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ABSTRACT

Economic theory predicts that an unexpected wealth windfall should increase consumption shortly after the windfall is received. We test this prediction using administrative records on over 40,000 401(k) accounts. Contrary to theory, we estimate a negative short-run marginal propensity to consume out of idiosyncratic 401(k) capital gains shocks. These results cannot be interpreted as standard intertemporal substitution, since the idiosyncratic returns that we study do not predict future returns. Instead, our findings imply that many investors are influenced by a positive feedback effect, through which higher recent returns encourage higher short-run saving. Like any other animal, 401(k) participants appear to increase behaviors that have been associated with high rewards in the past.

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1. Introduction

Economic theory predicts that an unexpected wealth windfall should immediately and permanently *increase* consumption, which is an income effect. For example, in an infinite-horizon model with complete markets, the marginal propensity to consume (MPC) out of a windfall roughly equals the discount rate.[1] If markets are not complete, economic theory predicts that the MPC may considerably exceed the discount rate (Carroll 1992, 1997).

In this paper, we present empirical evidence that contradicts these predictions. We find that the short-run MPC with respect to 401(k) capital gain windfalls is *negative*. At year-end 2001, 401(k) accounts contained $1.75 trillion owned by 45 million workers (Holden and Vanderhei 2003). Using administrative data on 40,000 401(k) accounts, we calculate idiosyncratic capital gains in the cross-section that do *not* forecast future returns. Standard theory predicts that a cross-sectional regression of consumption growth on these orthogonal capital gains shocks will identify only a positive income effect, since the standard substitution effect should be inoperative. Contrary to theory, we estimate a negative short-run MPC. These results are robust to a wide variety of alternative specifications motivated by theory and by the special institutional features of 401(k) plans.

At first glance, this result appears to be quite perverse. However, our results represent a natural extension of an old idea: investors chase returns. Several authors have shown that return-chasing influences asset allocation (e.g., Patel, Hendricks and Zeckhauser 1994, Benartzi 2001, Goetzmann and Massa 2002, Huberman and Sengmuller 2004). We are the first to show that return-chasing also plays a role in *consumption* decisions.[2] High transitory past investment returns encourage naïve households to invest more in the short run and therefore consume less.

Although the main thrust of our paper is empirical, we also show that combining reinforcement learning with the standard economic model can reconcile our results with the positive MPC estimates found in prior consumption studies. Reinforcement learning models have

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[1] In a continuous-time model with isoelastic preferences the MPC is given by $(1-\theta)[r + (\theta\pi^2)/(2\sigma^2)] + \theta\rho$, where θ is the elasticity of intertemporal substitution, r is the risk free real interest rate, π is the equity premium, σ is the standard deviation of stock returns, and ρ is the discount rate. When the elasticity of intertemporal substitution is one (log utility), this formula collapses to the discount rate.

[2] The first suggestions of such an effect can be found in work by Starr-McCluer (2002), who analyzes household surveys in which 11.6% of stockholders report that the 1990s bull market caused them to save more, while only 3.4% say they saved less. Our identification strategy differs from that of Starr-McCluer, since we identify wealth shocks cross-sectionally.

had success in predicting subject choices in experiments (Roth and Erev 1995, Erev and Roth 1998, Charness and Levin 2005). In our context, reinforcement learning encourages saving in response to high returns and discourages saving in response to low returns. Even though the standard income effect is operative, it is more than offset by the reinforcement effect in this particular case, yielding a negative MPC.

Section 2 describes our data set, which is comprised of detailed information for approximately 40,000 participants in five company-sponsored 401(k) plans. While ours is the first study to use these specific records, other papers have exploited different sets of individual-level 401(k) data to study savings rates (Huberman et al., 2004), asset allocation (Benartzi and Thaler, 2001, Agnew et al, 2003, Huberman and Jiang, 2006), trading (Choi et al., 2002, Agnew et al, 2003), and investment in employer stock (Huberman and Sengmuller, 2004, Choi et al., 2004). Section 3 lays out our empirical methodology and explains our methods for measuring wealth shocks. Section 4 presents our main results and reconciles them with the previous literature. Section 5 considers objections to our results, most of which fall into two categories. The first is that people adjust their consumption along margins that our consumption measure does not capture. The second is that our results are driven by wealth shocks outside of the 401(k) that we do not observe. We find no evidence to support these objections. Section 6 concludes.

2. Data description

Our data come from a large benefits administration and consulting firm. We have panel data for five companies that start when our data provider became the plan administrator at each firm and end at year-end 2000. These data contain the date, amount, and type of every transaction made in the 401(k) plans by every participant. In addition, we have cross-sectional snapshots of age, annual salary, date of hire, gender, marital status, 401(k) asset allocations, and 401(k) contribution rates in effect on the last pay period[3] of 1998, 1999, and 2000 for those actively employed at the companies on those dates.

Table 1 gives summary statistics as of year-end 2000 for our companies, which we code-name Company A through E. Our sample consists of large firms that span a wide range of industries. The employees are on average 42.9 years old and earn $55,292 a year. By comparison, the March 2001 Current Population Survey reports an average age of 40.8 years and

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[3] The pay period is typically two weeks in our sample.

average salary of $45,656 among full-time workers in companies employing over 1,000 workers and offering some kind of retirement plan. The average 401(k) participation rate across the firms is 79%, which is close to the 2000 national participation rate of 80% found by the Profit Sharing/401(k) Council of America (2001), and the average balance of participants is $65,964, which is similar to Holden and Vanderhei's (2001) reported average year-end 2000 balance of $61,207 among plans with more than 10,000 participants.

All of our companies offer matching contributions ranging from 25 cents to a full dollar for each dollar contributed to the 401(k) by the employee up to a threshold, although Company C did not introduce its match until 2000. All of the plans allow participants to take hardship withdrawals from and loans against their 401(k) plan balances, and two allow non-hardship withdrawals from current contributions. These provisions make 401(k) savings in the companies we study more liquid than for the 401(k) participant population at large.[4] Finally, all of the plans allow changes to the elected contribution rate and asset allocation on a daily basis. Changes can be made by talking to a benefits center representative on the phone during business hours, or by using a touch-tone phone system or the Internet 24 hours a day. The direct transaction costs involved in changing one's savings rate in these plans are therefore minimal.

3. Empirical methodology

Our empirical objective is to estimate the relationship between consumption growth and wealth shocks orthogonal to innovations in expected (under the rational probability measure) returns. The key assumption in our analysis is that consumption adjustments are observable through changes in the 401(k) contribution rate. This assumption is plausible: most households should be doing nearly all of their saving in the 401(k) because the employer match (for the plans in our data) and tax benefits make the 401(k) plan the most attractive savings vehicle available. Consistent with this normative view, among 401(k)-holding households earning between $20,000 and $70,000 a year in the 2001 Survey of Consumer Finances—a sample roughly comparable to the one we will use in our analysis—the median household has less than

[4] The U.S. Department of Labor (2003) reports that in 2000, 40% of full-time employees with savings and thrift plans in private industry were not allowed to take early in-service withdrawals for any reason, and an additional 29% could only take hardship withdrawals. The Profit Sharing/401(k) Council of America (2001) reports that 14% of plans did not permit loans in 2000.

one month's income in net financial assets outside the 401(k).[5] It is only at the 80th percentile that households have one year's income outside the 401(k), and this probably overstates outside asset holdings in our sample; the generosity of our 401(k) plans' early withdrawal and loan provisions substantially mitigates the need for a precautionary wealth stock outside the 401(k). We will, however, explore the possibility that the 401(k) contribution rate is not the savings adjustment margin in section 5.

Our reduced-form expression for individual *i*'s consumption growth from year-end $t-1$ to year-end *t,* normalized by income, is

$$\frac{C_{i,t} - C_{i,t-1}}{Y_{i,t-1}} = \alpha_i + \beta_1 \frac{Shock_{i,t}}{Y_{i,t-1}} + \beta_2 \frac{Shock_{i,t-1}}{Y_{i,t-1}} + \boldsymbol{\gamma}\mathbf{X}_{i,t\text{-}1} + \sum_{\tau}\sum_{j}(D_{\tau} \times F_j) + \varepsilon_{i,t}\,, \quad (1)$$

where $C_{i,t}$ is annualized consumption flow during the last pay period of year *t*, $Y_{i,t-1}$ is annualized salary flow during the last pay period of year $t-1$, α_i is the individual's fixed effect, $Shock_{i,t}$ is the wealth shock in dollars accrued from the beginning to the end of year *t*, $\mathbf{X}_{i,t-1}$ is a vector of demographic variables that change non-linearly with time (age squared, log of salary in 1998 dollars, and log of tenure at the company), D_τ are year dummies equal to 1 if $t = \tau$, F_j are firm dummies equal to 1 if *i* works in firm *j*, and $\varepsilon_{i,t}$ is the disturbance term. The coefficients of interest are β_1 and β_2. Under the approximation that a wealth shock changes consumption by a constant fraction of that shock each subsequent period, we can interpret β_1 as the one-year marginal propensity to consume out of wealth. β_2 should equal zero if consumption responds to wealth innovations without a lag, as is commonly assumed in theory. However, there is some empirical evidence that stock market return effects on consumption growth are long-lived (e.g. Dynan and Maki (2000), Gabaix and Laibson (2002)).

We transform this expression in order to make the dependent variable identifiable from our data. Let $S_{i,t}$ be *i*'s 401(k) savings/contribution rate during the last pay period of year *t*. We assume that

[5] On the assets side, we include CDs, bonds, savings bonds, publicly traded stock, mutual funds, cash value life insurance, other managed accounts, transactions accounts, non-401(k) pension accounts, and miscellaneous assets. For liabilities, we subtract credit card debt, non-home-equity lines of credit, business loans, education loans, other consumer loans, margin loans, loans against life insurance policies, loans against non-401(k) pension accounts, and car loans.

$$C_{i,t} = Y_{i,t}(1 - S_{i,t}) + k_i\ , \tag{2}$$

where k_i is a constant that represents consumption funded by income earned outside the company or savings outside the 401(k). Substituting this expression into (1) and simplifying yields

$$S_{i,t-1} - S_{i,t} + \left(\frac{Y_{i,t}}{Y_{i,t-1}} - 1\right)\left(1 - S_{i,t}\right) = \beta_1 \frac{Shock_{i,t}}{Y_{i,t-1}} + \beta_2 \frac{Shock_{i,t-1}}{Y_{i,t-1}} + \boldsymbol{\gamma}\mathbf{X}_{i,t-1} + \sum_{\tau}\sum_{j}(D_\tau \times F_j) + \varepsilon_{i,t}\ . \tag{3}$$

We add the before-tax and (if the plan offers the option) after-tax 401(k) contribution rates in effect for the last pay period of 1998, 1999, or 2000 to calculate $S_{i,t}$ in each of these years. Note that there are at most three consumption observations per individual, which translates into a maximum of two consumption growth observations. Because we are allowing for an individual fixed effect in consumption growth, we will require that all employees in our regressions have two consumption growth observations. $Y_{i,t}$ is set to annualized salary in the last pay cycle of year t in January 1998 dollars, assuming that salary during a calendar year is paid in nominally equal amounts each pay cycle and deflating by the monthly CPI series.

Constructing our key independent variable, the 401(k) wealth shock, is more complicated. Simply calculating the annual change in 401(k) balances would not generate a valid measure of the type of wealth shock that we are trying to identify. Much of the annual change in account balances is generated by payroll contributions to the plan, and these contributions should not be counted as wealth shocks because they are merely transfers from human wealth to financial wealth.[6] We could subtract annual 401(k) contributions from the change in 401(k) balances to isolate the change in balances that is due to capital gains (or losses). But a portion of these capital gains is expected and thus, in theory, should not affect consumption growth. We must therefore isolate the *unexpected* component of capital gains. With these considerations in mind, we define the wealth shock accrued over a year as the difference between the realized and expected dollar-denominated real capital gain in each asset, summed over all assets.

We calculate capital gains in the standard manner: for each asset, we multiply monthly percent returns by the participant's dollar holdings at the end of the prior month, and then add up across months and assets.[7] In order to compute expected capital gains, we must measure

[6] More explicitly, human wealth can be seen as the present value of all future labor income. Each paycheck is a dividend that diminishes human wealth by the same amount it increases financial wealth. The employee can choose to consume this dividend and diminish total wealth, or save it and keep total wealth unchanged.

[7] Assets are defined at the level of individual mutual funds and employer stock holdings. Dollar holdings are deflated by the same monthly CPI series used to deflate income, Y_t.

expected percent returns. We use two different proxies. The first measure, the “adaptive expected return,” is motivated by empirical evidence that the typical investor’s stock market return expectations comove positively with recent returns (Graham and Harvey (2003), Vissing-Jorgensen (2003), Benartzi (2001), Huberman and Sengmuller (2004), Choi et al. (2004)). We define the adaptive expected return as the lagged ten-year real return on an investment option’s asset class. Table 2 lists the eleven asset classes and the indexes used to measure their lagged returns.

The “constant expected return” is the average real return on the investment option’s asset class from January 1926 to December 1997. This measure of expected return does not change with asset return realizations during 1998 and 2000. We consider this to be the rational expected return, motivated by the evidence of Goyal and Welch (2006) that the historical average equity premium is the best out-of-sample predictor of future equity returns. We use the same indices to compute the constant expected returns and the adaptive expected returns, except that the constant expected returns use the S&P 500 historical return to form the employer stock expected return rather than the employer stock’s historical return because the latter contains a large idiosyncratic component and does not exist all the way back to 1926.[8]

To illustrate how our wealth shocks are calculated, suppose that there are only two funds available to investors. Fund A’s expected return is 1% this month, and Fund B’s expected return is 2%. Fund A actually returns 3%, and Fund B actually returns –3%. Investor 1 had $3,000 in Fund A and $1,000 in Fund B at the end of the prior month; Investor 2 had $1,000 in Fund A and $1,000 in Fund B. Then Investor 1 receives a $3,000 × (3 – 1)% + $1,000 × (–3 – 2)% = $10 wealth shock this month, while Investor 2 receives a $1,000 × (3 – 1)% + $1,000 × (–3 – 2)% = –$30 wealth shock this month. We sum monthly wealth shocks to form the annual wealth shock for each investor.

We take two econometric approaches to estimating equation (4), both of which rely upon differences in differences. First, we use a least-squares dummy variable estimator, which does not take into account the fact that 401(k) contribution rates cannot be negative or exceed the plan-imposed maximum. Second, we use the semiparametric Honoré (1992) estimator, which allows for individual fixed effects while correcting for censored observations. The fact that our

[8] We use the S&P 500 for the international and emerging market return indices before January 1988 because the MSCI indices were not calculated before then.

data are censored at both the left and the right necessitates the use of the least absolute deviations version of Honoré's estimator.[9] If $S_{i,t}$ is the plan's maximum contribution rate or $S_{i,t-1}$ is zero, the observation is considered left-censored; if $S_{i,t}$ is zero or $S_{i,t-1}$ is the maximum contribution rate, the observation is considered right-censored. Following Chay and Honoré (1998), we bootstrap the standard errors by drawing 1,000 samples of 1,000 individuals' consumption growth pairs with replacement from the data and computing the estimator for each sample. The standard error for an estimated coefficient $\hat{\beta}_j$ is

$$\sqrt{\left(\frac{1000}{N/2}\right)\left(\frac{1}{1000}\right)\sum_{b=1}^{1000}\left(\hat{\beta}_j^b - \hat{\beta}_j\right)^2}, \tag{4}$$

where N is the total consumption growth observations in the real data and $\hat{\beta}_j^b$ is the bth bootstrap estimate.

Variation in our wealth shocks comes from variation in unexpected fund returns and the dollar amounts individuals invested in each asset. Because of the individual fixed effects in our econometric specification, our identifying variation is cross-sectional variation in the difference between an individual's 1999 wealth shock and 2000 wealth shock. Cross-sectional variation in the size of the wealth shocks individuals experienced in those years normatively should not have induced cross-sectional variation in their beliefs about expected returns. In the previous example, a rational Investor 1 would make no inference about future returns from the fact that his wealth shock is $40 higher than Investor 2's wealth shock. Therefore, differences between the two investors' contemporaneous consumption responses should arise solely from income effects if investors are rational.[10]

Our sample is limited to workers who have been actively employed at a sample firm and continuously enrolled in the 401(k) plan from January 1, 1998 to December 31, 2000. We include employees whose contribution rate or plan balances are zero, provided that they had positive balances at some time in the past. We also require that individuals have salaries greater than $20,000 in 1998 because a large fraction of those with salaries under $20,000 are part-time

[9] The least squared deviation version of the two-sided Honoré estimator does not necessarily have a unique solution.

[10] Alternatively, heterogeneous preferences can cause the strength of the substitution effect to vary across individuals, so that contemporaneous substitution responses to the same aggregate return news covary negatively enough with the income effect to generate our empirical result. Although such utility functions could probably be constructed, we doubt that the range of preference variation required to replicate our empirical results would be economically reasonable.

employees.[11] In addition, we trim workers who have a one-year income growth observation above 30% or below –20%, which roughly corresponds to removing the top 2% and bottom 2% of the income growth distribution. These deleted outliers are likely caused by transitions between part-time and full-time work status.

Finally, we drop individuals if their salary is high enough in 1998 that they could exceed the $10,000 annual limit on before-tax 401(k) contributions by contributing at the plan's maximum before-tax contribution rate. The reason we impose this selection rule can be illustrated by the following example. Suppose a highly-paid employee contributes enough that he hits the before-tax dollar limit midway through the year. If his company only allows before-tax contributions (Companies B, C, and E), then his 401(k) contribution rate is frozen at 0 for the remainder of the year and does not reflect any changes in his consumption rate. If the company allows additional after-tax contributions to the 401(k) (Companies A and D) or before-tax contributions to a non-401(k) deferred compensation plan (Company A), consumption changes may still not be reflected in the contribution rate because these alternative savings vehicles are not as attractive and therefore may not attract the marginal savings dollar.[12]

These selection criteria leave us with 54,054 observations on 27,027 employees.

4. Main results

4.1. Regression estimates

Table 3 reports summary statistics for our consumption growth and normalized wealth shock measures. Normalized consumption growth has a median of 1.4% of income, exhibits slight positive serial correlation, and is right-skewed. Both normalized wealth shock measures have a median close to zero and a relatively narrow distribution. The 10th percentile of the normalized adaptive wealth shock is a loss of 39.4% of a year's income, and the 90th percentile is a gain of 22.7% of a year's income. The distribution is similar for the normalized constant returns wealth shock; the 10th percentile is a loss of 31.9% of a year's income and the 90th

[11] In the March 2001 Current Population Survey, 29.9% of workers who earned less than $20,000 a year worked less than 35 hours a week or fewer than 40 weeks per year. Only 5.6% of workers earning between $20,000 and $30,000 a year satisfied this definition of part-time work.

[12] If an employer declares bankruptcy, employees in the deferred compensation plan can lose their entire deferred compensation balance. We eliminate participants in Company A's deferred compensation plan from our sample.

percentile is a gain of 25.9% of a year's income.[13] Both normalized wealth shocks are *ex post* negatively serially correlated. This serial correlation is sample-specific and arises from the persistence of individual asset allocations and the fact that the stock market did well in the first half of our sample and poorly in the second half. It should not be interpreted as evidence that current wealth shocks are informative about future wealth shocks.[14]

Table 4 presents the coefficients from estimating equation (3). The first row shows that all four MPC estimates are negative and statistically significant. The point estimates range from –0.44% to –1.79%, which means that a positive wealth shock equal to one year of income will contemporaneously decrease annualized consumption flow by 0.44% to 1.79% of yearly income. In addition, there appears to be a significant lagged consumption response as well. In the year following a positive wealth shock of one year's income, annualized consumption flow drops by 0.55% to 2.10% of yearly income.

The certainty-equivalence permanent income hypothesis predicts that the MPC is higher (more positive) for the old than the young, since the young have a longer remaining lifespan over which to spread consumption of a windfall. This motivates our estimating separate MPCs for those who are under 30 years old, between 30 and 39, between 40 and 49, between 50 and 59, and 60 or above, while constraining the other regression coefficients to be equal across age groups. The results are in Table 5, where we have omitted coefficient estimates for the non-shock variables.

We find that the MPC does increase almost monotonically with age, but even the oldest workers do not exhibit a positive MPC. For example, the first column of Table 5 reports the results for a least-squares dummy variable regression using the adaptive wealth shock as the wealth shock variable. Our contemporaneous MPC estimate is –9.49% for employees under 30 and –0.50% for employees over 60. The lagged MPC also shows a nearly monotonically increasing pattern, from –11.77% for employees under 30 to –0.44% for employees over 60. These patterns are qualitatively robust across estimators and wealth shock definitions.

Overall, there is no compelling evidence that anomalous MPCs are restricted to a particular subset of the population. If our results simply reflected reallocation between outside

[13] The extremes of the wealth shock distributions come from middle-income individuals close to retirement who had large 401(k) balances.

assets and the 401(k), or if outside wealth shocks were contaminating our estimates, then we would expect to find positive MPC estimates among the young, who are the least likely to own non-401(k) assets. Instead, the young have the most negative MPCs. If negative MPCs were simply a pathology of inexperienced investors that eventually disappears, we would expect to see positive MPC estimates among the old. But in our data, even the oldest employees have negative MPCs.

In the long run, consumption and wealth are tied together by the budget constraint. If in the short run, 401(k) investors' consumption growth comoves negatively with wealth shocks, when does consumption catch up to wealth? A plausible answer is that consumption moves towards wealth in retirement, either through a higher consumption rate during retirement or an earlier retirement date. Table 5 presents weak evidence that the latter is happening. We take employees who were at least 60 years old at year-end 1999 and estimate a probit on the probability that these employees left the company in 2000. (Overall, 50.4% of this population left in 2000.) The dependent variables are normalized wealth shock in 1999 and 1998, company dummies, and age, log of salary, and log of tenure at year-end 1999. We estimate positive effects for all the shock variables, and the effects are economically large; a positive wealth shock in year t equal to one year's income increases the probability of retirement by over 2 percentage points in year t and over 11 percentage points in year $t + 1$. However, none of the coefficients are statistically significant.

These retirement results are not inconsistent with the existing literature on the relationship between wealth shocks and retirement, which has come to conflicting conclusions. (See Hurd and Boskin (1984), Burtless (1984), Krueger and Pischke (1992), Holtz-Eakin, Joulfaian and Rosen (1993), and Imbens et al. (2001).)

4.2. Interpretation and Reconciliation with Past MPC Estimates

Our estimates stand in sharp contrast to past empirical research that has found positive MPCs out of cash windfalls and aggregate stock market movements. We square our results with these previous findings by interpreting negative MPCs as the consequence of reinforcement learning working in opposition to the standard income effect. Roth and Erev (1995) identify two

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[14] If participants who held large amounts of equity in the first half of the sample and hence had high measured wealth shocks foresaw that equity returns would be low in the second half of the sample, they could have easily

key features of reinforcement learning models. The first is the Law of Effect: agents are more likely to repeat actions that have yielded favorable outcomes in the past. The second is the Power Law of Practice: learning curves are steep initially and then level out as the stock of reinforcement increases.

Reinforcement learning reconciles all of the evidence on MPCs:

- The Law of Effect predicts that if a consumer experiences a gratifyingly high return from her savings activity, she will allocate more resources to savings and less to consumption. This behavior is a generalization of the phenomenon commonly referred to as returns-chasing, where investors reallocate money to assets that have recently experienced high returns while holding total savings fixed. The Law of Effect is offset by the income effect, which pushes the investor to cut her savings. In our data, the reinforcement effect appears to dominate the income effect, causing the MPC to be negative even though variation in the returns from which the MPC is identified conveys no information about future returns.
- The Power Law of Practice is consistent with our finding that the young—whose stock of past reinforcements is the smallest—have the most negative MPCs, since they are the most swayed by the Law of Effect and have the smallest income effect.
- When financial investment does not causally precede windfalls, there is no reinforcement to invest more and only the income effect is operative. Hence, the MPC out of war veteran payments and Holocaust reparations range from 17% to 97% (Bodkin 1959, Kreinin 1961, Landsberger 1966).
- The income effect increases proportionally with the size of the windfall, whereas the reinforcement effect levels off due to the Power Law of Practice. Therefore, the MPC out of large lottery prizes (Imbens et al. 2001) is 86%.[15]
- Reinforcement learning—and hence negative MPCs—should be less prevalent among agents who are more sophisticated than the 401(k) investors in our sample. We also expect that the sophisticated are, on average, richer than the unsophisticated. Therefore, aggregate consumption growth comoves positively with aggregate stock market movements because sophisticates do most of the consuming in the economy.

traded out of equities and thus avoided the negative serial correlation in wealth shock.

Consistent with this hypothesis, Starr-McCluer (2002) finds that households with more than $250,000 in stockholdings were much more likely than poorer stockholders to report that the 1990s bull market caused them to decrease their saving or increase their spending.

5. Robustness checks

In this section, we further consider possible objections to our results. Subsection 5.1 examines whether the consumption responses we estimate reflect active choices made by employees. Subsections 5.2 through 5.5 test the possibility that the 401(k) contribution rate is not the relevant consumption adjustment margin for the people in our data. Subsection 5.6 discusses and tests the effect of non-401(k) wealth shocks on our results. We find no evidence that weakens the force of our main result. Of the 30 MPC estimates presented in this section, all are negative, and 26 of these are statistically significant.

5.1. Negative consumption responses do not reflect active savings choices

The passivity of 401(k) investors has been extensively documented (Samuelson and Zeckhauser (1988), Madrian and Shea (2001), Choi et al. (2002, 2004)). Therefore, the consumption "responses" we estimate may be due to a coincidental in-sample relationship between employee income growth and capital gains, rather than the result of active savings choices.

To address this concern, we estimate the main regression setting the income adjustment term in the dependent variable to zero, so that we are only measuring active contribution rate changes, $S_{t-1} - S_t$. The results are in the first row of Table 7. Because contribution rate changes are constrained to integer percentages of income (that is, they can be no smaller than 1 percent of income), the median contribution rate change is zero for almost all subsamples of the data. Therefore, the Honoré estimator is not meaningful in this context, since it is a median estimator, but we report its coefficients for completeness.

For both definitions of wealth shock, the least-squares estimate indicates that a positive wealth shock of one year's income causes the average employee to actively decrease his

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[15] Kearney and Liao (2004) do not find evidence of a negative same-day MPC out of small lottery prizes. However, they do not measure the effect of prizes on lottery purchases on subsequent days.

contribution rate by 0.27% to 0.29% of income. These coefficients are statistically significant at the 1% level. The lagged wealth effects are also negative and of similar magnitude, although the statistical significance is somewhat weaker.

We conclude that the anomalous consumption responses in our sample are due to active employee choices.

5.2. The 401(k) is not the relevant margin for consumption adjustment

Our MPC estimate hinges on the assumption that the 401(k) contribution rate is the margin at which participants adjust their savings rate. If participants find it worthwhile to adjust savings through contributions to other asset accounts, then the 401(k) contribution rate response to retirement wealth shocks may be offset by activity elsewhere.

We test this alternative explanation by restricting our sample to participants who at year-end 1998 were contributing less than the threshold to which their employer would provide matching contributions. These participants face instantaneous risk-free marginal returns to saving in their 401(k) of 25% to 100%. It is difficult to imagine that there are alternative investment vehicles that offer comparable risk-adjusted returns. Therefore, these employees have especially strong incentives to adjust their consumption expenditures exclusively through their 401(k) contribution rate.[16] Because Company C did not have a match until 2000, its participants are excluded from this analysis.

The results of this regression are found in the second row of Table 7. The least-squares estimates of the contemporaneous MPC remain statistically significant, and their magnitudes increase slightly to –1.95% and –1.89%. The Honoré estimates are negative, but their magnitudes are about half those of the baseline regressions and statistically insignificant. However, the standard errors are over five times as large as the baseline regressions', due in large part to our retaining only 16% of our baseline observations, a disproportionate number of which are censored. If our standard errors had remained what they were in the baseline regressions, the Honoré MPC estimates for those interior to the match would be strongly statistically significant. In contrast, the evidence for a lagged MPC effect is weaker for this

[16] One might be concerned that the bulk of the participants who are contributing less than the match threshold are new employees whose employer matches will not vest for a long time. If such employees have a high probability of leaving the firm before their vesting begins, this restricted sample would not face significantly higher marginal

subsample. The lagged least squares estimates are considerably attenuated and statistically insignificant, and the Honoré point estimates are nearly zero.

Participants may also respond to positive wealth shocks by purchasing a home. Because mortgage payments cover both the rental flow of housing services and the purchase of home equity, the home becomes a savings vehicle. The amount of money that goes towards home equity could come out of the 401(k) contribution rate, thus creating a spurious negative MPC estimate. In order to check for this possibility, we restrict our sample to those whose zip code didn't change between year-end 1998 and year-end 2000. The results in the third row of Table 7 show that all eight MPC estimates are negative and statistically significant, with little coefficient attenuation.

5.3. Consumption adjustment is occurring through spouse's 401(k)

401(k) accounts may be the most attractive savings vehicles available to the employees in our data, but the 401(k) accounts we see in our data may not be the only ones available to them. The employee's spouse's 401(k) may be more attractive and hence the one that attracts the marginal dollar. Alternatively, the consumption changes we measure may only reflect reshuffling of assets between the two 401(k) accounts. We test this story by restricting the sample to participants who were unmarried at year-end 1998. Because we do not have marital status data on employees at Company D, they are excluded from this analysis. The regression results are presented in the fourth row of Table 7. We find that our MPC point estimates become more negative, and all are statistically significant at the 1% level.

5.4. Consumption adjustment is occurring through in-service withdrawals

We have been identifying changes in consumption through changes in the contribution rate and salary. However, participants may be making their consumption expenditure adjustments through in-service withdrawals from their 401(k) instead. In practice, this is unlikely to be a significant factor, given that only 5% of our sample made any in-service withdrawals from the beginning of 1998 to the end of 2000. The main complication with a withdrawals analysis is the difficulty of assigning a time period to the consumption stream. At one extreme,

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incentives to save in the 401(k). However, it turns out that only 9% of those in the restricted sample are not vested at all at year-end 1998, while 79% are fully vested and 12% are partially vested.

one can assume that withdrawals are rolled over into another tax-deferred account and not consumed until the future, in which case withdrawals don't matter at all for our analysis. At the other extreme, one can assume that the entire withdrawal is consumed immediately. An intermediate case is to assume that the withdrawal is annuitized and consumed slowly over time.

We estimate regressions with two different assumptions about the timing of withdrawal consumption. Because withdrawals are infrequent events, we do not use a two-week measure of consumption as we did in the main analysis. Instead, we use yearly consumption, defined as the year's total income plus withdrawals consumed minus 401(k) contributions. We assume either that all withdrawals net of rollovers into other accounts are consumed in the year of the withdrawal, or that 5% of a withdrawal net of rollovers is consumed each year starting in the year of the withdrawal.[17] Withdrawals before age 59½ are assessed a 10% early withdrawal penalty. The dependent variable in our regressions is the year-over-year change in consumption normalized by prior year salary. The explanatory variables remain the same as in the previous regressions, as do the income, income growth, and plan enrollment restrictions.

In the Honoré regressions, we consider an observation left-censored if in year t, in-service withdrawals net of rollovers equals zero and the individual contributed the maximum allowable given his or her salary and plan contribution rate limits. In other words, the individual could not have saved any more in the 401(k) plan during the year. Conversely, an observation is considered right-censored if the above criteria are satisfied for year $t - 1$. An observation is also considered right-censored if total balances in the plan at the end of year t plus rollovers in year t equals zero. That is, the individual could not have funded any more consumption from the 401(k). If these conditions are satisfied in the lagged year, the observation is considered left-censored.

Assuming that the entire net withdrawal is consumed in the year of the withdrawal generates implausibly large outliers in consumption growth. These are caused by large withdrawals that were not directly rolled over into another asset account by the 401(k) administrator. It is unlikely that such large sums were entirely consumed in one year. Therefore, we trim the top 1% and bottom 1% of measured consumption growth, which corresponds to

[17] Our rollover measure is not comprehensive, however. We observe a withdrawal being rolled over into an IRA only when the employee asks that a check be sent directly from the employer to the IRA custodian. If an employee receives the withdrawal check him or herself and subsequently deposits some of the proceeds into an IRA, we do not observe this second transaction.

constraining consumption growth to lie between –18.5% and 34.7%. We do not trim the dependent variable in the regressions that assume that the withdrawals are annuitized.

The fifth row of Table 7 contains the results when we assume that net withdrawals are consumed immediately, and the sixth row contains the results when we assume that net withdrawals are annuitized. All MPC estimates remain negative and statistically significant, and the point estimates do not change much. We conclude that accounting for in-service withdrawals cannot generate a positive MPC out of 401(k) wealth shocks.

5.5. Consumption adjustment is occurring through 401(k) loans

Withdrawals are not the only way to access money from one's 401(k) account; one can also take out a 401(k) loan for up to 50% of vested plan balances or $50,000, whichever is lower. 401(k) loans are typically repaid through payroll deductions, with interest accruing to the individual's own 401(k) account. The maximum term of a 401(k) loan varies with its purpose. Legally, a primary residence loan can have a term of up to 30 years, while a general purpose loan can have a term of no longer than 5 years. In practice, many companies further restrict the term of the loans that they offer their 401(k) participants. Early repayment is possible with no penalties. While many companies charge loan origination fees, none of the companies in our data choose to do so. Loans are common in our sample: 51% of the sample had a loan outstanding at some point between year-ends 1998 and 2000.

Although a significant fraction of our population has a 401(k) loan, we do not believe that accounting for loans would capture significant consumption flow changes that are not already being measured by the contribution rate. Sundén and Surette (2000) find that only 8.5% of loans are used to finance non-durable consumption. 54.5% are used for durable expenditures on housing or cars, 21.6% are used for "bill consolidation" that is simply a reshuffling of liabilities, and 9.6% are used for education expenses. If durables are the most important consumption outlet for loans, then the consumption flow from durable purchases is approximately matched by the repayment schedule for the loan. If participants have only minimal liquid assets outside of their 401(k) (why would they need a loan otherwise?) and spend the entire amount of the loan (it is costly to withdraw more than one plans on spending because of the foregone tax benefits), then these repayments must be coming from either reducing the 401(k) contribution rate and hence increasing measured consumption, or from reducing other consumption flows by the amount of the loan repayments, leaving total consumption unchanged. Although the coordination between loan repayments and consumption from the loan is unlikely to be perfect—for example, the purchased durable could completely depreciate in three years, while the loan is paid off over five years—we believe that the measurement error from disregarding loan activity is of second order. Moreover, the error induced by timing mismatches distorts the magnitude of MPC estimates, but it cannot explain why all of our MPC estimates are negative. To see this, suppose that a positive wealth shock induces an employee to take out a loan and purchase a durable that yields a constant consumption flow for three years and then ceases to exist. The loan is paid off over five years, and this repayment is funded by a decrease in the 401(k) contribution rate. Then in the year after the inception of the loan, the increase in consumption is underestimated by the change in the contribution rate. However, we would not measure an actual decrease in consumption through the contribution rate. Similar logic applies if the durable lasts for longer than the term of the loan; the consumption change is overestimated but does not take the wrong sign.

5.6. Outside wealth shocks

The measures of wealth shock presented above are calculated only within the 401(k), but theory calls for a comprehensive wealth shock measure. Most participants—particularly the young, for whom we estimate the most negative MPCs—do not have significant financial wealth outside the 401(k). For those who do have significant outside financial assets, to the extent that outside assets' return shocks are uncorrelated or positively correlated with the shocks within the 401(k), our MPC estimates will be unbiased or positively biased. This condition is satisfied if outside assets load positively on beta risk.

Even though 401(k) participants generally have few financial assets outside of their 401(k), many of them have a significant non-financial asset—owner-occupied housing—whose return we do not observe. In order for housing wealth shocks to qualitatively affect our results, the surprise component of any real wealth innovation that occurs through housing must be negatively correlated with the surprise component of 401(k) wealth innovations. This seems unlikely to be true.

Nevertheless, to mitigate the possible effect of housing price changes, we conduct two tests. In the sixth row of Table 7, we present regression results where we have added dummy variables for the employee's state of residence interacted with year dummies to the baseline specification in equation (3). This allows us to control for state-level variation in real estate price appreciation. In the seventh row of Table 7, we present regression results using only the one-third of our sample which are least likely to own a home, judging by the proportion of housing units that are owner-occupied in their residential zip code, as measured by the 2000 U.S. Census.[18]

All of our MPC point estimates remain negative and significant. Including state-year interactions slightly attenuates the coefficients, but restricting to zip codes with low home ownership slightly increases the coefficients. Our ability to control for housing wealth is limited because of the nature of our data. However, in those tests that we are able to conduct, we find no evidence that would call our central result into doubt.

6. Conclusion

We have presented evidence that the short-run MPC out of orthogonal 401(k) capital gains shocks is negative, in violation of standard theory. Moreover, the magnitudes of some of these negative estimates are quite large, especially for the young. Our results suggest that many investors are influenced by a reinforcement learning heuristic that leads high capital gains to encourage saving and discourage consumption, even when those capital gains are not useful for predicting future returns. This reinforcement learning framework reconciles our results with past work that has estimated positive MPCs out of cash windfalls and aggregate stock market movements.

[18] The average owner-occupied housing fraction (weighted by employees living in the zip code) in the lower third of the sample is 61.1%, versus 74.8% for the entire sample.

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Table 1. Company Descriptions

Characteristic	Company A	Company B	Company C	Company D	Company E
Industry	Manufacturing	Healthcare	Manufacturing	Utility	Electronics
Number of employees	Over 20,000	Over 50,000	Over 20,000	Over 10,000	Over 10,000
Average age	44.1	42.7	44.6	43.5	39.5
Average salary	$51,835	$33,156	$66,700	$70,069	$54,702
% male	80%	19%	*	83%	65%
% married	56%	55%	75%	*	50%
401(k) participation rate	80%	61%	86%	85%	83%
Average 401(k) balance	$80,740	$19,501	$81,122	$88,033	$60,426
Maximum contribution rate (% of salary)	10% before-tax, 14% after-tax, 14% combined	15% before-tax	20% before-tax	25% before-tax and after-tax combined	1998-99: 14% before-tax 2000: 16% before-tax
Employer match	25% to 100% (varies by location) of first 6% of pay	25% of first 3% of pay	None until 2000, then 100% of first 1% of pay, 50% of next 4% of pay	50% of first 7% or 8% of pay (depends on union membership)	100% of first 3% of pay, 50% of next 3% of pay
Investment funds	1998: 3 bond, 3 large-cap, 1 mid-cap, 1 small-cap, 3 overseas, company stock. 1999: Added 1 bond, 1 large-cap, 1 overseas. 2000: Added 1 overseas and self-directed window.	1 cash, 1 bond, 3 pre-mix, 2 large-cap, 1 small-cap, 1 overseas, company stock	1 cash, 3 bond, 4 pre-mix, 8 large-cap, 5 mid-cap, 3 small-cap, 8 overseas, 3 sector, company stock	1998: 1 cash, 1 bond, 3 pre-mix, 1 large-cap, 1 mid-cap, 1 overseas, company stock 1999: Added 1 small cap, self-directed window	1 bond, 3 pre-mix, 5 large-cap, 1 small-cap, 1 overseas
Number of outstanding loans allowed	1 home loan, 1 general purpose loan	1	2	2	2
Hardship withdrawals allowed	Yes	Yes	Yes	Yes	Yes
Non-hardship withdrawal rules before age 59½	1 withdrawal allowed per month from after-tax, rollover, vested company match, and profit-share balances	After-tax and vested employer contribution money from grandfathered plans can be withdrawn at any time	Not allowed	After-tax and vested employer match money can be withdrawn at any time	After-tax and rollover balances can be withdrawn at any time

* Data unavailable

Table 2. Indices Used to Calculate Expected Returns

This table presents the indices used to calculate investors' expected return measures. All index returns assume that distributions are reinvested. Data are from Ibbotson Associates

Asset class	Index
Money Market	1-month Treasury Bill return
GIC/Stable Value	1-month Treasury Bill return
Bond	Ibbotson long-term corporate bond index
Balanced	(mixed according to particular plan's funds)
Lifestyle/Pre-mix	(mixed according to particular plan's funds)
Large US Equity	S&P 500
Mid US Equity	NYSE/AMEX/Nasdaq stocks in NYSE market cap deciles 3 to 5
Small US Equity	Ibbotson small stock index
International	MSCI AC World except U.S. (starting with Jan. 1988 index inception) S&P 500 (before January 1988)
Emerging Markets	MSCI Emerging Markets (starting with Jan. 1988 index inception) S&P 500 (before January 1988)
Employer Stock	Employer stock (for adaptive expected returns) S&P 500 (for constant expected return)

Table 3. Consumption Growth and Normalized Wealth Shock Distributions

This table presents summary statistics on consumption growth and the two wealth shock measures. Consumption growth is defined as the year-over-year change in real consumption during the last pay cycle of December, normalized by real income in the last pay cycle of the prior year (see equation (3)). The normalized adaptive wealth shock is the difference between the real capital gain actually realized by the participant during the year and what he would have realized had the real returns on his funds equaled the ten-year lagged average real returns of the funds' respective asset classes (Table 2), normalized by prior-year real annual income. The normalized constant return wealth shock is the difference between the real capital gain actually realized by the participant during the year and what he would have realized had the real returns on his funds equaled the average real returns of the funds' respective asset classes from 1926 to 1997, normalized by prior-year real annual income. The distributions shown are for yearly consumption growth from year-end 1998 through year-end 2000, and wealth shocks from 1997 to 2000.

	Normalized consumption growth	Normalized adaptive wealth shock	Normalized constant return wealth shock
Maximum	0.4251	7.5043	7.9207
99th percentile	0.2463	1.2734	1.4029
90th percentile	0.1362	0.2272	0.2591
75th percentile	0.0704	0.0397	0.0547
50th percentile	0.0136	-0.0082	0.0002
25th percentile	-0.0133	-0.1426	-0.1073
10th percentile	-0.0449	-0.3942	-0.3191
1st percentile	-0.1447	-1.3260	-1.1380
Minimum	-0.2801	-8.9672	-8.7353
Mean	0.0310	-0.0460	-0.0075
Std. Dev.	0.0760	0.4238	0.4146
Serial correlation	0.1027	-0.4232	-0.3672

Table 4. Regression of Consumption Growth on Normalized Wealth Shock

The dependent variable is the year-over-year change in real consumption in the last pay cycle of December, normalized by real salary in the last pay cycle of the prior year. Coefficients are shown for two estimators: a least squares estimator and the Honoré (1992) estimator. $Shock_t$ is defined in two ways. The normalized adaptive wealth shock is the difference between the real capital gain actually realized by the participant during the year and what he would have realized had the real returns on his funds equaled the ten-year lagged average real returns of the funds' respective asset classes (Table 2). The constant return wealth shock is the difference between the real capital gain actually realized by the participant during the year and what he would have realized had the real returns on his funds equaled the average real returns of the funds' respective asset classes from 1926 to 1997. Y_{t-1} is inflation-adjusted salary paid in year $t-1$. Age_{t-1} is the participant's age at the end of $t-1$. $Tenure_{t-1}$ is the number of years since original hire at the end of $t-1$. Coefficients for company-year dummies are omitted. Standard errors are in parentheses below the point estimates.

	Adaptive wealth shock		Constant return wealth shock	
	Least squares	Honoré	Least squares	Honoré
$Shock_t/Y_{t-1}$	-0.0179**	-0.0050**	-0.0174**	-0.0044**
	(0.0018)	(0.0012)	(0.0019)	(0.0014)
$Shock_{t-1}/Y_{t-1}$	-0.0210**	-0.0070**	-0.0183**	-0.0055**
	(0.0033)	(0.0019)	(0.0031)	(0.0020)
$Age^2_{t-1}/1000$	-0.1911**	-0.0802*	-0.1897**	-0.0883**
	(0.0371)	(0.0313)	(0.0371)	(0.0318)
Log($Tenure_{t-1}$)	-0.0203**	-0.0093*	-0.0209**	-0.0094
	(0.0068)	(0.0044)	(0.0068)	(0.0050)
Company-year dummies	Yes	Yes	Yes	Yes
N	54,054	54,054	54,054	54,054

* Significant at the 5% level
** Significant at the1% level

Table 5. Regression of Consumption Growth on Normalized Wealth Shock Interacted with Age

The dependent variable is the year-over-year change in real consumption in the last pay cycle of December, normalized by real salary in the last pay cycle of the prior year. Coefficients are shown for two estimators: a least squares estimator and the Honoré (1992) estimator. $Shock_t$ is defined in two ways. The normalized adaptive wealth shock is the difference between the real capital gain actually realized by the participant during the year and what he would have realized had the real returns on his funds equaled the ten-year lagged average real returns of the funds' respective asset classes (Table 2). The constant return wealth shock is the difference between the real capital gain actually realized by the participant during the year and what he would have realized had the real returns on his funds equaled the average real returns of the funds' respective asset classes from 1926 to 1997. The dummy variables ($n_1 \leq Age < n_2$) are equal to 1 if age at year-end 1998 falls in the specified range. Y_{t-1} is inflation-adjusted salary paid in year t – 1. Coefficients for age, age-squared, log of tenure, log of salary, and company-year dummies are omitted. Standard errors are in parentheses below the point estimates.

	Adaptive wealth shock		Constant return wealth shock	
	Least squares	Honoré	Least squares	Honoré
$Shock_t \times (Age < 30) / Y_{t-1}$	-0.0949**	-0.0862**	-0.0926**	-0.0846**
	(0.0169)	(0.0220)	(0.0180)	(0.0234)
$Shock_t \times (30 \leq Age < 40) / Y_{t-1}$	-0.0368**	-0.0241**	-0.0350**	-0.0239**
	(0.0044)	(0.0046)	(0.0046)	(0.0047)
$Shock_t \times (40 \leq Age < 50) / Y_{t-1}$	-0.0184**	-0.0040	-0.0179**	-0.0044
	(0.0024)	(0.0023)	(0.0025)	(0.0024)
$Shock_t \times (50 \leq Age < 60) / Y_{t-1}$	-0.0105**	-0.0007	-0.0102**	-0.0010
	(0.0029)	(0.0023)	(0.0030)	(0.0025)
$Shock_t \times (Age \geq 60) / Y_{t-1}$	-0.0050	-0.0038	-0.0045	-0.0038
	(0.0112)	(0.0195)	(0.0121)	(0.0234)
$Shock_{t-1} \times (Age < 30) / Y_{t-1}$	-0.1177**	-0.1214**	-0.1009**	-0.1048*
	(0.0350)	(0.0461)	(0.0336)	(0.0439)
$Shock_{t-1} \times (30 \leq Age < 40) / Y_{t-1}$	-0.0390**	-0.0393**	-0.0320**	-0.0329**
	(0.0090)	(0.0086)	(0.0087)	(0.0082)
$Shock_{t-1} \times (40 \leq Age < 50) / Y_{t-1}$	-0.0197**	-0.0055	-0.0173**	-0.0054
	(0.0045)	(0.0037)	(0.0043)	(0.0035)
$Shock_{t-1} \times (50 \leq Age < 60) / Y_{t-1}$	-0.0131*	-0.0006	-0.0115*	-0.0012
	(0.0051)	(0.0038)	(0.0049)	(0.0037)
$Shock_{t-1} \times (Age \geq 60) / Y_{t-1}$	-0.0044	-0.0063	-0.0029	-0.0043
	(0.0174)	(0.0388)	(0.0169)	(0.0395)
Company-year dummies	Yes	Yes	Yes	Yes
N	54,054	54,054	54,054	54,054

* Significant at the 5% level
** Significant at the 1% level

Table 6. Probit Regression of Older Workers Leaving the Company on Normalized Wealth Shock

The dependent variable equals 1 if the participant has left the company during 2000, and 0 otherwise. Individuals included in these regressions were active participants in their company's 401(k) plan for all of calendar years 1998 and 1999 and were at least 60 years old and not yet retired at year-end 1999. $Shock_t$ is defined in two ways. The normalized adaptive wealth shock is the difference between the real capital gain actually realized by the participant during year t and what he would have realized had the real returns on his funds equaled the ten-year lagged average real returns of the funds' respective asset classes (Table 2). The constant return wealth shock is the difference between the real capital gain actually realized by the participant during the year and what he would have realized had the real returns on his funds equaled the average real returns of the funds' respective asset classes from 1926 to 1997. Y_{1999} is inflation-adjusted salary paid in 1999. Age_{1999} is the participant's age at the end of 1999. $Tenure_{1999}$ is the number of years since original hire at the end of 1999. Estimates for company dummies are omitted. The columns labeled "Coefficient" present coefficient estimates from the probit. The columns labeled "Slope" present marginal effects evaluated at the means of the explanatory variables. Standard errors are in parentheses below the point estimates.

	Adaptive wealth shock		Constant return wealth shock	
	Coefficient	Slope	Coefficient	Slope
$Shock_{1999}/Y_{1999}$	0.0672	0.0268	0.0562	0.0224
	(0.0905)	(0.0361)	(0.0864)	(0.0345)
$Shock_{1998}/Y_{1999}$	0.2910	0.1160	0.3006	0.1199
	(0.2470)	(0.0985)	(0.2016)	(0.0804)
Age_{1999}	0.0129	0.0051	0.0126	0.0050
	(0.0141)	(0.0056)	(0.0141)	(0.0056)
$\text{Log}(Y_{1999})$	-0.3317**	-0.1323**	-0.3382*	-0.1349*
	(0.1210)	(0.0483)	(0.1215)	(0.0485)
$\text{Log}(Tenure_{1999})$	0.1510*	0.0602*	0.1466*	0.0585*
	(0.0667)	(0.0267)	(0.0669)	(0.0267)
Company dummies	Yes	Yes	Yes	Yes
N	1,457		1,457	

* Significant at the 5% level
** Significant at the 1% level

Table 7. Robustness Checks

This table presents variants of the regressions in Table 4. The aspect of the specification that has been modified is given in the first column. Coefficients for age, age-squared, log of tenure, log of salary, company-year dummies, and state-year dummies (where applicable) are omitted. Standard errors are in parentheses below the point estimates.

		Adaptive wealth shock		Constant return wealth shock	
Specification	Variable	Least squares	Honoré	Least squares	Honoré
Dependent variable is negative of change in 401(k) contribution rate	$Shock_t/Y_{t-1}$	-0.0027**	0.0000	-0.0029**	0.0000
		(0.0007)	(0.0009)	(0.0007)	(0.0009)
	$Shock_{t-1}/Y_{t-1}$	-0.0023	0.0000	-0.0024*	0.0000
		(0.0013)	(0.0012)	(0.0012)	(0.0011)
Sample restricted to participants interior to match threshold	$Shock_t/Y_{t-1}$	-0.0195**	-0.0028	-0.0189**	-0.0030
		(0.0057)	(0.0068)	(0.0059)	(0.0073)
	$Shock_{t-1}/Y_{t-1}$	-0.0068	-0.0001	-0.0044	-0.0002
		(0.0102)	(0.0108)	(0.0100)	(0.0103)
Sample restricted to participants who remain in the same zip code	$Shock_t/Y_{t-1}$	-0.0178**	-0.0038**	-0.0174**	-0.0044**
		(0.0019)	(0.0012)	(0.0020)	(0.0013)
	$Shock_{t-1}/Y_{t-1}$	-0.0211**	-0.0053**	-0.0187**	-0.0054**
		(0.0033)	(0.0019)	(0.0032)	(0.0018)
Sample restricted to unmarried participants	$Shock_t/Y_{t-1}$	-0.0228**	-0.0134**	-0.0223**	-0.0131**
		(0.0035)	(0.0032)	(0.0037)	(0.0034)
	$Shock_{t-1}/Y_{t-1}$	-0.0252**	-0.0177**	-0.0223**	-0.0152**
		(0.0066)	(0.0032)	(0.0064)	(0.0047)
Assume immediate consumption of in-service withdrawals	$Shock_t/Y_{t-1}$	-0.0187**	-0.0052**	-0.0180**	-0.0052**
		(0.0021)	(0.0014)	(0.0021)	(0.0014)
	$Shock_{t-1}/Y_{t-1}$	-0.0230**	-0.0071**	-0.0197**	-0.0062**
		(0.0037)	(0.0022)	(0.0036)	(0.0021)
Assume in-service withdrawals are annuitized	$Shock_t/Y_{t-1}$	-0.0145**	-0.0042**	-0.0140**	-0.0040**
		(0.0017)	(0.0010)	(0.0018)	(0.0011)
	$Shock_{t-1}/Y_{t-1}$	-0.0164**	-0.0057**	-0.0141**	-0.0049**
		(0.0031)	(0.0017)	(0.0030)	(0.0016)
Include state × year effects	$Shock_t/Y_{t-1}$	-0.0153**	-0.0036**	-0.0146**	-0.0036**
		(0.0018)	(0.0013)	(0.0019)	(0.0014)
	$Shock_{t-1}/Y_{t-1}$	-0.0166**	-0.0046*	-0.0141**	-0.0041*
		(0.0033)	(0.0021)	(0.0031)	(0.0019)
Sample restricted to those in the lowest third of the home ownership distribution	$Shock_t/Y_{t-1}$	-0.0196**	-0.0076**	-0.0188**	-0.0067*
		(0.0033)	(0.0025)	(0.0034)	(0.0026)
	$Shock_{t-1}/Y_{t-1}$	-0.0210**	-0.0124**	-0.0179**	-0.0087*
		(0.0058)	(0.0041)	(0.0056)	(0.0038)

* Significant at the 5% level
** Significant at the 1% level