17]Clearly, we can obtain only one observation of asset value for each household during the entire interview period. But this does not present a problem for constructing our sample with semiannual data, since we can obtain only one observation of semiannual consumption growth rate for each household during the entire interview period, as discussed in Section 3.1, so we need only one observation for the wealth-consumption ratio for each household.

To get the wealth-consumption ratio for period t, we further need to construct the consumption data c_t^h for household h in period t. This is done by adding up the household's reported consumption expenditures during the first two interview quarters. To obtain c_{t+1}^h, we add up the household h's reported consumption expenditures during the *last* two interview quarters. We then divide the wealth measure by the consumption expenditures to obtain the relevant wealth-consumption ratio w_{t+1}^h / c_{t+1}^h. Finally, we average across households in a given synthetic cohort j to obtain a time series of the cohort's wealth-consumption ratio

$$\chi_{t+1}^j = \frac{1}{H_t^j} \sum_{h=1}^{H_t^j} \ln \left(\frac{w_{t+1}^{jh}}{c_{t+1}^{jh}} \right). \tag{20}$$

Note that because of the rotating-panel feature of the CEX survey, we can construct the semi-annual wealth-consumption ratio for each month within the sample period for a given cohort. Table 2 presents some summary statistics of the wealth-consumption ratio, sorted by asset holder status and birth-year cohorts. Evidently, there is also a high degree of heterogeneity in the wealth-consumption ratios across households.

3.6 Asset Returns and Some Timing Issues

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. To calculate real returns, we use the consumer price index for urban households as a deflator. As discussed above, we are able to construct only one observation of consumption growth and of wealth-consumption ratio for each household at the semiannual frequency. Thus, we need to convert the monthly asset returns into semiannual returns.

Obtaining semiannual asset returns based on monthly returns involves a somewhat subtle timing issue. By construction, the consumption growth rate is measured by the ratio of a household's total consumption during the last two quarters of interview to that during the first two quarters (see (17)). The consumption-savings decision can be made in any month during the first two quarters. If the intertemporal consumption-savings decision is made between the first and the seventh month, then the relevant semiannual asset return should be $R_{m+1} R_{m+2} \cdots R_{m+6}$, where R_{m+1} denotes the gross real asset return between month m and $m+1$, R_{m+2} denotes the return between month $m+1$ and $m+2$, and so on. But if the intertemporal decision occurs between, for instance, the fourth and the tenth month, then the relevant semiannual return should be $R_{m+4} R_{m+5} \cdots R_{m+9}$. Our measure of the semiannual consumption growth rate does not distinguish between these two cases. We thus need to take a stand on what measure of the compounded returns is appropriate to serve our purpose of estimating the Euler equation. For simplicity and ease of comparison, we follow Vissing-Jorgensen (2002) and use the middle six months of relevant asset returns as a proxy for the asset returns of interest. In particular, we use $R_{m+3} \cdots R_{m+8}$ as a measure of semiannual asset returns.

Since the asset holders in our sample can hold a broad range of assets, we 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). For comparison with the literature, we also examine an alternative measure of asset returns, which is the real value-weighted NYSE returns (i.e., stock returns).

4 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.

4.1 Estimation Equations

We estimate the log-linearized intertemporal Euler equation (14) augmented by a factor that controls for family size and by 12 monthly dummies that adjust for seasonality. In particular, the estimation equation for a particular cohort j that consists of H_t^j households in period t is specified as

$$cg_{t+1}^j = \sigma \ln(R_{t+1}) + \phi \chi_{t+1}^j + \alpha \frac{1}{H_t^j} \sum_{h=1}^{H_t^j} \Delta \ln F_{t+1}^{jh} + \sum_{m=1}^{12} \delta_m D_m + \mu_{t+1}^j, \tag{21}$$

where σ is the EIS, the D's are monthly dummies, and $\Delta \ln F_{t+1}^{jh}$ is the the cross-sectional average of log changes in the households' family size. The variables cg_{t+1}^j and χ_{t+1}^j, to reiterate, are respectively the consumption growth rate and the wealth-consumption ratio for cohort j. 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}^j 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}^{j} contains the deviations of these higher moments from their unconditional means.

4.2 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 equations (21) and (23) 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, since we use CEX data, we need to confront issues related to measurement errors in the consumption growth rate and the wealth-consumption ratio when we select our instruments.

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. All these financial variables are known to be good predictors of real stock returns and Treasury bill returns.[18] Some caution needs to be exercised when constructing the lags. A decision period in our model is one-half of a year, while the time-series variables for our estimation are of monthly frequencies. The consumption growth rate of a given cohort for adjacent months contains overlapping months and thus overlapping expectation errors. For this reason, the expectation error component of μ_{t+1} may be autocorrelated. To ensure that the instruments are uncorrelated with the error term, we use the compounded return $R_{m-5}R_{m-4}\cdots R_m$ as the lagged asset returns in our set of instrumental variables.

The instrument that we use for the wealth-consumption ratio is the lagged wealth-income ratio (i.e., $\ln(w_t/y_t)$). Since our measure for wealth w_{t+1} is constructed under a "buy-and-hold" assumption (see (19)), it should be correlated with lagged wealth w_t.[19]

[18] The financial time series here are downloaded from the Center for Research of Security Prices (CRSP).

[19] To the extent that measurement errors in wealth are serially uncorrelated, the lagged wealth-income ratio should be an appropriate instrument. Motivated by concerns that measurement errors might be serially correlated, we also estimated a Euler equation without using the lagged wealth-income ratio as an instrument, and we obtained similar results (not reported). Note that we use the lagged wealth-income ratio instead of the lagged wealth-consumption

Table 3 reports the first-stage regression of the wealth-consumption ratio on the instrumental variables. The table reveals that the lagged wealth-income ratio is highly correlated with the wealth-consumption ratio, with regression coefficients significant at the 1% level under both the simple-cohort specification and the synthetic cohort approach.

4.3 Estimation Procedure

We estimate the EIS and the temptation parameter using GMM with an optimal weighting matrix. In our model, autocorrelations in the error term may arise from the overlapping nature of consumption growth and thus of expectation errors, and heteroscedasticities may be present because the size of the cohort cells may vary over time. In our estimation, we explicitly account for autocorrelations of the MA(6) form and for heteroscedasticities of arbitrary forms in the error term.

We estimate our model based on the birth-year cohort approach proposed by Attanasio and Weber (1995). Our birth-year cohorts consist of five-year intervals, and we have five birth-year cohorts and thus five cohort-specific time series for each variable in the estimation equation. For comparison, we also estimate our model based on a simple-cohort approach, under which we obtain a single time series for each variable of interest by taking the cross-sectional average of the relevant variable at the household level across all households classified as asset holders.

To test the statistical significance of the presence of temptation, we follow two steps. First, we estimate the unrestricted model described by (21) or (23). 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.

4.4 Estimation Results

The results of the GMM estimations of the log-linearized model of equation (21) are shown in Table 4. We report the estimated values of the parameters of interest under both the simple-cohort approach and the synthetic-cohort panel specification.

The first three columns (1)–(3) in Table 4 present the estimates with a single time series constructed by following the simple-cohort technique. The asset returns used here are a simple

ratio as an instrument, since the latter would be correlated with measurement errors in the consumption growth rate.

average between the real value-weighted NYSE returns and real 30-day Treasury bill returns (i.e., joint returns).[20] Column (1) reports the estimated value of the EIS in the restricted model without temptation (i.e., $\phi = 0$). The point estimate for EIS here is $\hat{\sigma} = 0.516$, with a standard error of 0.499. The estimated EIS is not statistically significant, although one cannot reject the over-identification restrictions based on Hansen's J statistic. Column (2) reports the estimated values for σ and ϕ in the unrestricted model with temptation. The point estimate for σ increases to 0.730, which remains insignificant, with a standard error of 0.525. The point estimate for ϕ is 0.023, with a standard error of 0.023. Similar to the model without temptation, one cannot reject the over-identification restrictions based on the J statistic. Yet, one cannot reject the null hypothesis that $\phi = 0$ based on the Wald statistic with a p value of 0.55. A problem with the estimates obtained under the simple-cohort approach is that the estimates are insignificant, and one cannot reject the null that the temptation parameter is zero. However, the rejection of the presence of temptation, as well as the inaccurate estimates of the EIS and the temptation parameter, may simply reflect a small-sample problem associated with the simple-cohort approach.

The synthetic cohort approach based on birth-year cohorts does not share this problem. Columns (4)–(9) report the estimation results using the pseudo-panel data constructed based on birth-year cohorts. Here, instead of having a single time series, we have a pseudo panel of data consisting of 5 time series, corresponding to the 5 birth-year cohorts. The sample size is now 988, close to 5 times as much as that under the simple-cohort technique.[21]

Columns (4)–(6) report the pseudo-panel estimation results using the joint returns as a proxy for asset returns. In the restricted model without temptation (Column (4)), the point estimate for the EIS is similar to that obtained under the simple-cohort specification (0.519 vs. 0.516) but with a slightly smaller standard error (0.393 vs. 0.499). In the unrestricted model with temptation (Column (5)), the point estimate for the EIS increases to $\hat{\sigma} = 0.905$, with a standard error of 0.430; and the point estimate for the temptation parameter is $\hat{\phi} = 0.031$, with a standard error of 0.015. In contrast to the simple cohort approach, we are able to obtain statistically significant estimates for the temptation parameter under the synthetic cohort approach. In the model restriction test, the Wald statistic and the associated p value overwhelmingly reject the null hypothesis that $\phi = 0$, suggesting that wealth-consumption ratio is a statistically important component in the pricing kernel, which lends empirical support to the GP theory.

[20]We obtained similar results under the simple-cohort approach when we used stock returns instead of joint returns as a proxy for asset returns (not reported).

[21]In the pseudo panel, some birth-year cohort cells are empty, so that the total number of observations in the panel is slightly less than five times that under the simple-cohort approach.

Our empirical results here survive when we use some other proxies for asset returns. Columns (7)–(9) report the results when we replace the joint returns by stock returns measured by the value-weighted NYSE returns. The estimates for the EIS here, with or without temptation (Columns (7) and (8)), are now notably smaller than those obtained using joint returns (Columns (4) and (5)), a pattern consistent with the findings in the literature (e.g., Vissing-Jorgenson, 2002). In the unrestricted model with temptation (Column (8)), the point estimate for the temptation parameter is apparently identical (0.031) to the estimate obtained using joint returns as a proxy for asset returns. As in the case with joint asset returns, the Wald test of the model restriction here rejects the null that the temptation parameter is zero.[22]

5 Desire for Commitment: Some Evidence

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 the ex-post cost of self-control. The desire for commitment helps distinguish self-control preferences from other preference specifications such as habit formation (e.g., Constantinides, 1990), non-expected utility (e.g., Epstein and Zin, 1989, 1991), and the spirit of capitalism (e.g., Bakshi and Chen, 1996).[23] We now exploit this theoretical implication of the GP theory in our empirical study.

5.1 Education as a Commitment Device

If the GP theory is correct, then an individual who is more susceptible to temptation should have a stronger incentive to hold more commitment assets, that is, assets that cannot be easily re-traded or used as a collateral for borrowing. One form of such assets is education (e.g., Kocherlakota, 2001). To capture the preference for commitment, and thereby to distinguish self-control preferences from other preference specifications, we generalize the estimation equation (21) by including an interaction term between the wealth-consumption ratio and an education dummy.

[22] In obtaining the estimates reported in Table 4, we use an aggregation approach that allows for the possibility of imperfect risk sharing among households (see Section 3). To examine the role of risk sharing, we have also estimated a version of the model with complete risk sharing, in which the consumption growth rate is measured by the growth rate of mean consumption and the wealth-consumption ratio is measured by the ratio of mean wealth to mean consumption. The point estimate for the temptation parameter ϕ is close to zero and insignificant. This result is consistent with what DeJong and Ripoll (2003) have obtained using NIPA data.

[23] Each of these alternative preference specifications introduces an additional element in the price kernel (in addition to consumption growth), as does the GP preference specification. It is important to distinguish the GP preferences from these alternative specifications because the additional component in the price kernel under these alternative specifications can be correlated with the wealth-consumption ratio.

The education dummy takes a value of one if the head of a household has a bachelor's degree or higher level of education, and zero otherwise. Specifically, we assume that the temptation parameter is a function of the education dummy (denoted by "EDUC"), so that

$$\phi = \phi_0 + \phi_1 EDUC. \tag{22}$$

Substituting this expression for ϕ in (21), we obtain

$$cg_{t+1}^{j} = \sigma \ln(R_{t+1}) + \phi_0 \chi_{t+1}^{j} + \phi_1 \frac{1}{H_t^j} \sum_{h=1}^{H_t^j} EDUC^{jh} \times \ln\left(\frac{w_{t+1}^{jh}}{c_{t+1}^{jh}}\right)$$
$$+ \alpha \frac{1}{H_t^j} \sum_{h=1}^{H_t^j} \Delta \ln F_{t+1}^{jh} + \sum_{m=1}^{12} \delta_m D_m + \mu_{t+1}^{j}, \tag{23}$$

where $EDUC^{jh}$ is an education dummy for household h in cohort j.

Columns (3), (6), and (9) in Table 4 report the estimation results when the interaction term is included. Under the simple-cohort approach (Column (3)), the point estimate for the EIS is 0.440, which is lower than the case without the interaction term (Column (2)) and remains statistically insignificant. A notable result is that, when we include the interaction term, the point estimate for the temptation parameter in the subgroup of individuals with high levels of education is much larger than its population counterpart: it increases by an order of magnitude of 0.023 to 0.237. To the extent that education is a form of commitment assets, this result is consistent with the model's implication that an individual who is more tempted has a stronger preference for commitment.

Under the synthetic-cohort approach with the interaction term included (Columns (6) and (9)), as in the case with the simple-cohort, the point estimate of the temptation parameter for the subgroup with high education levels is much larger than its population counterpart: it increases from 0.031 to 0.162 (with joint asset returns) or 0.173 (with stock returns). Further, under the synthetic-cohort approach, these estimates become statistically significant. The Wald statistics and the associated p values overwhelmingly rejects the null hypothesis that $\phi = 0$ and the joint hypothesis that $\phi_0 = 0$ and $\phi_1 = 0$. Our finding that the temptation parameter is larger for individuals who have received higher levels of education lends empirical support to the GP theory.

5.2 Further Evidence

Of course, there may be reasons other than the commitment aspect for education to be correlated with the level of temptation. To isolate education's role as a commitment device, one needs to take into account a few other covariates. One such covariate is pension participation. To the extent that pensions, like education, are highly illiquid and thus provide some commitment value, a GP agent with a high level of temptation should have both a high level of education and, other things equal, be more likely to participate in pension plans. On the other hand, although a GP agent would like to seek commitment ex ante, there are states of nature ex post, in which the cost of self-control becomes sufficiently high and the agent's spending urge becomes dominant. In such states, the agent succumbs to temptation. A manifestation of succumbing to temptation is to borrow on credit cards. In other words, we should observe that a more tempted individual is more likely to hold credit-card debt; and all else equal, more like to hold commitment assets such as education and pension. Based on the Survey of Consumer Finance (SCF), we find strong empirical evidence that supports these theoretical implications.

5.2.1 Ex-ante desire for commitment

Table 5 summarizes the effects of education on pension contributions in the 2001 SCF, controlling for a set of demographic characteristics. Panels (1) and (2) report logit regressions of pension participation on household education (measured by levels of education or years of schooling), liquid assets, age, total assets, and other demographic variables including gender, marital status, and number of kids. Panels (3) and (4) report regressions of the share of pension contributions in total assets on the same set of variables, conditional on participation. Standard errors are reported in the parentheses, and coefficients significant at 10% or better are indicated with stars. In the logit regressions, we also report the probability of pension participation for a reference household, and the change in this probability caused by a unit change in each binary variable (including age and years of schooling) or by a one-standard deviation change in a continuous variable (including log liquid assets and log total assets). The reference household here is defined as one in which the household head has received no high school diploma (Panel (1)) or one year of schooling (Panel (2)), with mean age, mean log liquid assets, mean log total assets, is not married, white, and has no kids.

The table shows that education has a strong positive effect on pension participation. All else equal, raising the education level of the reference household from no high school to high school increases the probability of pension participation by 9.4%; raising the education level further leads to further increase in the participation rate relative to the reference household: 11.7% for some college, 14% for college graduates, and 16.3% for post graduates. The results are similar when education is measured by years of schooling. An additional year of schooling raises the participation probability by 1.72%.

It is possible that, all else equal, a person with a higher eduction level typically works for an employer who provides better pension plans (e.g., the availability of various pension plans, employer matching of individual pension contributions, etc.). This provides an alternative explanation for the observed positive correlation between education and pension participation. This argument, however, does not apply to self-employed households. Restricting attention to a sample of self-employed households has a further advantage: the pension plans for these households are mostly defined-contribution plans rather than defined-benefit plans; and defined-contribution plans better reflect individual decisions.

Table 6 reports the same regression results as in Table 5, with the full sample replaced by a self-employment sub-sample. There, as in the full sample, we find a strong and positive correlation between education levels and the incidence of pension participation, particularly for those with a Bachelor's degree or higher. The reference household in the self-employment sample is more likely to contribute to pensions than that in the full sample (86.4% v. 55.5%). All else equal, a household with a Bachelor's degree is about 7.4% more likely to participate in pensions than the reference household who has no high-school diploma; and a household with a graduate degree is about 7.9% more likely to participate than the reference household. Since the households here are all self-employed, their choice of pension participation is not driven by incentives provided by employers. Nonetheless, we still obtain a positive effect of education on pension participation, which we interpret as evidence for individuals' desire for commitment.

Tables 5 and 6 also show that households' holdings of liquid assets have a significant, hump-shaped effect on pension participation. The liquid asset here is defined as the sum of annual income and all financial assets other than pension, corresponding to the definition of wealth (or temptation consumption) in our theory. Holding other characteristics fixed, a one-standard deviation increase in the holding of liquid asset from the mean level raises the probability of pension participation by about 7.9% in the full sample and 2.8% in the self-employment sub-sample. The marginal effect on pension participation levels off as the holding of liquid asset increases. This hump-shaped effect is consistent with the GP theory. The theory implies that, for a fixed value of the temptation parameter λ, the cost of self-control increases with wealth at a diminishing rate since the temptation utility is concave. As such, the desire for commitment (in the form of pension participation) also increases with liquid wealth at a diminishing rate.

The logit regression further reveals a significantly positive and hump-shaped effect of both age and total asset on pension participation, where total asset is defined as the sum of financial assets (such as stocks, bonds, and other savings) and non-financial assets (such as housing and private business). The life-cycle patterns of pension participation reflect the tradeoff between changes in spending urge and in the consumption possibility set, both associated with wealth accumulation over the life cycle. The hump-shaped effect of total asset on pension participation may reflect reduced dependence on pension wealth when the household has accumulated sufficient amount of other assets such as housing and private business equity.[24]

Panels (3) and (4) in Table 5 (and Table 6) report the portfolio share regression results. There, we see that, conditional on participation, an increase in the level of education or years of schooling significantly raises the share of pension contributions in total asset. In addition, liquid asset holdings have a positive and hump-shaped effect on the portfolio share of pension. To the extent that education provides commitment value and that liquid asset represents a source of temptation, these results provide further evidence in support of the GP theory.

5.2.2 Ex-post cost of self-control

Facing temptation, a GP agent would like to seek ex ante commitment. Nonetheless, if the ex post cost of self-control is sufficiently high, she may succumb to temptation. For instance, she may want to meet her spending urge by borrowing from credit cards. Thus, if the GP theory is correct, then we should observe a positive correlation between pension participation (or education) and credit card borrowing.

Table 7 reports the effects of education and pension participation on credit-card debt holdings, controlling for the same set of demographic characteristics as in the previous two tables. Columns (1) and (2) report the logit regression of credit-card borrowing (a dummy variable) on education and pension participation. Column (1) shows that, all else equal, a household with a high-school diploma is 13% more likely to borrow from credit cards than the reference household who has no high-school diploma and 29% of whom borrow from credit cards. The incidence of credit-card debt becomes 19% higher for a household with some college education than for the reference household. The marginal effects of having a Bachelor's degree (11%) or a graduate degree (8%), are positive relative to the reference household, but are lower than the marginal effects of having a high-school diploma or some college. This last observation may reflect that a person with a high level of education (Bachelor's or above) tends to rely less on credit card debts to meet her spending urge, should she succumb to temptation. Column (2) examines the effects of years of schooling on the incidence of credit-card borrowing and, as in Column (1), reveals a positive marginal effect of eduction on credit-card debt (an additional year of schooling raises the probability of credit-card borrowing by 0.66%). Similarly, pension participation has also a positive effect on credit-card borrowing. Compared to the reference household who does not participate in any pension plans,

[24] Investigating the driving forces of the life-cycle patterns of pension contribution is an important issue for future research.

a household who participates in some form of pension plans is about 5% more likely to borrow from credit cards.

Columns (3) and (4) reveal that, conditional on carrying a credit-card debt, a household with a higher share of pension assets in their total assets has also a higher share of their credit-card debt in total debts. The effects of education on the share of credit-card debt are not statistically significant. Nonetheless, the signs of the regression coefficients make economic sense: the share of credit-card debt is positively correlated with low levels of education (high school or some college) and negatively correlated with high levels of education (Bachelor's or higher), reflecting that households with high levels of education tend to substitute other forms of borrowing for credit-card debts.

To summarize, the evidence presented in Tables 5 through 7 supports the central implications of the GP theory that more tempted individuals are more likely to seek commitment (through education and pension participation) and also to borrow from credit cards to finance their spending urge. Based on this evidence, we argue that it is important to incorporate temptation and self-control in studying individuals' intertemporal decisions.

6 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.

6.1 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

$$W(k) = \max_{0 \leq k' < k^\alpha / g} \{(1+\lambda)\log(k^\alpha - gk') + \beta W(k') - \lambda \log(k^\alpha)\}. \tag{24}$$

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

$$k^* = \left(\frac{s^*}{g}\right)^{\frac{1}{1-\alpha}}, \quad y^* = k^{*\alpha}, \quad \text{where } s^* = \frac{\alpha\beta}{1+\lambda(1-\alpha\beta)}. \tag{25}$$

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 (25).

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

$$\frac{\bar{s}}{s^*} = 1 + \lambda(1-\alpha\beta), \quad \frac{\bar{k}}{k^*} = \left(\frac{\bar{s}}{s^*}\right)^{\frac{1}{1-\alpha}}, \quad \frac{\bar{y}}{y^*} = \left(\frac{\bar{s}}{s^*}\right)^{\frac{\alpha}{1-\alpha}}. \tag{26}$$

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 $\phi = 0.031$ based on our estimate, $\gamma = 1$ (corresponding to log utility), and $w/c = 7.7$ 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 0.3.

With the parameters so calibrated, we obtain $\bar{s}/s^* = 1.22$, $\bar{k}/k^* = 1.33$, and $\bar{y}/y^* = 1.09$. Thus, moving from an economy with temptation to one without entails a 22% increase in the saving rate, a 33% increase in the steady-state level of capital, and a 9% increase in steady-state income. Even with $\lambda = 0.1$, a value much lower than that suggested by our point estimates, we still obtain sizable gaps in the saving rates, the capital stocks, and the income levels (7%, 11%, and 3%, respectively). Figure 1 plots the gaps in the saving rate, the capital stock, and the income level for λ varying between 0 and 1. Evidently, even modest amount of temptation can lead to substantial reductions in savings and long-run income and wealth.[25]

6.2 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.[26] 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,

$$c_t = c + \mu t - \frac{1}{2}\sigma_z^2 + z_t, \tag{27}$$

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,

$$w_t = w + \mu t - \frac{1}{2}\sigma_u^2 + u_t, \tag{28}$$

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.[27] The assumption that consumption

[25] 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.

[26] 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 recent progress in this literature, see, for example, Barlevy (2004).

[27] 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.

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 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 (27) and (28), 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

$$\mathrm{CCE}_1 = \exp\left(\frac{1}{2}\sigma_z^2 - \frac{\lambda}{2(1+\lambda)}\sigma_u^2\right) - 1, \tag{29}$$

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

$$\mathrm{CCE}_2 = \exp\left(\frac{\gamma}{2}\sigma_z^2\right)\left\{1 + \frac{\lambda}{1+\lambda}\left(\frac{W}{C}\right)^{1-\gamma}\left[\exp\left(-\frac{\gamma(1-\gamma)}{2}\sigma_u^2\right) - 1\right]\right\}^{\frac{1}{1-\gamma}} - 1, \tag{30}$$

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 (29) and (30). 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.[28]

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 is the aggregate time series of consumption, income, and asset holdings constructed by Lettau and Ludvigson (2001) based on NIPA data; and the other is CEX data. The trends in the data are removed by applying the Hodrick-Prescott filter (for CEX data, we also make seasonal adjustments before applying the HP filter). From NIPA data, we obtain $\sigma_z = 0.008$, $\sigma_u = 0.025$, and $W/C = 6.1$. From CEX data, we obtain $\sigma_z = 0.025$, $\sigma_u = 0.039$, and $W/C = 8.6$.

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 $\phi = 0.031$ as a baseline. Given these values of γ and ϕ, we obtain $\lambda = 0.2849$ if NIPA data are used to construct the average wealth-consumption ratio, and $\lambda = 0.4795$ if CEX data are used instead. These parameter values imply that $CCE = -0.0037$ percent for NIPA data and $CCE = 0.0066$ percent for 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.

[28] 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.

We can generalize our welfare calculations to evaluate alternative stochastic consumption paths in the presence of temptation. Consider two stochastic equilibria in two economies characterized by

$$\mathcal{E} = \{\mu, \sigma_z, \sigma_u\} \quad \text{and} \quad \mathcal{E}' = \{\mu', \sigma'_z, \sigma'_u\}$$

respectively, and denote

$$\Delta\mu = \mu - \mu', \quad \Delta\sigma_z^2 = \sigma_z^2 - \sigma'^2_z, \quad \Delta\sigma_u^2 = \sigma_u^2 - \sigma'^2_u.$$

We then pose the following general question: What uniform percentage variation in consumption in $\mathcal{E}$ needs to be made so that the household would be indifferent between living in $\mathcal{E}$ and $\mathcal{E}'$?

With some algebra, we can show that, in the case with log utility (i.e., $\gamma = 1$), the answer to this question is given by

$$\text{SCE}(\mathcal{E}, \mathcal{E}') = \exp\left(\frac{\delta}{(1-\delta)(1+\lambda)}\Delta\mu + \frac{1}{2}\Delta\sigma_z^2 - \frac{\lambda}{2(1+\lambda)}\Delta\sigma_u^2\right) - 1, \tag{31}$$

where SCE (stochastic consumption equivalence) is our welfare measure, and δ is the subjective discount factor.[29] Clearly, in the special case where $\mathcal{E}' = \{\mu, 0, 0\}$, that is, in the deterministic economy without fluctuations and with the same trend growth rate as that in $\mathcal{E}$, the welfare expression would reduce to CCE_1 in (29). In general, the welfare cost of moving from one stochastic economy to another depends on the differences in trend growth rates, in consumption volatilities, and in wealth volatilities. The general conclusion is that, by moving from one economy to another, the welfare cost increases if the consumption volatility increases, the wealth volatility decreases, or the trend growth rate falls.

7 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 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.

[29] We have also obtained a corresponding expression for the more general case with $\gamma \neq 1$, but we omit it here to conserve space.

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, and our aggregation procedure allows for the possibility of uninsurable idiosyncratic risks. 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.

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Table 1.

Summary Statistics for Consumption Growth

	No. Obs	Mean	S.D.	Skew.	Kurt.	Min	Max	1%	99%
Panel A: Individual Consumption Growth									
ALL	19060	0.010	0.305	-0.017	5.240	-1.575	1.605	-0.805	0.825
Asset Holder	8116	0.010	0.308	-0.060	5.346	-1.575	1.605	-0.808	0.834
Panel B: Consumption Growth for Simple Cohort (single time series)									
ALL	199	0.010	0.044	-0.097	3.140	-0.109	0.123	-0.093	0.115
Asset Holder	199	0.011	0.061	-0.214	2.732	-0.157	0.143	-0.147	0.137
Panel C: Birth-Year Cohort, 1949 – 1953									
ALL	199	0.012	0.063	-0.014	2.664	-0.163	0.172	-0.140	0.150
Asset Holder	199	0.011	0.093	-0.054	3.295	-0.266	0.247	-0.245	0.244
Panel D: Birth-Year Cohort, 1944 – 1948									
ALL	199	0.008	0.070	0.249	2.925	-0.153	0.222	-0.119	0.209
Asset Holder	199	0.013	0.100	-0.323	3.926	-0.408	0.252	-0.201	0.242
Panel E: Birth-Year Cohort, 1939 – 1943									
ALL	199	0.007	0.081	-0.057	2.947	-0.217	0.217	-0.204	0.199
Asset Holder	199	0.019	0.130	-0.089	4.090	-0.465	0.469	-0.318	0.328
Panel F: Birth-Year Cohort, 1934 – 1938									
ALL	199	0.009	0.094	0.595	5.747	-0.299	0.479	-0.211	0.236
Asset Holder	193	0.011	0.138	0.820	6.856	-0.387	0.751	-0.308	0.449
Panel G: Birth-Year Cohort, 1929 – 1933									
ALL	199	0.008	0.099	-0.188	3.512	-0.368	0.256	-0.252	0.237
Asset Holder	198	0.005	0.155	-0.267	4.267	-0.522	0.465	-0.467	0.464
Panel H: Consumption Growth for All Birth-Year Cohorts (pooled synthetic panel)									
ALL	995	0.009	0.082	0.121	4.433	-0.368	0.479	-0.190	0.216
Asset Holder	988	0.012	0.125	0.041	5.461	-0.522	0.751	-0.319	0.315

Table 2.

Summary Statistics for Wealth-Consumption Ratio

	No. Obs	Mean	S.D.	Skew.	Kurt.	Min	Max	1%	99%
Panel A: Individual Wealth-Consumption Ratio									
ALL	19060	5.596	11.84	14.87	433.5	-146.5	501.2	0	46.76
Asset Holder	8116	9.021	17.09	10.96	225.7	-146.5	501.2	0	74.50
Panel B: Wealth-Consumption Ratio for Simple Cohort (single time series)									
ALL	199	5.732	2.110	2.048	8.601	3.143	16.78	3.215	15.15
Asset Holder	199	8.933	4.351	1.619	5.475	4.233	27.16	4.381	24.06
Panel C: Birth-Year Cohort, 1949 – 1953									
ALL	199	5.407	3.134	3.977	25.34	2.438	29.62	2.10	21.25
Asset Holder	199	8.192	6.428	4.059	25.71	2.233	58.53	2.041	39.03
Panel D: Birth-Year Cohort, 1944 – 1948									
ALL	199	5.544	2.561	2.396	11.33	2.397	20.14	2.772	17.58
Asset Holder	199	8.420	5.442	2.378	10.11	0.236	34.09	1.651	27.00
Panel E: Birth-Year Cohort, 1939 – 1943									
ALL	199	5.914	3.683	4.190	32.80	2.494	38.46	2.575	16.33
Asset Holder	199	9.397	8.558	4.472	30.70	2.945	77.74	3.231	36.54
Panel F: Birth-Year Cohort, 1934 – 1938									
ALL	199	5.849	3.765	2.787	12.98	0.889	26.50	1.006	25.15
Asset Holder	193	10.26	9.777	3.310	15.57	1.322	69.09	1.901	51.70
Panel G: Birth-Year Cohort, 1929 – 1933									
ALL	199	6.446	8.065	10.16	125.1	0.625	107.4	1.017	24.44
Asset Holder	198	11.53	12.47	5.044	34.89	0.449	107.4	1.333	63.35
Panel H: Wealth-Consumption Ratio for All Birth-Year Cohorts (pooled synthetic panel)									
ALL	995	5.832	4.677	11.57	229.6	0.625	107.4	1.567	20.65
Asset Holder	988	9.312	8.950	4.978	39.77	0.236	107.4	2.190	51.70

Table 3.

First Stage IV Regressions of $\log \frac{w}{c}$ on Instruments

Instruments	Variables being instrumented			
	Simple Cohort		Synthetic Cohort Panel	
	$\log \frac{w_{t+1}}{c_{t+1}}$	educ$\times \log \frac{w_{t+1}}{c_{t+1}}$	$\log \frac{w_{t+1}}{c_{t+1}}$	educ$\times \log \frac{w_{t+1}}{c_{t+1}}$
$\log \frac{w_t}{y_t}$	0.993***	0.582***	0.760***	0.405***
	(0.066)	(0.106)	(0.028)	(0.066)
educ$\times \log \frac{w_t}{y_t}$		-0.242		-0.292***
		(0.149)		(0.089)
dividend/price	-0.186***	-0.140***	-0.250***	-0.197***
	(0.031)	(0.051)	(0.025)	(0.041)
lagged stock return	0.093	0.164	0.031	0.055
	(0.098)	(0.128)	(0.099)	(0.150)
lagged bond returns	-1.172	1.278	-0.577	1.97
	(1.094)	(1.557)	(1.069)	(1.571)
$\Delta\ln(\mathit{familysize})$	-0.338	-0.238*	-0.328	0.227
	(0.445)	(0.584)	(0.171)	(0.386)
Constant	2.603***	1.330***	2.507***	1.224***
	(0.038)	(0.060)	(0.034)	(0.059)
Observations	199	199	988	988
R^2	0.83	0.49	0.70	0.18

Note: *, **, and *** stand for significant estimates at 10%, 5%, and 1% level, respectively. Robust standard errors are reported in the parentheses. The set of instrumental variables also includes twelve monthly dummies (not presented in the table). Stock returns are real value-weighted NYSE returns. Bond returns are real 30-day Treasury bill returns.

Table 4.

GMM Estimation of Log-Linearized Euler Equation with Self-Control Preferences

	Simple Cohort			Synthetic Cohort Panel			Synthetic Cohort Panel		
	Joint Returns			Joint Returns			Stock Returns		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$\hat{\sigma}$ or EIS	0.516	0.730	0.440	0.519	0.905**	0.999**	0.259	0.505*	0.598**
	(0.499)	(0.525)	(0.441)	(0.393)	(0.430)	(0.449)	(0.238)	(0.265)	(0.283)
ϕ_0		0.023	-0.113		0.031**	-0.044		0.031**	-0.048
		(0.023)	(0.119)		(0.015)	(0.043)		(0.015)	(0.044)
ϕ_1			0.237			0.162*			0.173*
			(0.212)			(0.089)			(0.093)
Obs	199	199	199	988	988	988	988	988	988
Hansen's J test	2.27	1.20	1.87	5.35	1.98	0.14	5.79	2.43	0.19
P-value	0.32	0.55	0.39	0.07	0.37	0.93	0.06	0.30	0.91
Model Restriction Test:									
Wald Stat (χ^2)		1.04	1.89		4.38	7.25		4.19	7.11
P-value		0.31	0.39		0.04	0.03		0.04	0.03
Mean of ($\frac{w}{c}$)		8.93	8.93		9.31	9.31		9.31	9.31
Average Cell Size	40.11	40.11	40.11	8.09	8.09	8.09	8.09	8.09	8.09

Note: *, **, and *** stand for significant estimates at 10%, 5%, and 1% level, respectively. Robust standard errors are reported in the parentheses. The regressions also include changes in family sizes and twelve monthly dummies as explanatory variables and instruments. The instrumental variables are those reported in Table 3. The null hypothesis for the model restriction test is that $\phi_0 = 0$ in the empirical specification without the interaction term between education and wealth-consumption ratio; and $\phi_0 = \phi_1 = 0$ in the specification with the interaction term. The Wald statistic for the model restriction test has a χ^2 distribution with a degree of freedom equal to the number of restrictions.

Table 5. Pension Participation and Portfolio Shares of Pension

	Pension Participation				Portfolio Shares for Participants	
	(1)		(2)		(3)	(4)
	Coef.	Prob.(%)	Coef.	Prob.(%)	Coef.	Coef.
Reference HH		55.54		45.41		
Educational Indicators:						
High school	0.394***	9.401			0.029*	
	(0.119)				(0.015)	
Some college	0.497***	11.72			0.045***	
	(0.126)				(0.015)	
Bachelor degree	0.604***	14.02			0.057***	
	(0.134)				(0.015)	
Graduate degree	0.714***	16.31			0.083***	
	(0.142)				(0.016)	
Years of schooling			0.070***	1.72		0.009***
			(0.014)			(0.002)
Log liquidity asset (temptation assets)						
Ln(liq)	1.162***	7.885	1.185***	8.312	0.085***	0.087***
	(0.264)		(0.264)		(0.030)	(0.030)
Ln(liq) squared	-0.038***		-0.039***		-0.003***	-0.003***
	(0.010)		(0.010)		(0.001)	(0.001)
Demographic control variables, (marriage,ethnic group, kids unreported)						
Age	0.074***	0.119	0.075***	0.115	0.014***	0.015***
	(0.013)		(0.013)		(0.002)	(0.002)
Age squared	-0.0007***		-0.0007***		-0.0001***	-0.0001***
	(1.2×10^{-4})		(1.2×10^{-4})		(1.5×10^{-5})	(1.5×10^{-5})
Ln(wealth)	1.182***	-13.21	1.191***	-12.63	-0.083***	-0.081***
	(0.137)		(0.136)		(0.019)	(0.019)
Ln(wealth) squared	-0.050***		-0.050***		0.002**	0.002**
	(0.006)		(0.006)		(0.001)	(0.001)
Sample Size	4189		4189		2637	2637

Note: *, **, and *** indicate significant estimates at the 10%, 5%, and 1% level, respectively. All regressions control for gender, marital status, and number of kids, in addition to the demographic variables displayed. In the reference household, the household head is not-married, white, with mean age (50.3), no kids, no high school diploma (Column (1)) or one year of schooling (Column (2)), and has mean log liquid assets (11.907) and mean log total assets (12.541). The columns under "Prob.(%)" report the probabilities of pension participation for the reference household and the marginal effects on the incidence of participation of a unit change in a binary variable (such as "age" and "years of schooling") or a one-standard-deviation change in a continuous variable (such as "Ln(liq)" and "Ln(wealth)" and their squared values). The variable "liq" denotes liquid assets defined as the sum of annual income and financial assets other than pension. The variable "wealth" denotes total assets defined as the sum of financial and non-financial assets.

Table 6. Pension Participation and Portfolio Share of Pension for Self-Employed Households

	Pension Participation				Portfolio Share for Participants	
	(1)		(2)		(3)	(4)
	Coef.	Prob.(%)	Coef.	Prob.(%)	Coef.	Coef.
Reference HH		86.43		67.34		
Educational Indicators:						
High school	0.329	3.416			0.028	
	(0.380)				(0.025)	
Some college	0.233	2.508			0.045*	
	(0.374)				(0.025)	
Bachelor degree	0.863**	7.360			0.037	
	(0.377)				(0.023)	
Graduate degree	0.955**	7.872			0.088***	
	(0.377)				(0.023)	
Years of schooling			0.128***	2.808		0.010***
			(0.038)			(0.002)
Log liquidity asset (temptation assets)						
Ln(liq)	3.808***	2.830	3.867***	5.903	0.132***	0.125***
	(0.727)		(0.721)		(0.044)	(0.044)
Ln(liq) squared	-0.129***		-0.131***		-0.004***	-0.004***
	(0.027)		(0.026)		(0.002)	(0.002)
Demographic control variables, (marriage,ethnic group, kids unreported)						
Age	0.206***	-0.119	0.208***	-0.224	0.010***	0.011***
	(0.047)		(0.047)		(0.003)	(0.003)
Age squared	-0.002***		-0.002***		-7.4×10^{-5}***	-8.0×10^{-5}***
	(4.3×10^{-4})		(4.3×10^{-4})		(2.6×10^{-5})	(2.6×10^{-5})
Ln(wealth)	1.816***	-3.565	1.831***	-6.262	-0.105***	-0.097***
	(0.620)		(0.616)		(0.040)	(0.041)
Ln(wealth) squared	-0.062***		-0.062***		0.002**	0.002**
	(0.022)		(0.022)		(0.001)	(0.001)
Sample Size	1050		1050		798	798

Note: *, **, and *** indicate significant estimates at the 10%, 5%, and 1% level, respectively. All regressions control for gender, marital status, and number of kids, in addition to the demographic variables displayed. In the reference household, the household head is not-married, white, with mean age (52.2), no kids, no high school diploma (Column (1)) or one year of schooling (Column (2)), mean log liquid assets (13.25), and mean log total assets (14.60). The notations are otherwise the same as in Table 5.

Table 7. Credit Card Debt: Incidence and its Share in Total Debt

	Incidence of Credit Card Debt				Share in Total Debt	
	(1)		(2)		(3)	(4)
	Coef.	Prob.(%)	Coef.	Prob.(%)	Coef.	Coef.
Reference HH		28.96		32.55		
Educational Indicators:						
High school	0.570***	12.94			0.006	
	(0.122)				(0.029)	
Some college	0.841***	19.64			0.008	
	(0.130)				(0.030)	
Bachelor degree	0.482***	10.81			-0.008	
	(0.139)				(0.033)	
Graduate degree	0.376**	8.30			-0.028	
	(0.150)				(0.036)	
Years of schooling			0.030**	0.656		-0.003
			(0.015)			(0.003)
Pension participation or pension share in total assets						
Pension participation	0.231***	4.98	0.242***	5.52		
	(0.076)		(0.075)			
Pension share in total asset					0.082*	0.081*
					(0.048)	(0.048)
Log liquidity asset (temptation assets)						
Ln(liq)	0.911**	-12.92	1.161***	-14.65	-0.258***	-0.251***
	(0.385)		(0.388)		(0.088)	(0.088)
Ln(liq) squared	-0.051***		-0.062***		0.013***	0.013***
	(0.016)		(0.016)		(0.004)	(0.004)
Sample Size	4189		4189		1640	1640

Note: *, **, and *** stand for significant estimates at 10%, 5%, and 1% level, respectively. All regressions control for gender, marital status, number of kids, age, and total wealth (we do not display the effects of age and total wealth to conserve space). The reference household here shares similar characteristics as that in Table 5 (e.g., unmarried, white, no kids, no high-school diploma, mean age, etc.), except that it does not participate in pension plans.

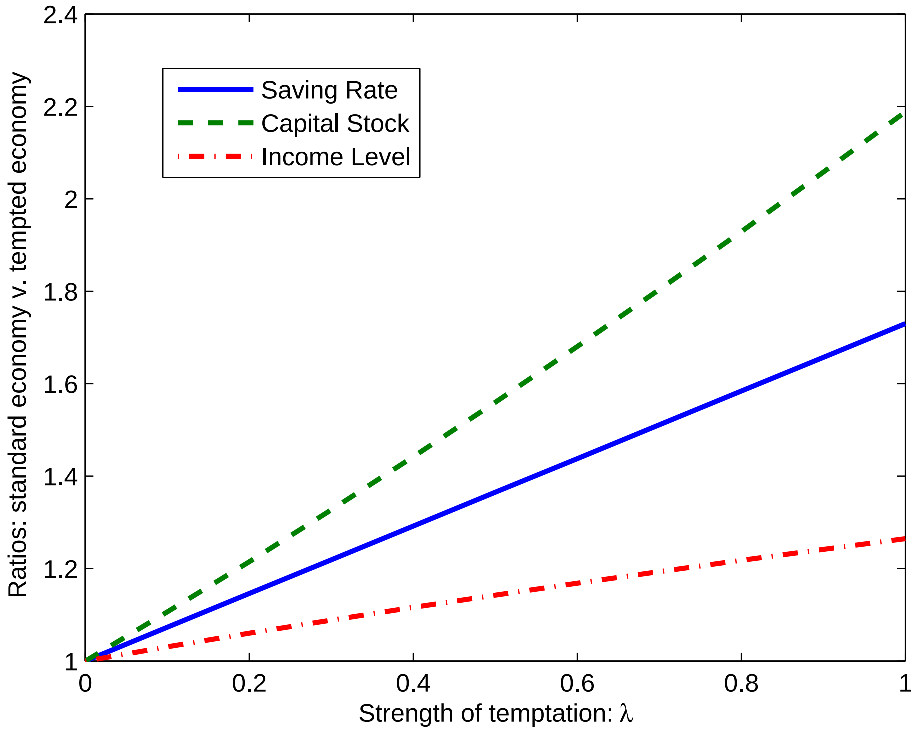

Figure 1:—Temptation and wealth accumulation

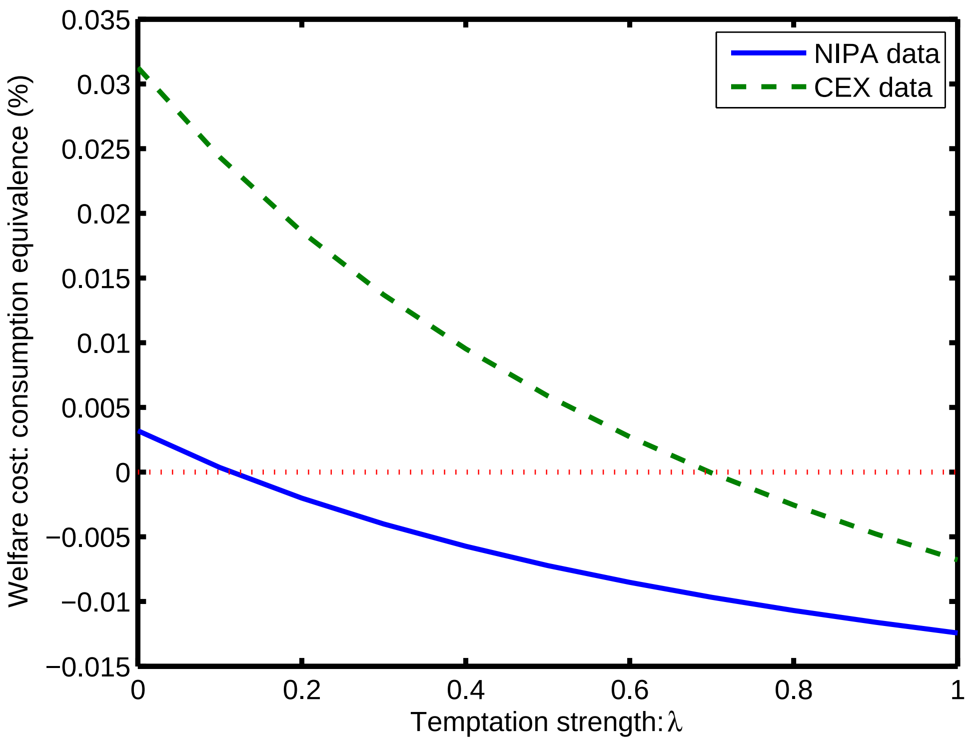

Figure 2:—Temptation and the welfare costs of business cycle fluctuations