Why Does Unemployment Risk Reduce the MPC over the Business Cycle?*

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Abstract

Previous research has studied how unemployment risk affects consumption dynamics, but little is known about its effect on the marginal propensity to consume (MPC), which is crucial for the analysis of fiscal stimulus during recessions. Using survey data, I document that unemployment risk significantly reduces the MPC, to an extent that standard buffer-stock models cannot replicate. To reconcile with the data, I introduce mental accounting to the model, where households treat income and savings as non-fungible and exhibit dissaving aversion. Mental accounting generally increases the MPC, but endogenously becomes less salient when unemployment risks heighten, effectively reducing the MPC. A quantitative HANK model with mental accounting reveals that stimulus checks are 30% less effective in stimulating aggregate consumption during recessions than predicted by the standard model. This state dependence of the MPC reconciles the modest aggregate effects of the 2008 tax rebate with the high MPCs documented in the empirical literature.

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1 Introduction

Recessions are marked by persistently elevated unemployment risk and significant declines in consumption. In recent years, fiscal stimulus, such as stimulus checks and extended unemployment insurance, has become increasingly prevalent and important as complements to monetary policy during recessions, especially in light of the zero lower bound.[1] The effectiveness of these countercyclical measures in stimulating the economy depends crucially on the marginal propensity to consume (MPC) *during recessions*, when unemployment risk is elevated. While prior research has examined the influence of unemployment risk on consumption dynamics (e.g., McKay 2017, Harmenberg and Öberg 2021, Carroll and Dunn 1997), its impact on the MPC—and therefore on the efficacy of stimulus policies—remains largely unexplored.

This paper fills this gap by examining how unemployment risk affects the marginal propensity to consume (MPC) during recessions. First, I use unique survey data to document that individuals who expect a temporarily higher risk of unemployment have significantly lower MPC. Second, through the lens of an analytical model and by conducting a battery of quantitative exercises, I show that buffer-stock models struggle to explain this fact because of the fundamental conflict between the borrowing constraint mechanism and the precautionary saving motive – the former decreases the MPC but the latter increases it when unemployment risk heightens. Third, I reconcile the model with the data by introducing a behavioral mechanism, mental accounting, where households treat income and savings as non-fungible and exhibit dissaving aversion. Lastly, I embed the mental accounting model into a HANK framework with endogenous unemployment risk to infer the MPC over the business cycle. I find that the MPC is substantially lower during recessions, and as a result, stimulus checks are not as effective as predicted by the standard model in stimulating aggregate consumption. This result reconciles the modest aggregate effects of the 2008 tax rebate in the U.S. (Orchard et al. 2024) with the high MPCs widely documented in the literature.

My empirical analyses leverage direct survey evidence on unemployment risk and MPC.[2] I combine individual-level data from the New York Fed's Survey of Consumer Expectations, which includes subjective unemployment risk, with a special survey module conducted by Fuster et al. (2021) that elicits individual consumption responses to hypothetical income changes. This dataset is uniquely suited to my purpose of examining the effect of increased unemployment risk on MPC for two reasons. First, I can directly observe both the expected unemployment risk and the MPC of the same person. Previous studies that use quasi-experimental designs such as lottery (Fagereng et al. 2021) and tax rebates (Parker et al. 2013, Johnson et al. 2006) to estimate the MPC can only explore the unemployment risk effect by imputing the risk. Second, the panel structure of the

[1] Fiscal stimulus packages in the U.S. have been substantial. For instance, the Economic Stimulus Act of 2008 (the 2008 tax rebate) and the American Recovery and Reinvestment Act during the Great Recession totaled $1 trillion, or 6.5% of U.S. GDP in 2009. More recently, the CARES Act and the American Rescue Plan, enacted during the pandemic recession, amounted to $4.1 trillion, or 19% of 2019 GDP.

[2] The use of survey questions to elicit MPCs has become increasing popular in this literature due to the difficulty in measuring MPCs in observational settings. See for example, Jappelli and Pistaferri (2014), Christelis et al. (2019), Fuster et al. (2021), Kosar and Melcangi (2025), Colarieti et al. (2024), Andre et al. (2024).

dataset allows me to exploit within-individual variations to examine the effect of transitory changes in unemployment risk on the MPC. This empirical design ensures that the results are not driven by cross-sectional permanent variation in unemployment risks, which is irrelevant to understanding the MPC over the business cycle.

Exploiting within-individual variations, I find that higher perceived probability of losing the job in the next 12 months significantly lowers the 3-month MPC. By design, this effect is not driven by unobserved permanent heterogeneity such as preferences and education. The effect remains significant after controlling for changes in expected income and shifts in aggregate expectations such as inflation and stock price expectation. Further analysis by expenditure category reveals that this negative effect is present in nondurable expenditures but not in durable expenditures, ruling out durable adjustment cost as an explanation.[3] Moreover, even households affluent in liquid wealth experience this negative effect, which is inconsistent with the buffer-stock theory.

Having established the negative effect of unemployment risk on the MPC, I then demonstrate that standard buffer-stock models cannot replicate this relationship. In these models, two opposing forces affect the MPC when unemployment risk rises, even though they both increase the steady-state MPC relative to the permanent-income benchmark. On one hand, higher unemployment risk strengthens the precautionary saving motive, making the consumption policy more concave and increasing the MPC via the classic Carroll and Kimball (1996) effect. On the other hand, this stronger saving motive renders the borrowing constraint less binding, reducing the MPC. The buffer-stock theory thus has two implications. First, the effect of unemployment risk varies *qualitatively* across the wealth distribution.[4] For households close to the borrowing limit, the borrowing constraint mechanism dominates and their MPCs fall; for affluent households, the precautionary saving motive dominates and their MPCs rise. Second, the average effect is determined by the relative strength of the two forces in the population.

To assess the average effect, I calibrate a quantitative buffer-stock model to match the liquid wealth distribution and the average MPC observed in the data. The model, however, fails to reproduce the strong negative effect of unemployment risk found empirically: a 10 percentage-point increase in the annual probability of unemployment reduces the average MPC of employed individuals by only 0.2 percentage points, just one-tenth of the empirical estimate. An alternative calibration that aligns with the observed unemployment risk effect results in an implausibly high steady-state MPC. This limitation arises because the model depends on the borrowing constraint mechanism to generate the negative effect of unemployment risk, requiring a large proportion of households near the borrowing limit with high MPCs. Introducing a two-asset structure (Kaplan and Violante 2014) does not resolve this issue; the MPC remains predominantly influenced by the two opposing mechanisms, while the additional portfolio-rebalancing channel has a weak impact under realistic

[3] In durable consumption models with fixed adjustment cost, higher unemployment risk can widen the sS band, thereby reducing the durable MPC.

[4] Carroll et al. (2021) examine how additional income risks influence precautionary saving motives within a theoretical model, concluding that higher risk may reduce the precautionary motive at certain wealth levels. My contribution clarifies the specific effects of unemployment risk and quantifies their importance in a calibrated model.

calibrations.

The theoretical and numerical results call for another mechanism to account for the empirical findings. I reconcile the model with the data by incorporating mental accounting (Graham and McDowall 2024, Shefrin and Thaler 1988), which generates a strong negative effect on the MPC through a novel behavioral switching mechanism. The consideration of mental accounting is motivated by extensive behavioral literature on consumer choice (e.g., Thaler 1985, Milkman and Beshears 2009, Hastings and Shapiro 2013) and recent macroeconomic studies that find evidence of mental accounting in responses to transitory income (e.g., Baugh et al. 2021, Bernard 2023, Boehm et al. 2024).

In my model, households maintain two mental accounts: income and savings. The marginal utility of consuming *savings* is strictly below that of consuming *income*, which violates the fungibility of money and creates a kinked region in the consumption policy. Households in this region exhibit mental accounting behavior instead of smoothing consumption: they have an MPC of 1 out of income but 0 out of savings due to the differing marginal utilities. This behavior is sensitive to unemployment risk: as the risk increases, the welfare loss from not smoothing consumption grows, prompting some households to switch back to consumption-smoothing behavior.[5] Consequently, their MPCs decrease substantially.

I calibrate the mental accounting model to match the liquid wealth distribution and the average MPC as before, finding that this channel is quantitatively strong and supports an empirically plausible relationship between unemployment risk and the MPC. Additionally, the model aligns with three other stylized facts about the MPC documented in the literature: 1) Consumption response to transitory income is front-loaded (Boehm et al. 2024, Graham and McDowall 2024, Borusyak et al. 2024); 2) Consumption response to income news is muted (Kueng 2018, Fuster et al. 2021, Graham and McDowall 2024); and 3) MPCs remain high for liquidity-affluent households (Boehm et al. 2024, Graham and McDowall 2024, Lewis et al. 2024).

To examine how unemployment risk influences the MPC during recessions and its policy implications, I incorporate the mental accounting model into a Heterogeneous Agent New Keynesian (HANK) framework with endogenous unemployment risk, the zero lower bound (ZLB), and aggregate uncertainty. I introduce an aggregate discount factor shock to simulate a demand-driven recession typical of New Keynesian models. The size and the expected duration of the shock are calibrated to match the peak unemployment rate and the length of the Great Recession. In response to the shock, the MPC immediately falls from 0.20 in steady state to 0.14 and remains low throughout the recession. In contrast, in the standard model without mental accounting, the MPC remains steady initially and only gradually declines as the recession continues and households accumulate enough savings to self insure.

[5] The notion that households act more rationally when the stakes are high has a long tradition in macroeconomics (Akerlof and Yellen 1985a, Akerlof and Yellen 1985b, Caballero 1995). More recently, Andre et al. (2024) show that households use "quick-fix" rules when facing small income shocks but switch to optimal consumption-smoothing policies for large shocks. See also Ilut and Valchev (2023) for a formal model of imperfect reasoning with similar predictions.

To illustrate the significance of my findings, I evaluate the effectiveness of stimulus checks in stimulating consumption. First, I ask: How large must the stimulus check be to close the initial consumption gap of 6% caused by the recession? I find that while it takes \$2,800 in the standard model, it requires \$5,200 in the mental accounting model—almost double the amount. This difference arises because general equilibrium (GE) effects amplify the initial disparities in the MPC.

Next, I calculate the GE multiplier for various sizes of stimulus checks issued at the onset of the recession. The GE multipliers are consistently 30% smaller in the mental accounting model than in the standard model. Specifically, for a stimulus check of \$1,000—similar to the average amount of the 2008 tax rebate—the GE multiplier is 0.17 in the mental accounting model versus 0.25 in the standard model. As Orchard et al. (2024) argued recently, the upper bound for the GE multiplier of the 2008 tax rebate is 0.20, a level too low for standard models with reasonably high MPCs to replicate. By accounting for state-dependent MPCs rooted in micro evidence, my model reconciles the high MPC estimates in the literature with the modest aggregate effects of the 2008 tax rebate.

Related literature This paper is related to four strands of the literature. First, an extensive empirical literature has documented large dispersions in MPCs across households and has explored the heterogeneity underlying such dispersions (e.g., Misra and Surico 2014, Lewis et al. 2024, Boehm et al. 2024). Two prominent examples of heterogeneity are liquidity (e.g., Jappelli and Pistaferri 2014, Kaplan and Violante 2014, Fagereng et al. 2021) and preferences (e.g., Parker 2017, Gelman 2021, Aguiar et al. 2024), though a common finding is that they together only explain a small fraction of the MPC dispersion. My empirical analysis adds to this literature by considering the role of unemployment risk and exploring the time-variation of the MPC.

Empirically, the closest papers are Kosar and Melcangi (2025) and Savoia (2024). Using data from the Survey of Consumer Expectation, Kosar and Melcangi (2025) document that the MPC is hump-shaped in individual-specific earnings growth uncertainty. Savoia (2024) uses the biannual household panel from the Bank of Italy Survey of Household Income and Wealth (SHIW) to show that high-income, low-income-risk households have higher MPC than low-income, high-income risk households. My empirical innovations are the use of within-individual variation and the focus on unemployment risk rather than mean-preserving spread, both important for understanding the time-variation of the MPC over the business cycle.

Theoretically, this paper adds to the earlier work of Kimball (1990a,b), Carroll and Kimball (1996), and Carroll et al. (2021) that examine how income risks change the curvature of consumption policy. In particular, Carroll et al. (2021) has shown that additional income risk may reduce the precautionary saving motive at some levels of wealth by hiding the effects of the pre-existing borrowing constraint. I clarify such effects for unemployment risk, quantify their importance in calibrated models, and contrast the magnitudes of the effects against new empirical evidence.

Regarding the MPC over the business cycle, Gross et al. (2020) documents that the MPC out of credit is higher during recessions for individuals who have filed bankruptcy before. Instead, my structural analysis focuses on the MPC out of income and the whole population of workers. I structurally characterize the MPC over the business cycle in a general equilibrium environment with nominal rigidity and endogenous unemployment risk. My results suggest that the MPC out of income is lower during recessions because of the heightened unemployment risk, complementing the empirical results of Gross et al. (2020).

Second, this paper is related to the literature that studies behavioral frictions in consumption-saving decision, such as present bias (e.g., Angeletos et al. 2001, Maxted et al. 2024), lack of self-control (e.g., Gul and Pesendorfer 2001, Attanasio et al. 2024), bounded rationality (Ilut and Valchev 2023), and mental accounting (e.g., Shefrin and Thaler 1988, Graham and McDowall 2024, Mijakovic 2024). In particular, Graham and McDowall (2024) and Mijakovic (2024) study mental accounting in the context of consumption responses to transitory income changes and find that it is broadly consistent with the sizes and temporal profiles of consumption responses. I add to this literature by documenting a new fact on the relationship between unemployment risk and the MPC and showing that a mental accounting model is consistent with it while the standard model is not.

Third, this paper is related to the literature on the aggregate implications of countercyclical income risk. Previous studies mostly focus on the first-order effects. For example, McKay (2017), Harmenberg and Öberg (2021), and Carroll and Dunn (1997) quantify the effects of heightened income risk on consumption during recessions. Bayer et al. (2019) and Graves (2023) emphasize the "flight-to-liquidity" channel of countercyclical income risk that depresses investment during downturns. Another line of researches focus on the destabilizing effects from the feedback loop between countercyclical income risk and precautionary motive (e.g., Challe and Ragot 2016, Ravn and Sterk 2017, Bilbiie 2024). I show that in addition to the first-order effects, countercyclical unemployment risk reduces the marginal propensities to consume, making fiscal stimulus less effective during recessions.

Finally, this paper is related to the burgeoning literature that studies stimulus check policy in a general equilibrium environment. Motivated by the empirical finding that durable expenditures account for most of the responses to the 2008 tax rebate, this literature focus on the role of durables in the transmission of stimulus checks. Beraja and Zorzi (2024) emphasize the size-dependence of the effectiveness of stimulus checks due to durable adjustment costs. Orchard et al. (2024) emphasize the dampening effect in general equilibrium due to inelastic supply of durable goods. Through the lens of a HANK model consistent with the empirical relationship between unemployment risk and the MPC, I show that the effectiveness of stimulus checks is state-dependent because the nondurable MPC is procyclical. My results also help explain the absence of a large nondurable expenditure response to the 2008 tax rebate.

The rest of the paper is structured as follows. Section 2 present empirical evidences on the negative effect of unemployment risk on the MPC. Section 3 explores this effect in a standard buffer stock model and concludes that the model is unable to reproduce the effect quantitatively. Section 4 shows that a mental accounting model can replicate the strong negative effect of unemployment risk, while simultaneously matching other stylized facts on the MPC. Section 5 studies the MPC over the business cycle and its implications for the effectiveness of stimulus check policy through the lens of a HANK model with mental accounting. Section 6 concludes.

2 Empirical Evidence

The major challenge in examining the relationship between unemployment risk and MPC is measurement. In this section, I use a unique survey that contains information on subjective unemployment probability and self-reported MPCs to explore this relationship. I find that within-individual change in the unemployment risk is strongly negatively correlated with the MPC.

2.1 Data

I use data from the New York Fed Survey of Consumer Expectation (SCE) and the special survey module designed by Fuster, Kaplan and Zafar (2021) (thereafter FKZ). The SCE is a monthly survey of a nationally representative rotating panel of approximately 1,300 household heads. Each participant is included in the survey for at most twelve months. The survey elicits individual expectations about the aggregate economy such as inflation and unemployment rate, as well as their future economic outcomes such as job loss and income growth. My measure of unemployment risk is the self-reported probability of losing the job in the next twelve months. The following is the corresponding survey question:

> What do you think is the percent chance that you will lose your current job during the next 12 months?

Note that only employed participants are prompted to answer this question. When prompted, they report a number between 0 and 100, representing their subjective probability of losing the job in the next twelve months.[6] Importantly, this question belongs to the monthly core survey module, allowing observation of within-individual variation in reported unemployment risk.

To measure individual's MPC, I use data from the FKZ survey module which was added to the core SCE survey during March and May 2016 and January and March 2017. The FKZ survey module asks the respondents to report how they would change their spending behavior in response to a *hypothetical* change in income. To fix idea, the following is the exact wording of the survey question:

[6] Wang (2023) compares the aggregate time-series of the subjective employment-to-unemployment rate with the time-series of the realized rate in the CPS and finds that they align with each other.

Now consider a hypothetical situation where you unexpectedly receive a one-time payment of **\$500** today.

We would like to know whether this extra income would cause you to change your spending behavior in any way over the next 3 months.

The question is precise on the size and the transitory nature of the income change as well as the horizon over which the spending behavior is concerned. By the FKZ survey design, respondents are randomly assigned a hypothetical income change scenario that is not limited to a receipt of \$500. Examples include a loss of \$500 and a gain of \$500 in 3 months.[7] For my purpose, I focus on immediate gain treatments only which have three different sizes – \$500, \$2,500, and \$5,000. The MPC is defined as the ratio of the reported change in spending over the next 3 months divided by the size of the hypothetical income change. See Table A.1 for the summary statistics.

2.2 Methodology

My empirical strategy is to exploit within-individual variation in unemployment risk and MPCs. To implement the strategy and obtain a clean comparison, I focus exclusively on the first two waves of the FKZ survey which were conducted in March 2016 and May 2016.[8] The variation I am exploiting is therefore the two-month changes in MPC and the two-month changes in unemployment risk. Specifically, I consider the following cross-sectional regression:

$$\Delta MPC_{it} = \beta_0 \Delta\, \mathbb{E}_{it}[s_{it,t+12}] + \beta_1 \Delta\, \mathbb{E}_{it}[y_{it+12}] + \beta_2 \mathbf{1}\{y_{it} > y_{it-2}\} + X_i'\gamma + \varepsilon_{it} \tag{1}$$

where $\mathbb{E}_{it}[s_{it,t+12}]$ is the subjective probability of job-loss in the next twelve months, $\mathbb{E}_{it}[y_{it+12}]$ is the expected income growth in twelve months, $\mathbf{1}\{y_{it} > y_{it-2}\}$ is a dummy variable for experiencing a positive income change from March 2016 to May 2016, and X_i is a set of demographic controls including age, age-squared, gender, race, marital status, education, SCE income group and FKZ treatment-group fixed effect, and ε_{it} is residual.

The inclusion of expected income growth helps isolate the effect of *risk* as unemployment risk is not a mean-preserving spread of income uncertainty. Controlling for income changes is important because they are likely to be correlated with changes in unemployment risk, especially when the income change is permanent. For example, a worker who is being promoted will experience an increase in income and a decrease in unemployment risk. Her spending behavior and hence MPC then could change because of the higher permanent income. I will return to this point when discussing the estimation results.

Demographic controls help alleviate concerns about selection as some demographic groups (e.g. young, low-income, and less-educated workers) are more exposed to unemployment risk. Lastly,

[7] See Appendix A.2 for the full treatment design.

[8] Due to the rotating panel structure of the SCE, most respondents answer the FKZ survey module only twice.

the FKZ treatment-group fixed effect absorbs the systematic differences in the MPC stemming from different sizes of the hypothetical income changes. The identification assumption is that conditional on observables, the change in unemployment risk is uncorrelated with the change in financial position or unobserved heterogeneity such as preferences. This assumption is plausible given that I am focusing on changes in a relatively short horizon.

Sample To identify the effect of unemployment risk, I follow Graves (2023) to include in the sample only households whose head is employed in both periods, is between 25 and 55 years old, has been in their job position for at least one year when entering the survey, and is not self-employed. I winsorize all the continuous variables at the 99% level in light of outliers.

2.3 Results

Table 1 reports the estimation results. Without controlling for income expectation or income changes (column 1), a 1 pp. increase in the probability of losing the job in the next 12 months decreases the quarterly MPC by 0.29 pp. To gauge the economic magnitude of the effect, the average probability of job-loss in 12 months during 2008 is about 8 pp. higher than during 2007, so the quarterly MPC was 2.4 pp. lower due to the higher unemployment risk. The size of the effect may seem small, but in Section 3, I will show that this is already large enough for the standard buffer stock model to reproduce. Moreover, in general equilibrium, seemingly small differences in the MPC can lead to large differences in the GE multipliers, which I will discuss in Section 5.

As shown in column 2 & 3, controlling for income expectation and income changes only slightly decrease the magnitude of the coefficient. Interestingly, an increase in income leads to a higher MPC. This can be rationalized in the buffer stock model if the income change is *permanent*, as argued in Commault (2024). Intuitively, a higher permanent income means a lower financial wealth relative to human wealth, essentially exposing the household to more income risk and raising the MPC by the precautionary saving mechanism.

Spending category One explanation of the large negative effect is that higher unemployment risk deters durable purchases, reducing the total MPC through the extensive margin channel (Bertola et al. 2005, Berger and Vavra 2015). It is possible to test this hypothesis. In the FKZ survey module, respondents are asked about the composition of the spending change induced by the hypothetical income change. Specifically, the respondents report a dollar amount for each of the following eight spending categories: leisure activities, donation, general living expenses, small durable purchases (costing \$1,000 of less), large durable purchases (costing more than \$1,000), home renovation, education expenses, and other expenses. I define nondurable spending as the sum of leisure activities, general living expenses, and education expenses and durable spending as the sum of small durable purchases, large durable purchases, and home renovation. Then I rerun regression (1) for nondurable

Table 1: MPC and Unemployment Risk (SCE)

	(1)	(2)	(3)
$\Delta\,\mathbb{E}_{it}[s_{it,t+12}]$	-0.292**	-0.297***	-0.276**
	(0.119)	(0.114)	(0.121)
$\Delta\,\mathbb{E}_{it}[y_{it+12}]$		0.235	0.155
		(0.164)	(0.186)
$\mathbf{1}\{y_{it} > y_{it-2}\}$			8.053*
			(4.800)
Observations	643	643	643
R-squared	0.052	0.057	0.063

NOTE. Sample only includes households whose head is employed in both periods, is between 25 and 55 years old, and has been in their job position for at least one year when entering the survey. Controls include age, age-squared, gender, race, marital status, education, SCE income group, and treatment group FE. Robust standard errors are reported. Regressions are weighted using sampling weights.

and durable MPC respectively.[9]

Table 2 reports the results. Perhaps surprisingly, all of the unemployment effect on the MPC is driven by nondurable expenditure, and indeed the durable MPC is completely insensitive to the variation in unemployment risk. This might seem contradictory to the prediction of durable consumption models with lumpy adjustment such as Berger and Vavra (2015), but it is actually consistent with this class of models as long as the adjustment hazard is reasonably smooth as in Beraja and Zorzi (2024). Intuitively, when durable purchases are mostly triggered by idiosyncratic taste shocks, changes in unemployment risk have little impact on the timing of durable purchases. Finally, it is worth noting that durable MPC is particularly sensitive to changes in income or income expectation, consistent with the previous hypothesis that these changes are permanent in the view of households.

Heterogeneous effects by liquid wealth The empirical literature has emphasized and debated the role of liquid wealth in determining the MPC, as suggested by the buffer stock theory of consumption. It is therefore interesting to ask whether and how the unemployment risk effect depends on liquid wealth.[10] To answer this question, I use the SCE Household Finance Survey, which contains information on household balance sheet, to construct the net-liquid-wealth-to-income ratio for each household. I define net liquid wealth as the sum of checking and savings accounts, CDs, stocks, bonds, and mutual funds minus the sum of credit card debt, other personal loans,

[9] More precisely, the MPCs here refer to the marginal propensities to spend (MPX). These two concepts differ for durable consumption (Laibson et al. 2022). For ease of terminology, I use the abbreviation "MPC" for MPX in this paper.

[10] I review the empirical evidence on the relationship between liquid wealth and MPC in section 4.3.

Table 2: (Non)durable MPC and Unemployment Risk (SCE)

	(1)	(2)	(3)
	Total	Nondurable	Durable
$\Delta\, \mathbb{E}_{it}[s_{it,t+12}]$	-0.276**	-0.303***	-0.004
	(0.121)	(0.116)	(0.046)
$\Delta\, \mathbb{E}_{it}[y_{it+12}]$	0.155	0.016	0.119
	(0.186)	(0.109)	(0.106)
$\mathbf{1}\{y_{it} > y_{it-2}\}$	8.053*	1.304	6.192**
	(4.800)	(3.306)	(2.766)
Observations	643	633	633
R-squared	0.063	0.080	0.051

NOTE. Column (1) is a replication of column (3) in Table 1. The decrease in sample size in column (2) and (3) is due to missing data. Sample only includes households whose head is employed in both periods, is between 25 and 55 years old, and has been in their job position for at least one year when entering the survey. Controls include age, age-squared, gender, race, marital status, education, SCE income group, and treatment group FE. Robust standard errors are reported. Regressions are weighted using sampling weights.

medical bills, and legal bills. Unfortunately, the survey is field only once a year, so I do not observe within-individual variation in savings. Instead, I bin households into three groups based on the most recent ratio and estimate an extension of equation (1) that allows for group-specific unemployment risk effects. Motivated by a recent study by Koşar et al. (2024) which finds that indebted households intend to pay debt with their transitory income, I define the first group as households whose net liquid wealth is negative or zero. Then I divide the remaining households into two equal-sized groups. The resulting cutoff is 2.5 months of income.

Table 3 reports the estimation results. The estimated effect is negative for all three groups, has similar magnitude as in the baseline, and is most statistically significant for the second group which has net liquid wealth between 0 and 2.5 months of income. This result suggests that the negative effect is not entirely driven by a particular subgroup, say indebted households, but is instead a widespread phenomenon across the wealth distribution. As will be elaborated in Section 3, this pattern is inconsistent with the buffer stock theory which predicts that only the MPC of households close to the borrowing limit are negatively affected.

2.4 Robustness

In the following, I discuss several robustness checks of my main result. All the additional empirical results can be found in Appendix A.

Table 3: Heterogeneous Effects by Liquid Wealth (SCE)

	(1)	(2)	(3)
$\Delta\,\mathbb{E}_{it}[s_{it,t+12}] \times$ first group	-0.404*	-0.429*	-0.322
	(0.209)	(0.218)	(0.219)
$\Delta\,\mathbb{E}_{it}[s_{it,t+12}] \times$ second group	-0.365***	-0.362***	-0.321**
	(0.127)	(0.127)	(0.131)
$\Delta\,\mathbb{E}_{it}[s_{it,t+12}] \times$ third group	-0.261	-0.294	-0.274
	(0.252)	(0.258)	(0.252)
Observations	344	344	344
Control for exp. income growth	$\times$	✓	✓
Control for income change	$\times$	$\times$	✓
Tercile FE	✓	✓	✓
R-squared	0.154	0.156	0.174

NOTE. First group: $a/y \leq 0$; Second group: $a/y \in (0, .20)$; Third group: $a/y \geq .20$. Sample only includes households whose head is employed in both periods, is between 25 and 55 years old, and has been in their job position for at least one year when entering the survey. Controls include age, age-squared, gender, race, marital status, education, SCE income group, and treatment group FE. Robust standard errors are reported. Regressions are weighted using sampling weights.

Aggregate expectation Household expectation of the aggregate economy could be influenced by their idiosyncratic experiences. For example, Kuchler and Zafar (2019) find that in the SCE, unemployed households have a more pessimistic expectation of aggregate unemployment. Thus, changes in subjective unemployment risk can be correlated with changes in aggregate expectations, which means that my baseline results could be contaminated by the aggregate expectation channel.[11] In Table A.2, I report estimation results after controlling for changes in expectation of the unemployment rate, stock prices, interest rate, and inflation rate. The magnitude of the unemployment risk effect attenuates but still remains statistically significant at the 5% level. Moreover, almost all coefficients on the aggregate expectation terms are statistically insignificant, except the unemployment rate which is statistically significant at 10% level but much smaller in magnitude than the effect of individual unemployment risk.

Reliability of self-reported MPCs A valid concern regarding survey evidence is the potential discrepancy between survey responses and actual behaviors.[12] To address this concern, in Appendix A.3, I revisit the 2008 tax rebate episode to examine households' actual expenditure responses to transitory income. I utilize data from the Consumption Expenditure Survey, which provides detailed

[11] In general, the aggregate expectation channel can be a mechanism through which the unemployment risk affects the MPC. Nonetheless, in Section 3, I will use the direct effect of unemployment risk on the MPC as an identified moment to inform the modeling of consumption behavior. It is therefore important to distinguish this channel.

[12] Parker and Souleles (2019) evaluate the consistency between reported spending and actual spending for the 2008 economic stimulus payments. They find that survey-reported spending is highly informative about the revealed-preference propensity to spend, and that the estimated average propensities to spend are similar across both methods. See also Fuster and Zafar (2023) for a general discussion of the survey approach.

information on household expenditures and rebate payments, and construct a household-level measure of unemployment risk based on a logit model estimated from the Current Population Survey. Following Parker et al. (2013) and Orchard et al. (2024), I exploit the random timing of rebate receipt to identify the treatment effects of the rebate payments. By extending their difference-in-differences specifications to allow for heterogeneous treatment effects, I corroborate the survey findings that households facing higher unemployment risk respond significantly less to the tax rebate, with all differences stemming from nondurable expenditures.

3 Standard Consumption Model

The empirical evidence points to a strong negative effect of unemployment risk on the MPC. Can the standard buffer stock model (Carroll 1997, Deaton 1991) explain this relationship? In this section, I first present a stylized two-period model to illustrate analytically how the two key mechanisms in the buffer stock model, namely the precautionary saving motive and the borrowing constraint, effect the MPC when the unemployment risk increases. The two mechanisms have opposite effects: precautionary saving motive raises the MPC but the borrowing constraint lowers it. The net effect is therefore ambiguous. Then I calibrate a quantitative model to the data and show that the model is unable to replicate the strong negative effect estimated in the previous sections.

3.1 Stylized model

There are two periods $t = 0, 1$. The household has a time-separable preference over consumption in the two periods, given by a smooth utility function $u : \mathbb{R}_{++} \to \mathbb{R}$ that satisfies $u' > 0$, $u'' < 0$, and $u''' > 0$ and a discount factor $\beta \in [0, 1]$. At time 0, the household is employed, receives labor income $y > 0$, and has savings $a_0 \in \mathbb{R}$. The household faces an uninsurable unemployment risk for time 1: with probability $\delta \in [0, 1]$, the household becomes unemployed and receives unemployment benefit $b < y$; with probability $1 - \delta$, the household remains employed and receives the same labor income y. The household has access to a risk-free asset with gross return $R \geq 0$ subject to a borrowing limit $\underline{a} \leq 0$.

For simplicity, assume $\beta = R = 1$. Denote the initial wealth at time 0 by $m := a_0 + y$. The household problem can be written as:

$$\max_{c_0, c_1^e, c_1^u, a_1} \quad u(c_0) + (1 - \delta)u(c_1^e) + \delta u(c_1^u)$$

$$\begin{aligned} s.t. \quad c_0 + a_1 &\leq m \\ c_1^e &\leq a_1 + y \\ c_1^u &\leq a_1 + b \\ a_1 &\geq \underline{a} \end{aligned}$$

We are interested in how the MPC at time 0 will respond to a change in the unemployment risk δ. Formally, the MPC is defined as the derivative of the time-0 consumption policy function with respect to the intial wealth, i.e., $\frac{\partial c_0}{\partial m}$. First, to understand the effect of precautionary saving motive, let's assume that there is no borrowing constraint (i.e. $\underline{a} = -\infty$). We have the following proposition.

Proposition 1. *The MPC is given by*

$$MPC \equiv \frac{\partial c_0}{\partial m} = \frac{\Delta}{1+\Delta} < 1$$

where

$$\Delta \equiv (1-\delta)\frac{u''(m-c_0+y)}{u''(c_0)} + \delta\frac{u''(m-c_0+b)}{u''(c_0)}$$

Furthermore, under CRRA preference and when $\delta \to 0^+$, we have $\frac{\partial \Delta}{\partial \delta} > 0$ and hence $\frac{\partial MPC}{\partial \delta} > 0$ for $m > y - 2b$.

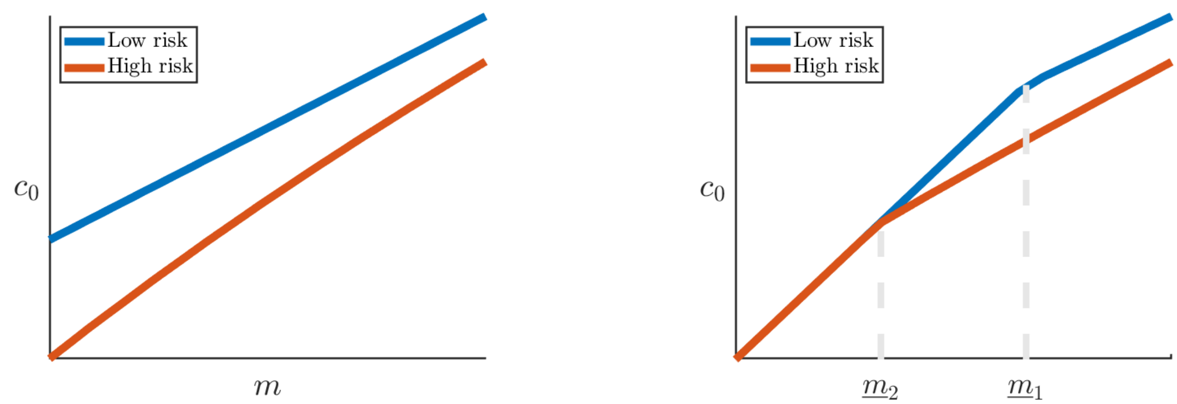
The proof can be found in Appendix **??**. Two observations worth making. First, if the household is not prudent (i.e. $u''' = 0$), we have $\Delta = 1$ so the MPC does not vary with the unemployment risk. Second, when the unemployment risk is small to begin with, the MPC is *increasing* in the unemployment risk, inconsistent with the empirical evidence.[13] This is a resemblance to the classic result of Carroll and Kimball (1996) that income uncertainty raises the slope of the consumption policy of a prudent consumer, except for the fact that the unemployment risk I consider is not a mean-preserving spread of future income. Intuitively, wealthy households are sufficiently self-insured compared to poor households, so their consumption decreases less in response to an increase in the unemployment risk. As a result, the slope of the consumption policy with respect to wealth becomes steeper and more concave. Figure 2a illustrates this intuition by comparing the consumption policy under different levels of risk.

Next, let's impose a borrowing limit $\underline{a} > -b$. Since the model has only two periods, it is well known that the consumption policy is given by $c_0(m) = \min\{c_0^*(m),\ m - \underline{a}\}$ where $c_0^*(\cdot)$ is the consumption policy without the borrowing constraint. In particular, there exists a cutoff value $\underline{m} \in \mathbb{R}$ below which $c_0(m) = m - \underline{a}$ and the MPC is equal to 1. The effect of increasing the unemployment risk is therefore intermediated through the change in the cutoff value, which is characterized by the following proposition.

Proposition 2. *Let $\delta_1 < \delta_2$ be two different levels of unemployment risk. There exist two corresponding cutoff values $\underline{m}_1 > \underline{m}_2$ such that for households with initial wealth $m \in (\underline{m}_2, \underline{m}_1)$, their MPCs decrease when the unemployment risk increases from δ_1 to δ_2.*

[13] Both the condition $m > y - 2b$ and the limiting condition $\delta \to 0$ are only for technical reasons. Numerically, I verify that $\frac{\partial \Delta}{\partial \delta} > 0$ for reasonable values of δ.

Figure 1: Two effects of unemployment risk on the MPC in buffer-stock models



(a) Precautionary saving motive

(b) Borrowing constraint

The intuition is simple. When the unemployment risk increases, the household wants to save rather than borrow, meaning that the borrowing constraint is effectively less binding. Thus, some households who were previously hand-to-mouth (i.e. MPC = 1) now choose to save some of their income and have an MPC strictly below one. Figure 2b illustrates this phenomenon. Note that this mechanism does not require positive prudence ($u''' > 0$) because higher unemployment risk decrease expected income. The concavity of the utility function is sufficient to guarantee that households want to save to smooth consumption.

In a model with more than two periods, the borrowing constraint mechanism will also apply to households who are not yet at the borrowing limit. The reason is that the concern of hitting the borrowing limit in the future increases the prudence of the value function, thereby making the consumption policy today more concave (Carroll et al. 2021). Higher saving today makes future borrowing constraint less likely to bind, dampening this mechanism and lowering the MPC as before.

The discussion here suggests that the effect of unemployment risk on the MPC is heterogeneous across the wealth distribution. For poor households who are close to the borrowing constraint, a further increase in the unemployment risk reduces their MPCs because the constraint is effectively less binding. Conversely, for wealthy households who are away from the borrowing constraint, a further increase in the unemployment risk increases their MPCs through the precautionary saving mechanism. The average effect of the unemployment risk therefore depends on the shape of the wealth distribution. Next, I test these predictions and quantify the average effect in a more standard quantitative model.

3.2 Quantitative model

The model is an infinite-horizon version of the stylized model with two additional features: idiosyncratic productivity and discount factor heterogeneity (Carroll et al. 2017). The first feature is standard, but the second one warrants some explanation. I assume that in the model there are two permanent types of households with different discount factors so that the model can simultaneously match two important moments for the analysis of stimulus checks policy: the average liquid wealth holding and the average MPC. This modeling strategy is common in the business cycle literature (e.g. Kekre 2023, Auclert et al. 2020, Krueger et al. 2016), and reassuringly, finds extensive support in the data (e.g. Aguiar et al. 2024, Calvet et al. 2021, Gelman 2021).

Model The economy is populated by a unit measure of households. Households are infinitely lived and have a common time-separable CRRA preference over consumption. There are two types of households who differ only in their discount factors $\beta \in \{\beta^L, \beta^H\}$. In each period, households are endowed with some income y_t which depends on their own productivity z_t and employment status $e_t \in \{0, 1\}$. If the household is employed ($e_t = 1$), she receives labor income $y_t = z$. If the household is unemployed ($e_t = 0$), she receives unemployment benefits $y_t = \lambda z$ where $\lambda \in (0, 1)$ is the UI replacement rate. The idiosyncratic productivity z_t and employment status e_t are independent Markov processes. Finally, households have access to a risk-free asset with interest rate $r \geq 0$ subject to a borrowing limit $\underline{a} \leq 0$.

Each household is characterized by a state vector $(a, z, e; \beta)$ where a denotes the savings. The Bellman equation of the household problem is given by:

$$\begin{aligned} V(a, z, e; \beta) = \max_{c,a'} \frac{c^{1-\sigma}}{1-\sigma} + \beta\, \mathbb{E}\left[V(a', z', e'; \beta) \mid z, e\right] \\ s.t. \quad c + a' = y(z, e) + (1 + r)a \\ y(z, e) = [e + (1 - e) \cdot b]z \\ a' \geq \underline{a} \end{aligned} \tag{2}$$

Parameterization One period is a quarter. I assume that the idiosyncratic productivity follows a standard log AR(1) process and calibrate the process as in Auclert et al. (2024). The job-loss rate (EU) and the job-finding rate (UE) are calibrated to match the corresponding average rate in the CPS from 1996 to 2019. The resulting unemployment rate is 5.5%. The UI replacement rate is set to 45% according to the average replacement rate reported by the BLS. The relative risk aversion coefficient is set to 2 and the annual real interest rate is 1%. I set the borrowing limit to one month of average labor earnings which corresponds to the median credit limit in the 2004 Survey of Consumer Finance (SCF). Lastly, I follow Carroll et al. (2017) to assume that the two household types have equal population share and calibrate the two discount factors to target an average MPC out of \$1,000 equal to 0.20 (Kaplan and Violante 2022) and a ratio of average liquid wealth holdings to average labor earnings equal to 1.04 as in the 2004 SCF. Table 4 summarizes the calibration of the model.

Table 4: Calibration of standard model

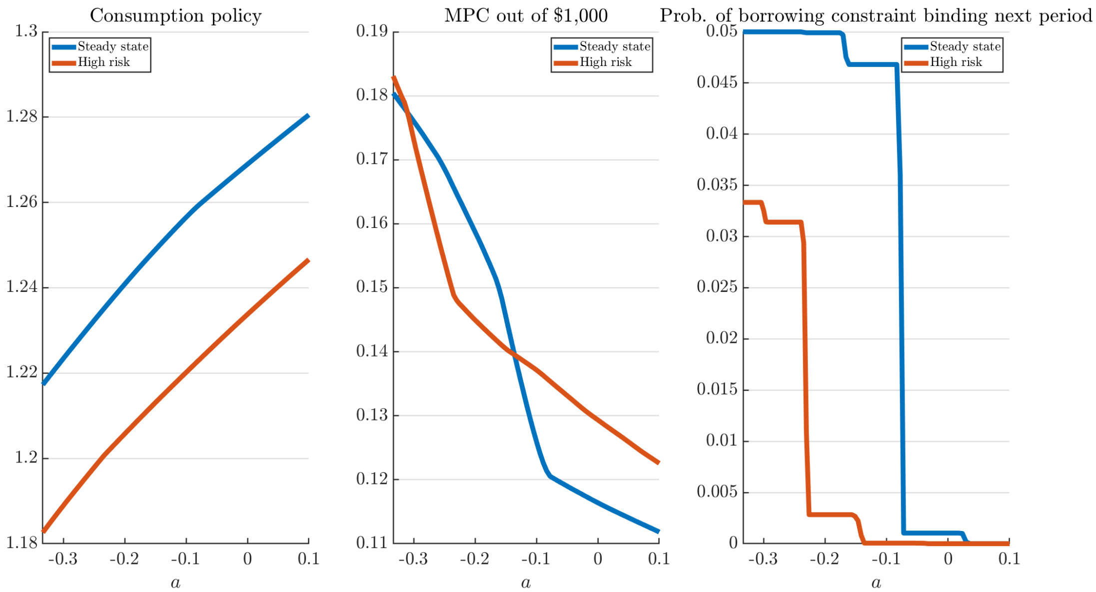
Parameter	Interpretation	Value	Source/Target
Assigned parameters			
σ	Relative risk aversion	2	Standard
r	Real rate (annualized)	1%	Standard
$\underline{a}$	Borrowing limit	-0.33	Median credit limit (SCF 2004)
b	UI replacement rate	0.45	BLS
δ	EU rate	0.037	CPS (1996-2019)
f	UE rate	0.632	CPS (1996-2019)
ρ_z	Income process (persistence)	0.978	Floden and Lindé (2001)
σ_z	Income process (std)	0.122	Auclert, Rognlie and Straub (2024)
p^L	Share of impatient type	0.5	Carroll et al. (2017)
Internally calibrated			
β^L	Discount factor (low)	0.9220	Avg. MPC = 0.20 (Kaplan and Violante 2022)
β^H	Discount factor (high)	0.9806	Avg. liquid wealth = 1.04 (SCF 2004)

Experiment Our goal is to examine how the MPC change when unemployment risk heighten through the lens of the model. To this end, I engineer an AR(1) high-risk shock that persistently decreases the EU rate and increases the UE rate. The correlation between the EU rate and the UE rate as well as the persistence of the shock are disciplined by the CPS data. The size of the shock is chosen to deliver an increase in the annual EU rate of 10 pp. for the ease of comparison to the empirical results. This leads to an increase in the EU rate by 3 pp., a decrease in the UE rate by 10 pp., and a persistence of .93. For the notion of MPC, I consider the MPC out of a one-time transfer of $1,000, corresponding to the average size of the transfer in the 2008 tax rebate.

The economy starts in its steady state and then is unexpectedly hit by the shock. The interest rate is fixed at the steady-state value so that the only effect of the shock on household consumption policy is from increasing the unemployment risk. Before discussing the average effect, let's have a look at the consumption policy. The left subplot of Figure 3 shows the consumption policy of an employed household with median labor income on the lower end of the wealth distribution. Because of the higher risk and the lower expected income, the consumption policy is everywhere below its steady-state level. However, with respect to the MPC that is plotted in the middle subplot of Figure 3, the effect depends on the savings of the household. In general, the MPCs of wealthy households decrease, whereas the MPCs of poor households increase. The only exception are households who are very close to the borrowing limit, of whom the MPCs marginally decrease.

As discussed before, the heterogeneous effect on the MPCs is a consequence of the interplay of the precautionary saving motive and the borrowing constraint. To help understand the role of the borrowing-constraint channel, the right subplot of Figure 3 shows the probability of the borrowing constraint binding in the next period. For wealthy households who are far away from the borrowing limit, the borrowing constraint is unlikely to bind in the near future with or without the high-risk shock, so they are only affected by the precautionary saving channel which unambiguously

Figure 3: Effects of unemployment risk on the MPC in quantitative model



NOTE. The figure above plots the consumption policy, MPC (out of $1,000), and the probability of borrowing constraint binding in the next period for an employed household over the lower end of the wealth distribution.

raises the MPC. In contrast, for poor households who may hit the borrowing limit in the near future, their MPCs are mostly driven by their concerns of the borrowing constraint binding, of which the probability actually decreases in response to the higher unemployment risk thanks to the endogenously higher saving. As a result, the MPCs of poor households decrease.

The overall effect on the average MPC depends on the wealth distribution. In the following, I compare the average MPC out of $1,000 in the steady state and in the period when the high-risk shock hits, which means that the underlying household distribution is unchanged. This comparison highlights the direct effect of unemployment risk on the consumption policy and is more in line with the survey evidence in Section 2 where household savings do not fully respond to the unemployment risk due to the short horizon (two months) considered.

The upper panel of Table 5 makes the comparison under the baseline calibration considered so far. When the unemployment risk increases, the average MPC slightly decreases from 0.2 to 0.195, which means that overall the borrowing-constraint channel dominates. Conditional on the employed households which are the empirical sample in Section 2.2, the size of the decrease is even smaller, only 0.002. The smaller decrease for employed households can be explained by the fact that they are more willing to save than the unemployed households and hence are less prone to the borrowing-constraint channel. Moreover, as mentioned before, when the households are away from the borrowing constraint, their MPCs actually increase due to a stronger precautionary-saving motive, offsetting some of the decrease from the borrowing-constraint channel. Quantitatively, the

Table 5: Unemployment risk and the MPC in the quantitative model

	Steady state	**High risk**
Baseline calibration		
MPC	0.200	0.195
MPC (Employed)	0.178	0.176
Target ΔMPC		
MPC	0.280	0.252
MPC (Employed)	0.260	0.232
Single β		
MPC	0.114	0.116
MPC (Employed)	0.100	0.104

NOTE. The first column shows the average MPCs in the steady state. The second column shows the average MPCs in the first period when the unemployment risk increases.

small size of the decrease in the average MPC of employed households is far below the empirical estimates in Section 2 & A.3 which suggest a size of decrease of around 0.03, ten times of what the model generates.

What is the limit of the model to reconcile with the large negative effect of unemployment risk? In the middle panel of Table 5, I consider an alternative calibration of the model that targets a size of the decrease in the average MPC of employed households equal to 0.028 (taken from column 3 of Table 1) and the same level of average liquid wealth as in the baseline. The model is able to generate a sizable decrease at the cost of having a substantially higher average MPC in the steady state. The reason is because the model can only achieve a sizable decrease by pushing more households towards the borrowing constraint, which necessarily raises their MPCs. Compared to the literature, an average quarterly MPC of 0.28 implied by the alternative calibration is above the upper bound of the empirical range of $[0.15, 0.25]$ reported in Kaplan and Violante (2022). Thus, the model faces a trade-off between matching the MPC and the effect of unemployment risk.

Lastly, in the bottom panel of Table 5, I consider a calibration of the model without discount factor heterogeneity, targeting only the level of average liquid wealth. The average MPC is substantially smaller because most households are away from the borrowing constraint. As a result, the precautionary-saving channel dominates, and the average MPC slightly increases when the unemployment risk heightens. This example stresses the presence of the precautionary-saving channel and clarifies that even under a standard calibration, the buffer stock model does not always predict a negative relationship between the average MPC and the unemployment risk.

3.3 Alternative models

The theoretical and quantitative analyses show that the standard buffer stock model is unable to replicate the large negative effect of unemployment risk on the MPC in the data because the precautionary saving motive and the borrowing constraint have opposite effects. Since these two mechanisms are fundamental, consumption models that build on the buffer stock model would also have difficulty replicating the large negative effect of unemployment risk. In the following, I discuss two common extensions of the standard model to illustrate that the impossibility result is a robust phenomenon.

Two-asset model The first model I consider is the two-asset extension of the buffer stock model proposed by Kaplan and Violante (2014). In this model, households have access to two financial instruments: a liquid asset with low return and an illiquid asset that provides a high return but incurs a fixed cost for every transaction. Because of the transaction costs, households primarily use the liquid asset to self-insure and adjust their illiquid asset positions occasionally. One feature of the model is the presence of wealthy hand-to-mouth households who have high net worth but hold little liquid asset and have high MPC. This allows the model to generate a high level of average net worth and a high average MPC.

How does the two-asset structure possibly change the effect of unemployment risk on the MPC? For households who do not plan to adjust their illiquid asset position, they act similarly to households in the one-asset model so the previous logic applies. On the other hand, for households who plan to adjust their illiquid asset position, there are two effects. First, increasing unemployment risk can discourage the household from investing in the illiquid asset because of the need of liquidity. Second, even if the household still chooses to adjust, it can lower the size of the investment or increase the amount of withdrawal as liquidity becomes more valuable. Both effects increase the average liquid asset holding in the economy and thereby lower the average MPC.

In Appendix C.1, I examine the effect of increased unemployment risk on the MPC in a calibrated two-asset model. I find that the additional portfolio rebalance channel is quantitatively weak because most adjusting households are withdrawing their illiquid assets for liquidity. Higher unemployment risk thus does not affect most households adjustment decisions, as they need the liquidity anyway. Given the small effect of the additional channel, the average MPC only slightly decrease in face of higher unemployment risk, same as in the standard one-asset model.

Borrowing spread The second extension I consider is to allow for an exogenous spread between the borrowing rate and the saving rate. This simple extension has two consequences. First, the spread allows the model to better match the share of borrowers and hence the lower end of the wealth distribution, which is crucial for gauging the strength of the borrowing constraint mechanism. Second, in the presence of a borrowing spread, borrowers have low MPC because of the strong incentive to save to avoid the high cost of debt (Koşar et al. 2024). Heightened unemployment risk further increases the desire to save, amplifying this mechanism and reducing the MPC.

In Appendix C.2, I examine the ability of the borrowing spread extension to remedy the shortcoming of the standard model. In addition to the average MPC and the average liquid wealth, I calibrate the extended model to match the share of borrowers and the median wealth-to-income ratio using the borrowing spread and the share of impatient type. This calibration strategy maximally captures the strength of the borrowing constraint mechanism. As a result, the calibrated model predicts a larger drop in the average MPC when the unemployment risk rises, though still only explains half of the empirical magnitude. Moreover, because the model still relies on the borrowing constraint mechanism to generate the drop, the MPC decreases are exclusively accounted for by the indebted households, inconsistent with the data.

4 Reconcile with the Data: Mental Accounting Model

The conclusion in the last section calls for another behavioral mechanism to account for the effect of unemployment risk on the MPC. In this section, I show that incorporating a mental accounting mechanism (Graham and McDowall 2024, Shefrin and Thaler 1988) into the buffer stock model helps generate the large negative effect of unemployment risk in the data. The idea is as follows: households subject to mental accounting prefer consumption out of income to consumption out of saving, leading to a high MPC out of additional income. When unemployment risk increases, households want to save rather than consume, so they are less influenced by mental accounting and behave as a rational consumer with a low MPC. At the end of the section, I validate the mental accounting model by showing its success in matching other stylized facts on the MPC in the literature.

4.1 Mental accounting preference

I consider the following mental accounting utility function proposed by Graham and McDowall (2024):

$$U(c\,;\,y) = \begin{cases} u(c) & \text{if } c \leq y \\ u(c) - \psi[u(c) - u(y)] & \text{if } c > y \end{cases}$$

where $u(\cdot)$ is the standard CRRA utility function, y is current income, and $\psi \in [0, 1]$ is a parameter that captures the extent of mental accounting. The utility function $U(\cdot\,;\,y)$ is piecewise continuous and monotonically increasing in consumption. When the household is consuming less than her income, she derives utility from consumption as if she has a CRRA preference. When the household is consuming more than her income, which means she is *dissaving*, additional consumption is associated with a "mental cost" that lowers the marginal utility of consumption. Formally, we have

$$U'(c;y) := \lim_{h\to 0^+} \frac{U(c+h;y) - U(c;y)}{h} = (1 - \mathbf{1}\{c \geq y\}\psi)u'(c)$$

The interpretation is that the household treats consumption out of income differently than consumption out of saving, violating the fungibility of money. In Appendix C.3, I provide a decision theoretic foundation for the mental accounting model building on the temptation with self-control preference of Gul and Pesendorfer (2001).

How does mental accounting change the consumption policy in the buffer-stock model? The left subplot of Figure 4 plots the consumption policy with mental accounting preference in the infinite-horizon model (C.9) studied in Section 3.2. The mental accounting policy is, in general, increasing except on an interval where it stays constant. The kinks in the policy function result from the discontinuity of the marginal utility. To see why, recall the Euler equation:

$$(1 - \mathbf{1}\{c \geq y\}\psi)u'(c) = \beta R\,\mathbb{E}\left[\frac{\partial V(a', z')}{\partial a'}\right]$$

where V is the value function. For households with little savings, consumption is less than income ($c < y$), so the Euler equation degenerates to the standard case and consumption is increasing in savings as with standard preference. However, for households with a moderate level of savings, consumption smoothing requires dissaving ($c > y$) which discontinuously reduces the marginal utility of consumption below the marginal return to saving. In other words, the following inequalities

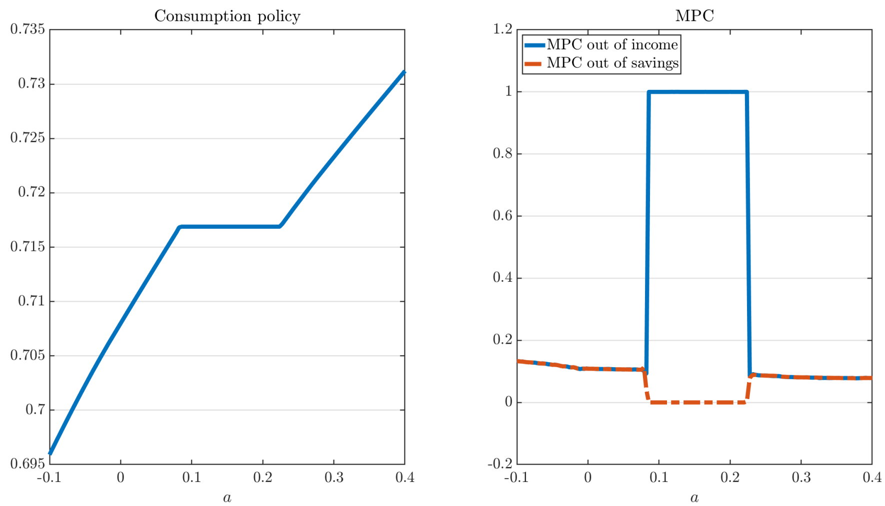
$$u'(c) > \beta R\,\mathbb{E}\left[\frac{\partial V(a', z')}{\partial a'}\right] \tag{3}$$

$$(1-\psi)u'(c) < \beta R\,\mathbb{E}\left[\frac{\partial V(a', z')}{\partial a'}\right] \tag{4}$$

hold and we have a corner solution $c_t = y_t$. Finally, for households that are sufficiently wealthy, the marginal return to saving is so low that it is optimal to dissave ($c > y$) despite the disutility. That is, the Euler equation holds at $c > y$, explaining the last increasing part of the policy function.

Importantly, in the mental accounting model, the MPC out of *income* can be different from the slope of the consumption policy which essentially captures the MPC out of *savings*. The right panel of Figure 4 compares the two notions of the MPC. In the increasing portions of the policy function, the two notions of MPC agree because the Euler equation holds and the household behaves as if with standard preference. In the flat region of the policy function, the MPC out of income is equal to one, whereas the MPC out of savings is zero. This is because consuming the additional income does not incur the marginal disutility penalty and in light of (3), consuming all of it is optimal. Note that the MPC out of income is substantially smaller when the household is not (directly) subject to mental accounting. This MPC difference is at the core of how this model can deliver a large drop in the MPC when the unemployment risk increases.

Figure 4: Consumption policy and the MPC under mental accounting



NOTE. The figure above plot the consumption policy and the MPCs as functions of savings.

4.2 Unemployment risk and the MPC under mental accounting

To understand how unemployment risk affects consumption behavior under mental accounting, let's first consider a simple two-period model. The environment is identical to the stylized model in Section 3.1. For simplicity, assume that there is no borrowing limit and no unemployment benefit. The household problem is given by:

$$\max_{c_0, c_1^e, c_1^u, a_1} \quad U(c_0; y) + (1-\delta)U(c_1^e; y) + \delta U(c_1^u; 0)$$
$$\begin{aligned} s.t. \quad c_0 + a_1 &\leq a_0 + y \\ c_1^e &\leq a_1 + y \\ c_1^u &\leq a_1 \end{aligned}$$

where $U(\cdot;\cdot)$ is the mental accounting utility function with parameter $\psi \in (0,1)$. We are interested in how an increase in the unemployment risk ($\delta \uparrow$) changes the MPC out of income, formally defined as

$$MPC := \lim_{h \to 0^+} \frac{c_0(a_0 + y + h; y + h) - c_0(a_0 + y; y)}{h}$$

Recall that when the savings a_0 is either sufficiently low or high, consumption is determined by the Euler equation. In this case, the effect of unemployment risk is still characterized by Proposition 1, which asserts that the MPC should increase. The remaining case is when the Euler equation does not hold, which is characterized by the following proposition.

Proposition 3. *Fix $\delta_1 < \delta_2$. There exist corresponding intervals $(\underline{a}_1, \bar{a}_1)$ and $(\underline{a}_2, \bar{a}_2)$ such that*

1. *$MPC = 1$ over the interval; $MPC < 1$ otherwise*
2. *Higher risk shifts the interval to the right: $\underline{a}_2 > \underline{a}_1$ and $\bar{a}_2 > \bar{a}_1$*

In particular, for $a_0 \in (\underline{a}_1, \underline{a}_2)$, the MPC decreases when the risk increases from δ_1 to δ_2.

The proof can be found in Appendix **??**. Proposition 3 reveals that in the mental accounting model, higher unemployment risk can reduce the MPC of a household by disengaging her from mental accounting behavior. Intuitively, higher unemployment risk increases the marginal return to save, inducing some of the relatively poor infra-marginal households to save ($c < y$) instead of consume ($c = y$). These households then have a small MPC because of consumption smoothing.

Note that the opposite is true for relatively wealthy infra-marginal households. Nonetheless, in a full-fledged quantitative model, it's expected that these households are only a small share of the population, as will be confirmed next.

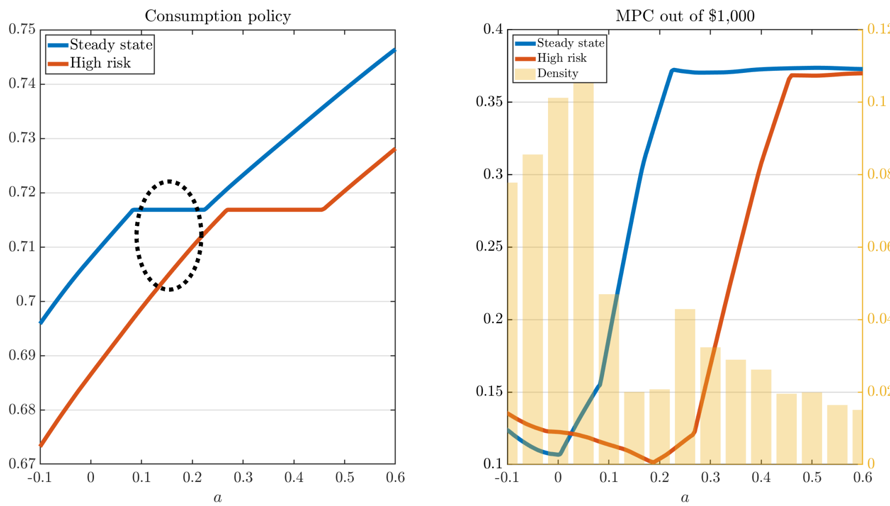
Quantitative model To quantify the mechanism, I embed the mental accounting preference in the infinite-horizon model studied in Section 3.2. As I have an additional parameter ψ that determines the degree of mental accounting, I remove discount factor heterogeneity and calibrate (β, ψ) to target the same two moments as before, namely the average liquid wealth and the average MPC out of \$1,000. All other parameters remain unchanged. The calibration exercise leads to $\beta = 0.975$ and $\psi = 0.065$.[14]

I repeat the same experiment of high-risk shock as in Section 3.2. The left subplot of Figure 5 shows the consumption policy of an employed household in steady state and in the period when the high-risk shock hits. Same as the standard model, the high-risk consumption policy is everywhere below the steady-state policy. The flat region is shifted to the right, consistent with the prediction of Proposition 3. The right subplot of Figure 5 shows the corresponding MPC out of \$1,000, overlaid with the density of the distribution. We can see that for households that used to be in the flat region, their MPCs drop dramatically. Note that unlike in Figure 4, the MPC is smoother, below one, and is high for households beyond the flat region. This is because the size of the income change is not infinitesimal. Nonetheless, the economic mechanism is exactly the same as in the stylized model.

Although not shown in the figure, some of the wealthy households that were close to the upper bound of the flat region do see their MPCs increase. That being said, their population share is small, as can be inferred from the decreasing density of the wealth distribution. This is not an arbitrary result of the calibration. Recall that for households that are above the flat region, they are dissaving, and vice versa for households that are below the flat region. Given the idiosyncratic

[14]To gauge the plausibility of the implied mental accounting bias, I evaluate the welfare loss of adopting the mental accounting policy under standard preference. The loss is around 0.01% of life-time consumption, so the distortion to consumption smoothing is modest and the household can be regarded as "near-rational" in the sense of Akerlof and Yellen (1985a).

Figure 5: Effects of unemployment risk on the MPC under mental accounting



NOTE. The MPC plot is underlaid with the histogram of the steady-state savings distribution to illustrate the share of household switching from high MPC to low MPC.

Table 6: MPC in Mental Accounting Model

	Mental Accounting		**Standard**	
	Steady state	High risk	Steady state	High risk
MPC	0.200	0.173	0.200	0.195
MPC (Employed)	0.191	0.164	0.178	0.176

unemployment spells that induce dissaving, the mass of the population naturally concentrates at the lower end of the flat region, as shown in Figure 5. Finally, note that for the relatively poor households that do not engage in mental accounting behavior, their MPCs actually increase due to the stronger precautionary saving motive.[15]

Finally, Table 6 compares the average MPC in the mental accounting model with the standard model. There are two critical differences. First, we see a sizable drop in the average MPC of 2.7 pp. when the unemployment risk increases, which is in the ballpark of the empirical estimates. Second, the size of the drop remains the same even conditional on employment, as the decease is driven by the mental accounting mechanism that applies to relatively wealthy households who want to consume. Neither are true in the standard model.

Heterogeneous effects by wealth As shown in Section 2.3, the empirical results indicate that the negative effect of unemployment risk on MPC is evident across the wealth distribution. Here we revisit this fact in the mental accounting model and the standard model. Table 7 reports the average change in MPC across the three wealth-to-income groups, defined consistently with the empirical

[15]These households are not close to the borrowing limit which is not covered in the figure for visual clarity.

Table 7: Effect of Unemployment Risk on the MPC across the Wealth Distribution

	Data (SCE)	Mental Accounting	Standard Baseline	Standard Target ΔMPC
ΔMPC	-2.90	-2.71	-0.24	-2.90
ΔMPC ($a/y \leq 0$)	-3.22	-4.17	-0.59	-4.67
ΔMPC ($a/y \in (0, 0.2)$)	-3.21	**-2.80**	0.68	0.67
ΔMPC ($a/y \geq 0.2$)	-2.74	-0.16	0.14	0.14

analysis. Remarkably, the mental accounting model reproduces the negative effect of unemployment risk even for households away from the borrowing limit. This is because the mechanism targets those near their savings target, unlike in the standard model, where such households are primarily driven by precautionary motives that raise their MPCs. Despite its simplicity, the mental accounting extension significantly enhances the model's ability to replicate the strong negative effect of unemployment risk on MPC in the data.

4.3 Model validation

The mental accounting model has also been proven success in matching other stylized facts on the MPC (Graham and McDowall 2024, Mijakovic 2024). Here I revisit these facts through the lens of my quantitative models.

Fact 1. Consumption response to transitory income is front-loaded The first fact concerns the time path of consumption responses after a transitory income shock. Many studies have found that the consumption response is concentrated in the month when the household receives additional income (Boehm et al. 2024, Graham and McDowall 2024, Borusyak et al. 2024, Fuster et al. 2021). For instance, Boehm et al. (2024) run a RCT on cash transfer in France and find that almost all the response happen in the first three weeks. This font-loaded time profile is inconsistent with consumption smoothing, but can be explained by mental accounting, as shown in Figure 6.[16] Intuitively, after the initial period, unspent income becomes savings out of which the household has very low MPC.

Fact 2. Consumption response to income news is modest The second fact is about anticipated response to upcoming transitory income. Previous studies have explored that the anticipated effect in the context of tax refund (Graham and McDowall 2024, Baugh et al. 2021), the Alaska Permanent Fund (Kueng 2018, Hsieh 2003), and direct survey (Fuster et al. 2021) and consistently find that the effect is small albeit large response when the income arrives.[17] This

[16] In standard models, if there is a large share of households at the borrowing limit, then the time-profile will be more front-loaded. For example, Auclert et al. (2024) generates a front-loaded response in a two-asset model where 58% of the households are at the borrowing limit.

[17] An exception is Hsieh (2003) who do not find significant consumption responses before and in the quarter when the payment from Alaska Permanent Fund arrives. Kueng (2018) revisits this study with data of better quality and find large consumption

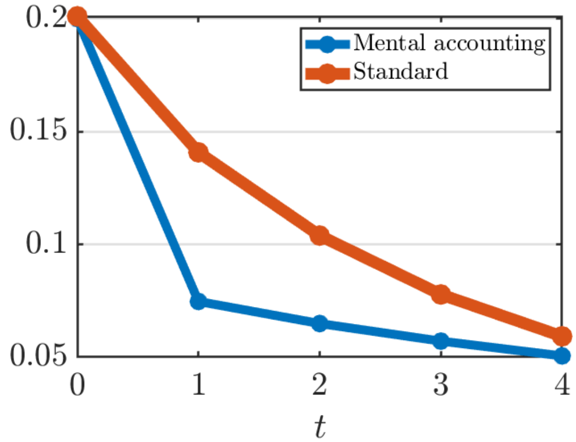


Figure 6: Front-loaded consumption response to transitory income

pattern is again at odd with consumption smoothing. Moreover, these studies find that even liquidity-affluent household do not respond, ruling out liquidity constraint as an explanation.

Mental accounting can explain this pattern as the utility benefits only occurs when the income arrives. Figure 7 shows the consumption response to \$1,000 that arrives at $t = 0$ but is announced at $t = -1$. In the standard model, consumption smoothing calls for immediate large response when the income shock is announced. In the mental accounting model, the anticipated response is modest but the response at the period when the income arrives is large, consistent with the empirical pattern.

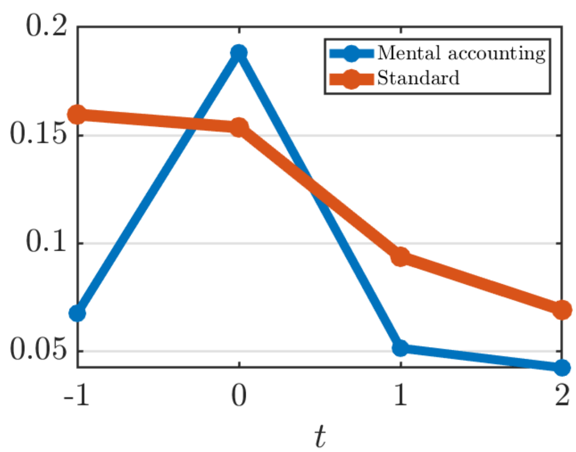


Figure 7: Modest consumption response to income news

Fact 3. MPC remains high for liquidity-affluent households Our last fact is about the cross-sectional relationship between MPCs and liquidity. The standard model predicts a strong

responses when the payments arrives but not beforehand.

negative relationship between liquid wealth and MPCs. Yet, the empirical evidence is mixed, with some of them finding a significant negative relationship (Fagereng et al. 2021, Jappelli and Pistaferri 2020) but not the others (Boehm et al. 2024, Lewis et al. 2024, Fuster et al. 2021).

Figure 8 plots the MPCs by liquid wealth quantiles for the two models. In the standard model, the MPC drops substantially when the liquid wealth increases. In particular, the MPC of the upper 20% households is below 0.04, about one-tenth of those in the lowest quantile. In the mental accounting model, the MPC still deceases with liquid wealth but not as dramatically. This is because when households build up their savings, they start to be influenced by mental accounting which raises their MPCs substantially. The attenuated relationship explains the absence of empirical evidences for a strong relationship. Note that even the upper 20% households have a MPC above 0.12, consistent with previous studies that find high MPCs for liquidity-affluent households (Boehm et al. 2024, Graham and McDowall 2024, Baugh et al. 2021, Kueng 2018).

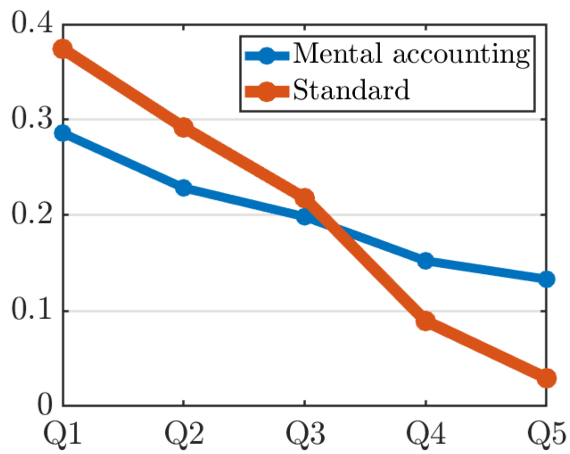


Figure 8: MPC and liquid wealth quintile

In conclusion, the mental accounting model not only can explain the newly-documented, strong negative relationship between unemployment risk and MPCs, but is also consistent with other stylized facts in the literature.

5 Aggregate Implications

In this section, I embed the mental accounting model into a HANK framework to explore the aggregate implications of the high risk-sensitivity of the MPC. The model features endogenous unemployment risk, a ZLB on the monetary policy, and aggregate uncertainty. I use the model to answer two questions: 1) How does the MPC vary over the business cycle? 2) How effective are stimulus checks during recessions?

5.1 Model

Time is discrete and runs forever, $t = 0, 1, \ldots$.

Household The household block is essentiall identical to the partial-equilibrium model. The economy is populated by a unit measure of infinitely-lived households. Households face idiosyncratic risk to their labor productivity z_t and also transition risk to their employment status $e_t \in \{0, 1\}$. If the household is employed ($e_t = 1$), she works and earns real labor income $y_t = w_t z$ where w_t is the real wage. If the household is unemployed ($e_t = 0$), she receives unemployment benefits $y_t = b w_t z$ that replaces a fraction $b \in (0, 1)$ of her employed earnings. Both labor earnings and unemployment benefits are subject to progressive taxation à la Heathcote et al. (2017). Households have access to a one-period risk-free government bond with nominal return R_t^n, subject to a borrowing constraint $a \geq \underline{a}$.

The Bellman equation of a household with asset a, productivity z, and employment status e at time t is given by:

$$
\begin{aligned}
V_t(a, z, e) &= \max_{c, a'} \left\{ \frac{c^{1-\sigma}}{1-\sigma} - \mathbf{1}\{c > y_t(z, e)\} v(c, y_t(z, e)) + \beta e^{\nu_t^d} \mathbb{E}_t \left[V_{t+1}(a', z', e') | z, e \right] \right\} \\
c + \frac{a'}{R_t^n} &= y_t(z, e) + \frac{a}{\Pi_t} \\
y_t(z, e) &= (1 - \tau_t)([e + (1 - e) \cdot b] w_t z)^{1-\xi} + \mathcal{T}_t \\
v(c, y_t(z, e)) &= \psi \left(\frac{c^{1-\sigma}}{1-\sigma} - \frac{y_t(z, e)^{1-\sigma}}{1-\sigma} \right) \\
a' &\geq \underline{a}
\end{aligned}
$$

where ν_t^d is an aggregate discount-factor shock, Π_t is gross inflation rate, τ_t is labor tax, and $\mathcal{T}_t$ is uniform lump-sum transfer from the government. In the steady state, I assume $\mathcal{T}_{ss} = 0$. A stimulus check is modeled as a positive transfer $\mathcal{T}_t > 0$ of which the financing is done through a fiscal rule discussed later. Note that the notion of income related to mental accounting is the real after-tax labor income including the stimulus check.

Timing of labor transition At the beginning of the period, a fraction δ of employed households are separated from their jobs and are immediately available for hire (i.e. possibly short-term unemployed). After job separation, a fraction f_t of currently unemployed households find a job and become employed. Formally, the overall transition matrix for employment status from time t to time $t + 1$ is given by

$$
Q_t^e = \begin{bmatrix} 1 - \delta + \delta f_t & \delta(1 - f_t) \\ f_t & 1 - f_t \end{bmatrix}
$$

where the first (second) row is the transition probability for the employed (unemployed). Note that although the separation rate is constant, the EU rate is not because the job-finding rate f_t is endogenously time-varying.

Production The production block has the standard Dixit-Stigilitz setup. Final-goods firms operate in a perfectly competitive market. They demand intermediate goods from the intermediate-goods firms and transform them into the final goods using a CES technology with elasticity of substitution ϵ. The intermediate-goods market is monopolistically competitive. Intermediate-goods firms purchase labor service from the labor agency at a price p_t^ℓ, produce with a linear technology, and face a quadratic price-adjustment cost à la Rotemberg (1982). Optimal decisions of the (symmetric) intermediate-goods firms give rise to the New Keynesian Phillips Curve:

$$\log \Pi_t = \kappa_p \left(p_t^\ell - \frac{\epsilon - 1}{\epsilon} \right) + \mathbb{E}_t \left[\frac{\Pi_{t+1}}{R_t^n} \cdot \frac{Y_{t+1}}{Y_t} \cdot \log \Pi_{t+1} \right]$$

All firms are owned by a risk-neutral capitalist who consumes all profits each period.

Labor market The labor market has a standard search-and-matching setup. At the beginning of every period, a labor agency can post a job vacancy at a cost k and meet an unemployed worker with probability q_t. The labor agency pays the matched worker at real wage w_t for each effective labor unit she provides and sells the labor units to the intermediate-goods firms at real price p_t^ℓ. The expected (real) job match value to a labor agency satisfies the following recursion:

$$J_t = (p_t^\ell - w_t)\, \mathbb{E}[z] + (1 - \delta)\, \mathbb{E}_t \left[\frac{\Pi_{t+1}}{R_t^n} J_{t+1} \right]$$

where $\mathbb{E}[z]$ is the average productivity. The real wage is assumed to be fixed $w_t = w_{ss}$ according to a wage norm (Hall 2005).[18] Standard no-entry condition implies the optimal vacancy posting equation:

$$k = q_t J_t$$

The aggregate matching function takes the CES form (Den Haan et al. 2000) which implies the following relationship between the vacancy-filling rate and the job-finding rate:

$$q_t = (1 - f_t^\alpha)^{\frac{1}{\alpha}}$$

where α is the mathcing function parameter. Note that the job-finding rate is bounded between zero and one, as desired.

[18] I have checked that in equilibrium every job match is bilaterally efficient. As is well-known, some form of real wage rigidity is needed for the model to generate enough unemployment responses to aggregate shocks. For example, Kekre (2023) assumes that the real wage is 95% of the steady-state wage plus 5% of the Nash-bargained wage. I have tried another wage rule that links the real wage to the price of labor unit (Graves 2023) and do not find the result change.

Government Monetary policy follows a Taylor rule subject to the ZLB:

$$\log R_t^n = \max\left\{\log R_{ss} + \phi_\pi \log \Pi_t + \phi_u(\mathcal{U}_t - U_{ss}), 0\right\}$$

where $\mathcal{U}_t$ is the unemployment rate. The government inter-temporal budget constraint is given by:

$$B_{t+1} = R_t^n \left(\frac{B_t}{\Pi_t} + G_t + UI_t - T_t\right)$$

where B_t is total real debt outstanding priced at time $t-1$ price level, G_t is real government spending, UI_t is the outlay of unemployment benefits, and T_t is total tax collected. Since the model does not satisfy Ricardian equivalence, how the government finances its expenditure matters for the aggregate dynamics. This is especially true for the analysis of fiscal stimulus, as pointed out by Angeletos et al. (2023). I assume that the government deficit is partially financed with debt according to the following fiscal rule:

$$T_t - T_{ss} = (1-\rho_B)\left(\frac{B_t}{\Pi_t} - B_{ss} + G_t - G_{ss} + UI_t - UI_{ss}\right)$$

The extent of debt financing is increasing in ρ_B. In particular, when $\rho_B = 1$, the government finances all its deficit with debt. The fiscal rule is implemented by adjusting the proportional labor tax τ_t. In the baseline model, the government spending is constant over time ($G_t = G_{ss}$).

I defer the definition of an equilibrium to Section 5.3 after introducing the structure of the aggregate shock. See Appendix D for the full system of equations.

5.2 Calibration

One period is a quarter. For comparisons, I also consider the standard model with heterogeneous discount factors for the household block. I use the same calibration of the household block as before. See Table 4. I set the separation rate to be 0.10 such that the implied steady-state EU rate is consistent with the previous calibration. This level is also in line with the separation rate in JOLTS. The steady-state output is set to be 1 by normalizing the average labor productivity.

The steady-state inflation rate is set to be zero. For the aggregate parameters, I follow closely the calibration in Birinci et al. (2024). The slope of the NKPC is $\kappa_p = 0.021$, and the Taylor rule coefficients are $\phi_\pi = 1.5$ and $\phi_u = -0.1$. The fiscal rule parameter is set to be $\rho_b = 0.93$, taken from Angeletos et al. (2023). The progressivity of the tax system is set to be $\xi = 0.181$ as estimated by Heathcote et al. (2017). The steady-state ratio of government spending to output is equal to 0.20. Lastly, the matching function parameter is set to be $\alpha = 1.6$ (Birinci et al. 2024) and the vacancy posting cost is set to be 0.05 such that the quarterly hiring cost equals 7% of the average wage (Graves 2023). Table 8 summarizes the calibration.

Table 8: Calibration of the GE model

Parameter	Interpretation	Value	Source/Target
Assigned parameters			
δ	Separation rate	0.10	JOLTS
f	UE rate	0.632	CPS (1996-2019)
κ_p	Slope of NKPC	0.021	Birinci et al. (2024)
ϕ_π	Taylor rule (inflation)	1.5	Birinci et al. (2024)
ϕ_u	Taylor rule (unemployment)	-0.10	Birinci et al. (2024)
ρ_b	Fiscal rule	0.93	Angeletos, Lian and Wolf (2023)
ξ	Progressivity of labor tax	0.181	Heathcote, Storesletten and Violante (2017)
G_{ss}/Y_{ss}	Government spending to output ratio	0.20	McKay and Reis (2021)
α	Matching function elasticity	1.6	Birinci et al. (2024)
k	Vacancy posting cost	0.0496	Hiring cost = 7% of average wage (Graves 2023)
Internally calibrated			
β	Discount factor	0.975	Avg. liquid wealth = 1.04 (SCF 2004)
ψ	Mental accounting	0.065	Avg. MPC = 0.20 (Kaplan and Violante 2022)

5.3 Aggregate risk and recession

I consider a demand-driven recession triggered by an increase in the discount factor as my benchmark.[19] This scenario is particularly suitable for the analysis of stimulus check policy: Without the ZLB, monetary policy alone is enough to stabilize the economy; However, at the ZLB, additional stimulus is needed, making the case for the stimulus check policy.

I assume that the aggregate shock follows a two-state Markov process with the steady state being an absorbing state. At time 0, the economy begins in its deterministic steady state and is hit by the shock (i.e. discount factor increases) and enters recession. From time 1 onward, there is a constant probability $\theta \in (0,1)$ that the discount factor reverts permanently back to the steady-state level and the economy transitions to the original steady state. This structure allows me to solve the model globally taking into account aggregate uncertainty with a new sequence-space-based method developed by Lin and Peruffo (2024). See Appendix D.2 for the computational details. Note that up to first order, this shock is equivalent to a standard AR(1) shock.

Fiscal adjustment during recessions Another benefit of the two-state structure is the possibility of introducing state-contingent policy. As mentioned, the financing of the stimulus check matters for its aggregate effects. In the US, the 2008 tax rebate as well as the recent Covid-19 stimulus are all funded by debt. Therefore, I assume that during recessions, the government finances all the deficit with debt (i.e., $\tau_t = \tau_{ss}$) and only adopt the prescribed fiscal rule along the recovery path.

Equilibrium Given the structure of the aggregate shock, an equilibrium can be described by a collection of contingency paths different in the realized length of the recession. Let $\mathrm{\tau} \geq 1$ index the time the economy exits the recession. We are ready to define the equilibrium concept:

A *rational expectation equilibrium* consists of contingency paths of policy functions $\{(c_t, a_t)_\mathrm{\tau}\}$,

[19]For the standard model with heterogeneous discount factors, the discount factors of both types increase.

household value functions $\{(V_t)_\tau\}$, prices $\{(R^n_t, \Pi_t, w_t, p^\ell_t)_\tau\}$, job match values $\{(J_t)_\tau\}$, fiscal instruments $\{(B_t, \tau_t, \mathcal{T}_t)_\tau\}$, aggregate objects $\{(Y_t, C_t, G_t, UI_t, T_t, \mathcal{V}_t, \mathcal{U}_t, D_t)_\tau\}$, household distribution $\{(F_t)_\tau\}$, and a sequence of beliefs over prices such that

1. Given the sequence of value functions, prices, and policy functions, the household Bellman equation holds.

2. Given the sequence of beliefs over prices, all agents optimize.

3. The evolution of the distribution is consistent with the policy.

4. The sequence of beliefs over prices is rational.

5. Monetary and fiscal policy follows the prescribed rules.

6. All markets clear.

Parametrization I set $\theta = .95$ and calibrate the size of the shock to deliver an increase of the unemployment rate from the steady-state level of 5.5 pp. to 10 pp., the peak during the Great Recession. The expected duration of recessions is $1/(1-\theta) = 20$ quarters, in line with the length of the Great Recession.

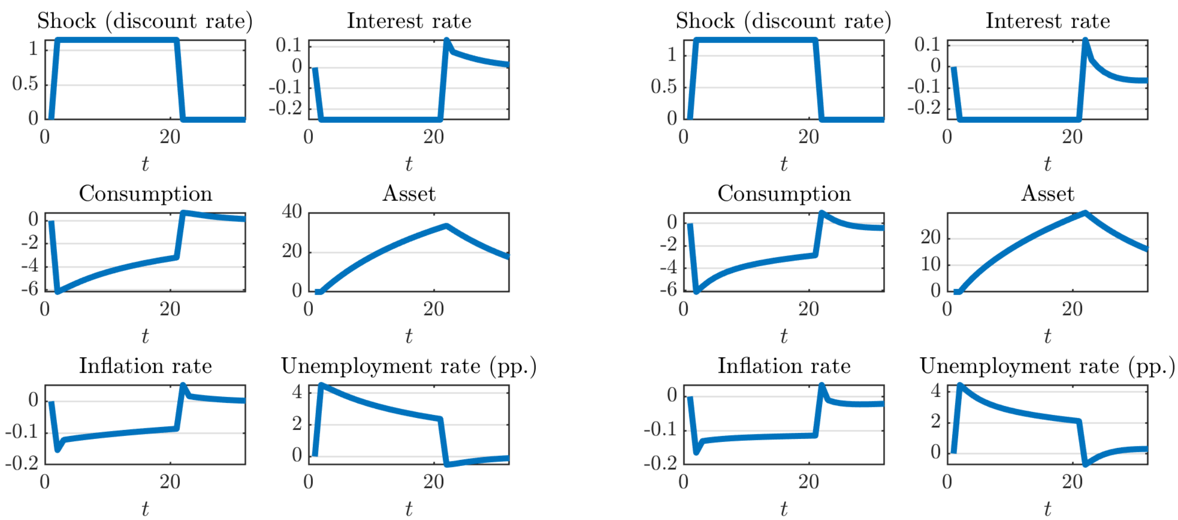
Conditional impulse response Figure 9a shows the impulse responses of the mental accounting model conditional on the recession ends after 20 quarters ($\tau = 20$). The economy experiences a typical demand-driven recession where the unemployment rate elevates, consumption decreases, and deflation occurs. Since the ZLB is binding, the real rate does not decrease enough to accommodate the discount rate shock, leading to a severe recession. During the recession, households gradually build up their saving stocks, as shown in the middle panel of the second column. When the recession finally ends, households spend down their excess savings, generating a boom where the economy overshoots and then transitions back to the original steady state.

Figure 9b shows the same conditional transition paths for the standard model. By construction, the initial increase in the unemployment rate is identical, though it requires a slightly larger shock. The overall dynamics are mostly the same as in the mental accounting model. This is not surprising because the two models target the same level of average liquid wealth and the average MPC and share the same aggregate parameters. The similar dynamics of the two models reassure that their differences in the MPC dynamics and the effectiveness of stimulus checks are not due to the differences in the severity of the recession.

5.4 The MPC over the business cycle

How does the MPC vary over the business cycle? For illustration purposes, I again focus on the transition path conditional on $\tau = 20$. I compute the partial-equilibrium contemporaneous MPC out

Figure 9: Conditional impulse response ($\tau = 20$)



(a) Mental accounting **(b)** Standard

NOTE. The figure above plots the impulse responses of several aggregate variables conditional on the shock dissipates after 20 periods for the two models. For consumption and asset, the unit is percent deviation from the steady state. For interest rate, inflation rate, and unemployment rate, the unit is pp. deviation from the steady state.

of \$1,000 at each point of the transition path. Figure 10 shows the MPC paths (the blue lines) for both the mental accounting model and the standard model. Unlike the dynamics of the aggregate variables discussed before, the MPC dynamics are vastly different in the two models.

In the mental accounting model, the MPC drops immediately and substantially from 0.2 to 0.14 at the beginning of the recession and stays low thereafter. When the recession ends, the MPC overshoots and then converges to the steady-state level. On the other hand, in the standard model, the MPC is roughly unchanged at the onset of the recession and only gradually decreases when the recession persists. After eight quarters, the MPC drops from 0.2 to 0.17, still above the corresponding level in the mental accounting model. Lastly, when the recession ends, the MPC does not overshoot and gradually increases to the steady-state level.

To understand the driving force of the remarkably different dynamics, I decompose the MPC as follows:[20]

$$
\begin{aligned}
MPC_t &:= \int MPC_t(s)\, dF_t(s) \\
&\approx \underbrace{\int MPC_t(s)\, dF_{ss}(s)}_{\textbf{Policy channel}} + \underbrace{\int MPC_{ss}(s)\, dF_t(s)}_{\textbf{Compositional channel}} - \underbrace{\int MPC_{ss}(s)\, dF_{ss}(s)}_{=MPC_{ss}}
\end{aligned}
$$

The policy channel term isolates the contribution of the time-varying consumption policy by holding the household distribution fixed at the steady-state value, vice versa for the compositional channel term. In the mental accounting model, the huge drop in the MPC is driven by the exceptionally strong policy channel that is consistent with the empirical evidence presented in Section 2. During recessions, the higher incentive to save disengages households from mental accounting behavior, lowering their MPCs. Interestingly, the compositional channel contributes positively to the MPC dynamics and is increasing over the recession. This is because when the households approach their targeted saving stocks, they start to be influenced by mental accounting which raises their MPCs. Lastly, the overshoot of the MPC after recession is due to the desire of the household to spend down their excess savings which triggers mental accounting behaviors.[21]

In the standard model, the policy channel is much weaker, only decreasing the MPC by 0.02. This drop is due to the increase in the discount factor as the MPC is not sensitive to unemployment risk in the standard model. The small drop also clarifies that the large decrease in the mental accounting model is not a mechanical result of the discount factor shock. In contrast to the mental accounting model, the compositional channel first contributes positively to the MPC, then it declines and eventually contributes negatively. The initial positive effect is due to the increase in the number of unemployed households who have high MPCs. Over time, households build up their saving stocks and their MPC gradually decreases, explaining the decline and the eventually negative effect. At the beginning of the recession, the negative policy channel and the positive compositional channel cancels out, resulting with an unchanged MPC.

To sum up, the mental accounting model that is consistent with the empirical facts implies a procyclical MPC over the business cycle. Next, I study its implications for the effectiveness of stimulus check policy.

5.5 Effectiveness of stimulus check policy

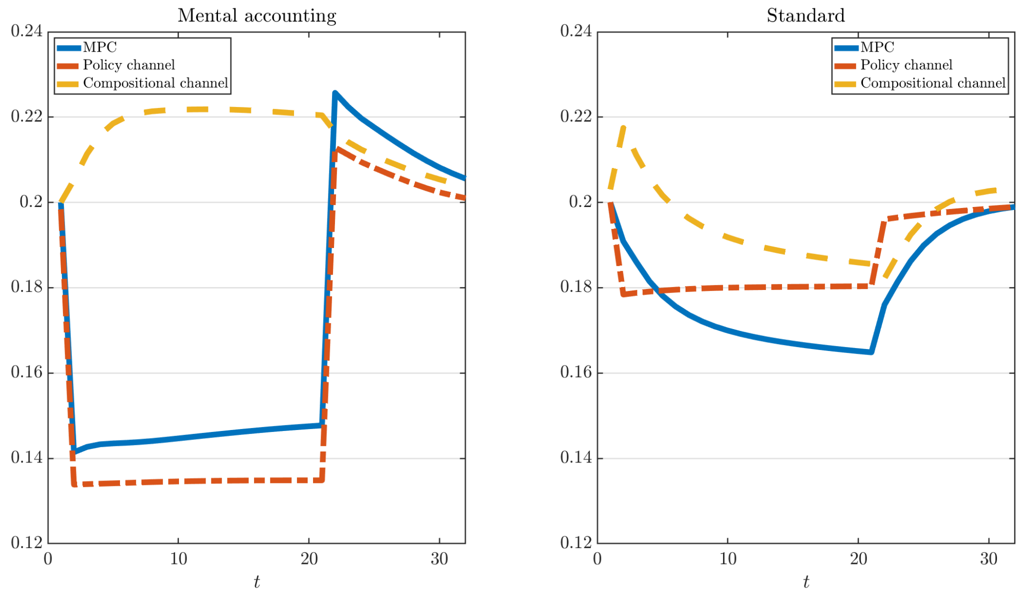
The MPC discussed in the last section measures the direct effect of the stimulus check policy, abstracting from any general equilibrium effect. In general equilibrium, the stimulus effect is stronger for two reasons.[22] First, the direct effect reduces the unemployment risk, boosting consumption by

[20] The decomposition is exact up to first order.

[21] One implication is that the MPC rises after an unexpectedly short recession. Therefore, delayed delivery of stimulus checks may generates too much stimulus, leading to a burst of inflation. Note that this is not true in the standard model.

[22] Thanks to the realistic assumption of slow fiscal adjustment, the negative effect of tax hikes is limited.

Figure 10: MPC over the business cycle



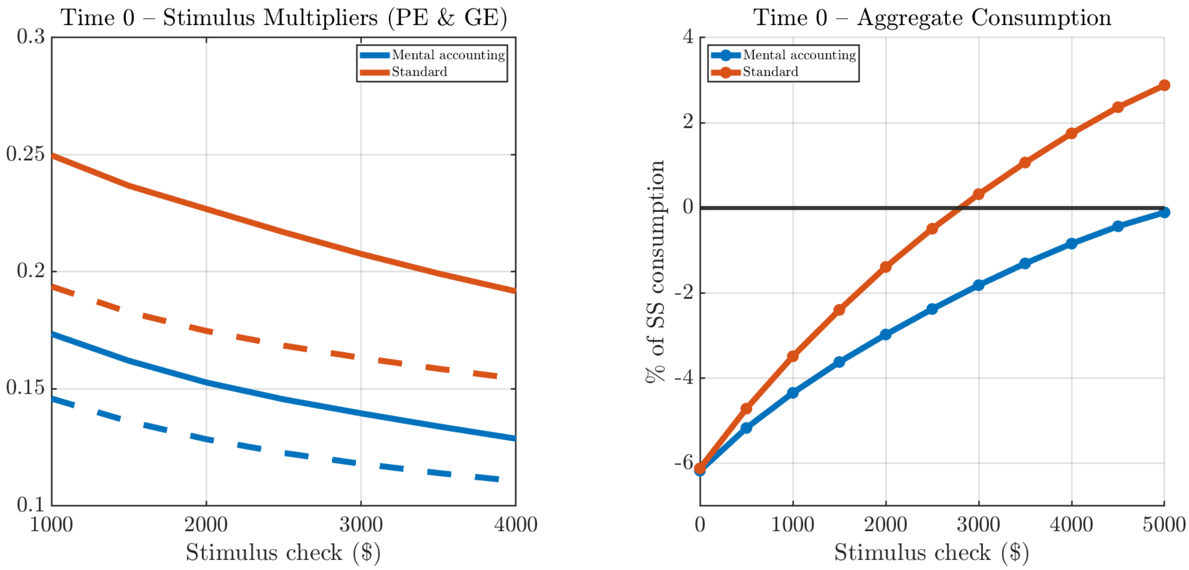
NOTE. The figure above plots the transition path of the MPC conditional on the shock dissipates after 20 periods for the two models. The policy channel (red dash-dot line) holds the distribution fixed at the steady state, while the compositional channel (yello dash line) holds the consumption policy fixed at the steady state.

weakening the precautionary saving motive. Second, at the ZLB, the increased inflation rate lowers the real interest rate, further increasing consumption by the standard intertemporal substitution channel.[23] Figure 11a shows the GE (solid line) and PE (dash line) multipliers for different sizes of the stimulus checks sent out in the first period of the recession. The general equilibrium effect amplifies the consumption response by about 30% in the standard model but only 15% in the mental accounting model. As a result, the GE multipliers in the mental accounting model are 30% smaller than in the standard model.

It is important to note that the smaller GE multiplier in the mental accounting model is actually more in line with the empirical estimate. Using a structural model and narrative evidence, Orchard et al. (2024) argue that the GE multiplier associated with the 2008 tax rebate is at most 0.20 and claim that it is inconsistent with the high MPC estimates in the literature. In my model, the corresponding GE multiplier of \$1,000 (= average size of the rebate) is 0.175, well within the empirical bound. By contrast, the standard model has a GE multiplier of 0.25, outside the empirical bound as claimed by Orchard et al. (2024). Therefore, the state-dependence of the MPC in my model reconciles the modest aggregate effects of the 2008 tax rebate and the high MPCs documented in the literature.

[23] For large enough stimulus checks, the economy actually leaves the ZLB unless the recession continues.

Figure 11: Effectiveness of stimulus check policy



(a) Multipliers **(b)** Aggregate effect

NOTE. The figure above plots the consumption multipliers and the aggregate consumption responses for different sizes of stimulus checks in the two models. For the multiplier plot (left), the dash lines are the partial-equilibrium multipliers (i.e. MPC) while the solid lines are the general-equilibrium multipliers.

Lastly, I analyze how the aggregate effect scales with the size of the stimulus checks. Figure 11b shows the equilibrium outcomes of aggregate consumption at time 0 for different sizes of the check. Since the GE multiplier is higher in the standard model, the effect of the policy scales much better with the size of the stimulus check than in the mental accounting model. To close the initial consumption gap of 6%, it requires a check of $2,800 in the standard model but a check of $5,200 in the mental accounting model, almost double the size.

6 Conclusion

In this paper, I first study empirically how unemployment risk affects the MPC in the individual level and then explore its implications for the dynamics of the MPC over the business cycle in a structural model that is consistent with the micro evidence. Using survey data and revisiting the 2008 tax rebate episode, I find consistent evidence that unemployment risk substantially lowers the MPC to an extent that standard buffer stock models are difficult to reproduce. The difficulty arises from the opposing effects of the precautionary motive which increases the MPC and the borrowing constraint which lowers the MPC.

I show that incorporating a mental accounting mechanism into an otherwise standard buffer stock model helps generate an empirically plausible negative effect of unemployment risk. The large effect stems from households endogenously switching from "hand-to-mouth" caused by mental accounting to rational consumption smoothing. I validate the model by showing that it is also consistent with other stylized facts on consumption responses to transitory income in the literature.

Embedding the mental accounting model into a HANK framework, I find that the MPC drops significantly during recessions, making stimulus checks ineffective in boosting consumption. The state-dependence of the MPC reconciles recent estimates of the modest aggregate effects of the 2008 tax rebate and the high MPCs documented in the literature.

As a first attempt to study the MPC over the business cycle, my general equilibrium model abstracts from capital and investment which are obviously important for aggregate dynamics. Mental accounting may have intriguing interaction with the investment channel, as the MPC out of capital income can be different from the MPC out of labor income. Furthermore, procyclical MPC suggests state-dependent responses to aggregate shocks, which can be analyzed in a more sophisticated HANK model solved globally. I leave the investigation of this exciting area to future work.

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Appendix A Additional Empirical Results

A.1 Additional SCE results

Table A.1: Summary statistics (SCE)

	All					Nonzero responses only	
	Mean	SD	Share < 0	Share = 0	Share > 0	Mean	Median
MPC	10.87	26.58	0.08	0.65	0.27	30.98	20
Prob. Job-loss in 12m	12.12	17.70	0.00	0.18	0.82	14.88	9
Change between 2016/3-5							
ΔMPC	4.35	30.36	0.19	0.50	0.31	8.72	11.6
ΔProb. Job-loss in 12m	-0.38	12.89	0.37	0.30	0.33	-0.53	-1

NOTE. Sample only includes households whose head is employed in both periods, is between 25 and 55 years old, and has been in their job position for at least one year when entering the survey. Statistics are computed with sampling weights.

Figure A.1: Binscatter plot of main SCE regression

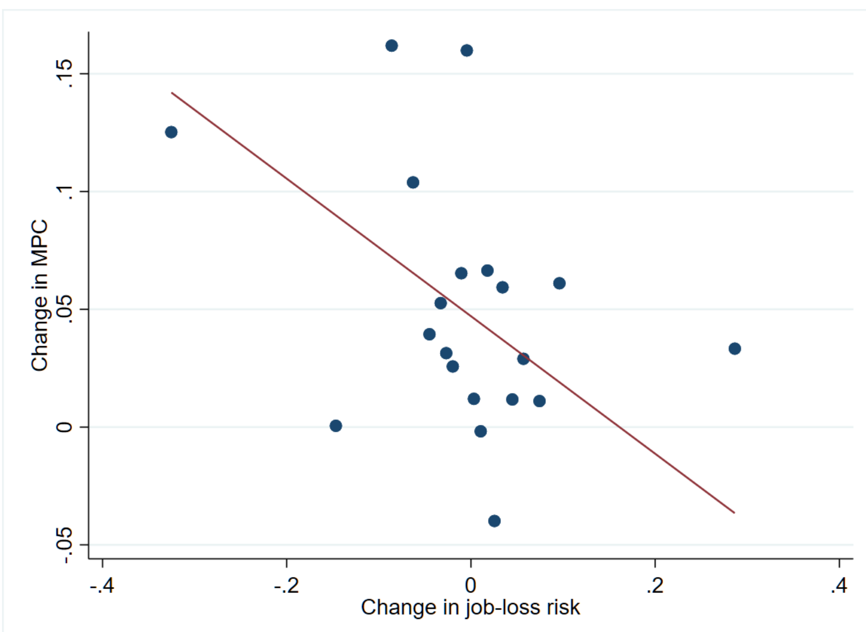

Table A.2: Controlling for Aggregate Expectations (SCE)

	(1)	(2)	(3)	(4)	(5)
$\Delta\,\mathbb{E}_{it}[s_{it,t+12}]$	-0.276**	-0.269**	-0.271**	-0.244**	-0.221**
	(0.121)	(0.123)	(0.123)	(0.114)	(0.097)
Δ(prob. of higher unemp. rate after 12 months)		-0.084	-0.072	-0.096	-0.100*
		(0.059)	(0.060)	(0.059)	(0.059)
Δ(prob. of higher stock prices after 12 months)			-0.040	-0.099	-0.089
			(0.088)	(0.095)	(0.095)
Δ(prob. of higher interest rate after 12 months)				0.105	0.093
				(0.064)	(0.063)
Δ(expected inflation rate over the next 12 months)					0.351
					(0.321)
Observations	643	643	643	643	637
Control for exp. income growth & income change	✓	✓	✓	✓	✓
R-squared	0.063	0.065	0.066	0.069	0.070

NOTE. All regressions have controlled for expected income growth and recent income change as in the main specification (1). The decrease in sample size in column (5) is due to missing data. Sample only includes households whose head is employed in both periods, is between 25 and 55 years old, and has been in their job position for at least one year when entering the survey. Controls include age, age-squared, gender, race, marital status, education, SCE income group, and treatment group FE. Robust standard errors are reported. Regressions are weighted using sampling weights.

Table A.3: Estimation Results by Treatment Group (SCE)

	(1)	(2)	(3)	(4)	(5)
$\Delta\,\mathbb{E}_{it}[s_{it,t+12}]$	-0.276**	-0.343**	0.019	-0.232**	0.107
	(0.121)	(0.166)	(0.286)	(0.104)	(0.326)
$\Delta\,\mathbb{E}_{it}[y_{it+12}]$	0.155	0.208	-0.633*	0.698**	-0.289
	(0.186)	(0.251)	(0.380)	(0.340)	(0.849)
$\mathbf{1}\{y_{it} > y_{it-2}\}$	8.053*	6.411	36.537***	3.942	26.336
	(4.800)	(6.729)	(13.443)	(8.145)	(18.639)
Observations	643	320	113	159	51
R-squared	0.063	0.069	0.220	0.151	0.408
Treatment group	All	($500, $5,000)	($5,000, $5,000)	($500, $2,500)	($5,000, $2,500)

NOTE. Column (1) is a replication of column (3) in Table 1. Sample only includes households whose head is employed in both periods, is between 25 and 55 years old, and has been in their job position for at least one year when entering the survey. Controls include age, age-squared, gender, race, marital status, education, SCE income group, and treatment group FE. Robust standard errors are reported. Regressions are weighted using sampling weights.

A.2 Fuster, Kaplan and Zafar (2021) survey module

Treatment design The FKZ survey module was added to the SCE core survey in March 2016, May 2016, January 2017, and March 2017. In each wave, each SCE survey respondent was randomly assigned two hypothetical scenario of income changes and reported how their spending behaviors would change correspondingly. Table A.4 summaries the treatment plan.

Table A.4: FKZ treatment

	March 16	May 16	January 17	March 17
Gain				
$500 Gain	$n = 1,085$		$n = 594$	
$2,500 Gain		$n = 540$		
$5,000 Gain	$n = 361$	$n = 1,084$	$n = 595$	
$500 Gain in 3 months	$n = 362$			
$5,000 Gain in 3 months			$n = 594$	
Loss				
$500 Loss	$n = 362$			$n = 1,174$
$500 Loss in 3 months			$n = 594$	$n = 586$
$500 Loss in 2 years				$n = 589$
Loan				
$5,000 Loan		$n = 541$		

NOTE. This is Table 2 from Fuster et al. (2021). Treatments in red color are included in the empirical analysis in the main text.

In the main analysis, I use only the immediate-gain treatments in March 2016 and May 2016, colored in red in Table A.4. Note that there are four treatment groups: 1) $500 in March, $2,500 in May; 2) $500 in March, $5,000 in May; 3) $5,000 in March, $2,500 in May; 4) $5,000 in March, $5,000 in May. See Table A.3 for a treatment-group analysis.

Survey questions Below are the survey questions regarding the spending composition, taken from Online Appendix of Fuster et al. (2021).

You indicated that you would increase [reduce] your spending/donations over the next 3 months following the receipt of the $500 [or $2,500, or $5,000] payment.

Question: How much more [less] would you spend/donate than if you hadn't received the $500 [or $2,500, or $5,000]?
[Enter value]

Spending Composition Follow-Up:
And how much of these $(entered value) would you spend on each of the following:
[And how much of this $(entered value) would come from a reduction in spending on each of the following:]
(Please note: The numbers need to add up to [entered value].)

- Traveling / vacation / eating out / other leisure activities: $ __________
- Donation / gifts: $ __________
- General living expenses: $ __________
- Purchase of durables typically costing $1,000 or less (e.g., electronics, sports equipment, clothing, etc.): $ __________
- Purchase of durables typically costing more than $1,000 (such as a car, etc.): $ __________
- Renovations or improvements to my home: $ __________
- Pay for college / education / training for members of my household (including myself): $ __________
- Other (please specify: __________): $ __________

A.3 Revisiting the 2008 Tax Rebate

The empirical analysis in the last section is based on direct survey evidence. Although survey responses provide a clean measurement of the MPC which is otherwise difficult to observe, one may be concerned that actual household behaviors are very different from what they report.[24] To alleviate the concern, in this appendix, I examine the relationship between unemployment risk and *actual* spending responses to the 2008 tax rebate. My empirical methodology builds upon the quasi-experimental design that exploits the random timing of rebate receipt in Parker et al. (2013) and Johnson et al. (2006). I find that an increase in unemployment risk significantly reduces the nondurable spending response to the tax rebate, consistent with the main findings from the SCE.

A.3.1 Data

I use data from the quarterly interview survey of the Consumer Expenditure Survey (CE) during 2007-2009. The CE is administered by the Bureau of Labor Statistics to collect information on households' expenditure pattern, income, and characteristics. Similarly to the SCE, the CE survey has a rotating panel structure, where each household is in the sample for at most four quarters. During the quarterly interview, households report their expenditure over the last three months in detail, covering fine spending categories such as dining and automobile purchases.

The 2008 tax rebate is part of the Economic Stimulus Act of 2008 intended to stimulate the United States economy during the financial crisis. A total of $100 billion was disbursed to approximately 130 million tax filers in the form of a tax rebate between May and July 2008. To understand how households use the stimulus payment, during the period from June 2008 to March 2009, additional questions about the tax rebate were added to the quarterly CE interview. Households are asked to report whether they receive a tax rebate and if so, in what month and how much they receive. These information allow one to measure the treatment (tax rebate) and the outcome (expenditure) in a classic difference-in-difference (DiD) setting.

Imputation of unemployment risk Unlike the SCE, the CE survey does not contain any question about the household's belief of unemployment risk. Therefore, I follow Carroll, Dynan and Krane (2003) to impute unemployment risk based on demographic variables available in the CE data. Specifically, I first estimate a logit model for the monthly probability of an employment-to-unemployment (EU) transition using data from the Current Population Survey (CPS) for each month. The predictors include gender, race, marital status, education, occupation, region, age, age squared, age interacted with occupation, and age interacted with education. Then I use the estimated model to predict unemployment risk in the next 12 months for each household in the CE data based on the demographics of the household's head. Formally, the unemployment risk is

[24] Colarieti et al. (2024) examines the reliability of survey evidence using a cross-validation approach. They give survey participants scenarios that resemble those in previous observational studies and find that the survey responses closely match the actual behaviors.

computed as

$$Risk_{it} := 1 - \prod_{j=0}^{11} [1 - \hat{\mathbb{P}}_{t+j}(EU \mid \mathbf{Z}_i)]$$

where $\hat{\mathbb{P}}_{t+j}(EU \mid \mathbf{Z}_i)$ is the predicted probability of an EU transition between month $t + j$ and month $t + j + 1$ for an individual with demographic variables $\mathbf{Z}_i$. By construction, $Risk_{it}$ can be interpreted as the probability of at least once EU transition in the next 12 months, conceptually comparable to my unemployment risk measure in SCE.

Figure A.2: Validation of Unemployment Risk Measure

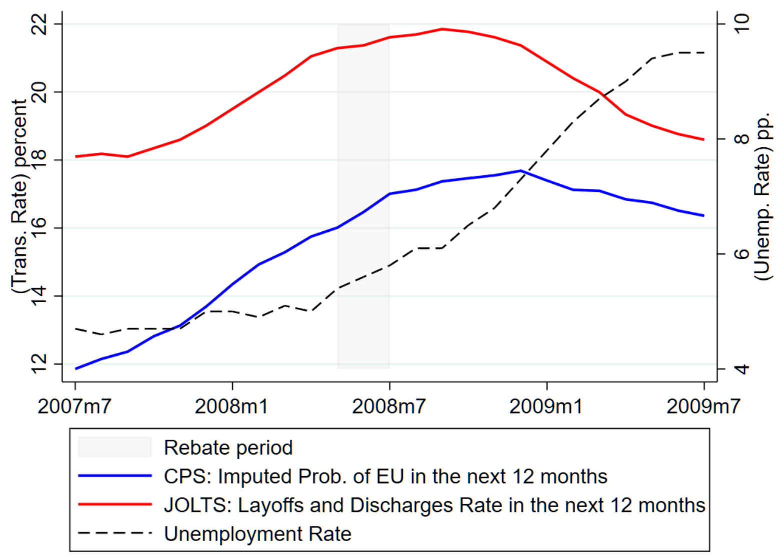

Figure A.2 plots the time-series of the aggregated imputed risk against the layoff and discharges rate series in JOLTS. In terms of level, the imputed risk remains consistently lower than the layoff and discharges rate, though this difference narrows in 2009 when the unemployment rate is particularly high. This can be explained by the fact that the layoff and discharges rate includes also the transition from employment to non-participation as well as job finding within a month. Importantly, the dynamics of these two series are broadly consistent over this period. Finally, it's worth noting that during the rebate period (May-July 2008), the unemployment rate started to rise and the imputed risk approached its peak. This alignment reinforces my confidence that unemployment risk became a salient factor influencing household spending decisions regarding the tax rebate.

A.3.2 Methodology

As mentioned in Parker et al. (2013), the timing of rebate disbursement was determined by the last two digits of the recipient's Social Security number which is effectively random. The authors leveraged this plausibly exogenous variation to estimate the average MPC out of the tax rebate – a DiD design. Recently, Orchard et al. (2024) argue that the original estimates in Parker et al. (2013) are biased for three reasons: (1) the lack of dynamic treatment effects, (2) a correlation between lagged expenditure and the report of receipt of a rebate, and (3) "forbidden comparisons" across households with heterogeneous treatment effects (Goodman-Bacon 2021, Sun and Abraham 2021).[25] To avoid the biases, I consider the following DiD specification:

$$C_{it} = \sum_{j=0}^{h}[\beta_0^j \mathbb{T}_{it-j} + \beta_1^j Risk_{it-j} \times \mathbb{T}_{it-j}] + \rho C_{it-1} + X_{it}'\gamma + \alpha_i + \delta_t + \varepsilon_{it} \tag{A.1}$$

where C_{it} is the level of expenditure at time t, $\mathbb{T}_{it-j}$ is an indicator for receiving the rebate at month $t-j$, $Risk_{it}$ is the imputed unemployment risk, X_{it} is a set of controls including family size and unemployment risk ($Risk_{it}$), α_i is household fixed effect, δ_t is month fixed effect, and ε_{it} is residual. The coefficient of interest is β_1^j, which captures how transitory changes in unemployment risk affect the response of expenditure to the tax rebate. The saturation of dynamic effects and the inclusion of lag expenditures address the first two sources of biases. To avoid forbidden comparisons, I use the robust estimation method developed by Borusyak, Jaravel and Spiess (2024) to estimate the dynamic treatment effects (β_0^j, β_1^j).

Sample I start with the sample used in Parker et al. (2013) which covers households who were in the CE sample when the 2008 tax rebate questions were field. Then I follow the advice by Orchard, Ramey and Wieland (2024) to exclude households who report receiving multiple rebates in different reference periods. To identify the effect of unemployment risk, I further restrict the sample to households whose head was between 25 and 55 years old and was not self-employed, consistent with the SCE sample.

A.3.3 Results

I focus on the contemporaneous treatment effects which correspond to the expenditure responses in the next three months after receiving the rebate. To compare with the SCE results, I estimate (A.1) for total, nondurable, and durable expenditures respectively.[26] Table A.5 reports the estimation results. The first row shows the average treatment effects for each broad spending category and

[25]The second reason seems to contradict the randomness of rebate timing. Nontheless, Orchard et al. (2024) show that even though the true rebate timing is random, the timing reported by the household is subject to a recall bias that associates the receipt of rebate with the period of large expenditure.

[26]Total expenditure includes all CE spending category except cash contributions, life insurance, and pension. Durable expenditures include spending on cars (purchases, insurances, and maintenance and repairs), housing (major and small appliances, furniture, and household equipments) and entertainment equipments. Nondurable expenditures are the residuals.

Table A.5: MPCs and Unemployment Risk (CEX)

	Total	Nondurable	Durable	Rebate amount
Avg. 3-month response	357.83	27.48	330.35	1051.60***
	(488.05)	(279.56)	(390.67)	(17.92)
$\mathbb{T}_{it} \times Risk_{it}$	-31.99	-29.84**	-2.15	-9.92***
	(27.49)	(13.62)	(23.95)	(2.22)
Implied 3-month MPC	0.341	0.026	0.315	
Change in 3-month MPC (1 pp.↑ Risk)	-0.030	-0.028	0.002	
Observations	6,148	6,148	6,148	6,148

NOTE. Sample only includes households whose head was between 25 and 55 years old and was not self-employed. Controls include lag of total expenditure, family size, and unemployment risk. Standard errors are clustered by household and are computed according to Borusyak et al. (2024).

the size of the rebate.[27] The average total expenditure response is \$358 and the average size of the rebate is \$1,052, which means the average quarterly MPC is $358/1052 = 0.34$. This is slightly above Orchard et al. (2024)'s estimate (=0.28), likely due to different samples and specifications. Nonetheless, consistent with Orchard et al. (2024), I also find that almost all of the expenditure response comes from durable expenditures.

The second row shows the estimated coefficients on the interaction term, representing the unemployment risk effect. A 1 pp. increase in the unemployment risk is associated with \$32 less total expenditure response, almost all of which is accounted for by nondurable expenditures. This is in stark contrast to the pattern of average responses, but is consistent with the SCE results in Section 2.3. In terms of magnitude, the effect estimated here is even larger than the SCE estimates. There are three reasons why the two estimates differ. First, the size of the rebate is negatively correlated with unemployment risks, exacerbating the drop in expenditure response. Second, unlike the SCE sample period (i.e. 2016 Q2), the rebate period is in the onset of a recession, so the estimates could be contaminated by aggregate conditions and expectations. Third, as shown in Figure A.2, the unemployment risk started to rise before the rebate period, so high-risk households might have built up their saving stocks already, leading to lower MPCs. In light of these caveats, the estimates here serve as an upper bound for the magnitude of the unemployment risk effect, while the SCE estimates serve as a lower bound.

Confounding factors Unemployment risk is correlated with other observable characteristics that determine the MPC, such as liquid wealth and income. Guided by the literature, I consider three factors: 1) liquid wealth, 2) income, and 3) average propensity to consume. In light of the incomplete coverage of income and wealth information, I follow Lewis et al. (2024) to use data from the first interview for these factors, meaning that the factors are time-invariant for each household.

[27] The average treatment effect is given by $\beta_0 + \beta_1 \mathbb{E}[Risk_{it}]$.

Specifically, I define:

- Liquid asset: sum of checking/savings accounts, CDs, stocks, bonds, and mutual funds
- Income: total amount of family income before taxes in the last 12 months
- Average propensity to consume: total expenditure divided by Income

For each factor, I bin the households into three groups and allow the treatment effect to differ across groups as well as vary with unemployment risk. Table A.6, A.7, A.8 report the results. The negative effect of unemployment risk on expenditure responses is remarkably robust across these specifications, both in terms of magnitude and statistical significance, highlighting the importance of risk in spending decisions.

Table A.6: MPC and Unemployment Risk (controlling for liquid wealth)

	Liquid asset			
	Total	Nondurable	Durable	Rebate amount
Avg. 3-month response	357.83	27.48	330.35	1051.60***
	(488.05)	(279.56)	(390.67)	(17.92)
$\mathbb{T}_{it} \times Risk_{it}$	-30.98	**-29.03****	-1.95	-9.39***
	(29.05)	(13.73)	(25.59)	(2.26)
$\mathbb{T}_{it} \times Low_i$	671.46	-28.95	700.41	48.81
	(560.07)	(293.01)	(471.57)	(45.13)
$\mathbb{T}_{it} \times High_i$	345.98	74.87	271.12	72.58
	(524.09)	(308.53)	(448.62)	(46.93)
Implied 3-month MPC	0.341	0.026	0.315	
Observations	6,148	6,148	6,148	6,148

NOTE. *Low* (*High*) refers to the bottom (top) tercile group, so the coefficient should be interpreted as relative to the middle group. Sample only includes households whose head was between 25 and 55 years old and was not self-employed. Controls include lag of total expenditure, family size, and unemployment risk. Standard errors are clustered by household and are computed according to Borusyak et al. (2024).

Table A.7: MPC and Unemployment Risk (controlling for income)

	Income			
	Total	Nondurable	Durable	Rebate amount
Avg. 3-month response	357.83	27.48	330.35	1051.60***
	(488.05)	(279.56)	(390.67)	(17.92)
$\mathbb{T}_{it} \times Risk_{it}$	-36.98	**-32.21****	-4.77	-7.01***
	(30.44)	(14.19)	(26.44)	(2.26)
$\mathbb{T}_{it} \times Low_i$	952.48	-355.80	1308.28**	-59.04
	(621.80)	(285.56)	(534.46)	(44.26)
$\mathbb{T}_{it} \times High_i$	178.30	-358.27	536.56	167.59***
	(555.37)	(308.50)	(471.37)	(42.56)
Implied 3-month MPC	0.341	0.026	0.315	
Observations	6,148	6,148	6,148	6,148

NOTE. *Low* (*High*) refers to the bottom (top) tercile group, so the coefficient should be interpreted as relative to the middle group. Sample only includes households whose head was between 25 and 55 years old and was not self-employed. Controls include lag of total expenditure, family size, and unemployment risk. Standard errors are clustered by household and are computed according to Borusyak et al. (2024).

Table A.8: MPC and Unemployment Risk (controlling for APC)

	Average Propensity to Consume			
	Total	Nondurable	Durable	Rebate amount
Avg. 3-month response	357.83	27.48	330.35	1051.60***
	(488.05)	(279.56)	(390.67)	(17.92)
$\mathbb{T}_{it} \times Risk_{it}$	-21.94	**-26.84****	4.91	-9.59***
	(27.89)	(13.66)	(24.23)	(2.21)
$\mathbb{T}_{it} \times Low_i$	-92.73	351.66	-444.39	-44.91
	(529.04)	(250.99)	(534.46)	(41.42)
$\mathbb{T}_{it} \times High_i$	-2286.79	-489.76	-1797.03	-95.49**
	(669.84)	(316.49)	(581.33)	(45.29)
Implied 3-month MPC	0.341	0.026	0.315	
Observations	6,148	6,148	6,148	6,148

NOTE. *Low* (*High*) refers to the bottom (top) tercile group, so the coefficient should be interpreted as relative to the middle group. Sample only includes households whose head was between 25 and 55 years old and was not self-employed. Controls include lag of total expenditure, family size, and unemployment risk. Standard errors are clustered by household and are computed according to Borusyak et al. (2024).

Appendix B Proofs

B.1 Proof of Proposition 1

Proof. The Euler equation is given by

$$u'(c_0) = (1-\delta)u'(m - c_0 + y) + \delta u'(m - c_0 + b) \tag{B.2}$$

Differentiate it with respect to m:

$$u''(c_0)\frac{\partial c_0}{\partial m} = \big[(1-\delta)u''(m - c_0 + y) + \delta u''(m - c_0 + b)\big]\left(1 - \frac{\partial c_0}{\partial m}\right)$$

Rearrange and we have

$$\frac{\partial c_0}{\partial m} = 1 - \frac{1}{1+\Delta} = \frac{\Delta}{1+\Delta}$$

where

$$\Delta \equiv (1-\delta)\frac{u''(m - c_0 + y)}{u''(c_0)} + \delta\frac{u''(m - c_0 + b)}{u''(c_0)}$$

Note that $\Delta > 0$ so $\frac{\partial c_0}{\partial m} < 1$. Next, differentiate Δ with respect to δ:

$$\begin{aligned}
\frac{\partial \Delta}{\partial \delta} &= \frac{u''(c^u) - u''(c^e)}{u''(c_0)} + \frac{-[(1-\delta)u'''(c^e) + \delta u'''(c^u)] - \frac{u'''(c_0)}{u''(c_0)}[(1-\delta)u''(c^e) + \delta u''(c^u)]}{u''(c_0)}\frac{\partial c_0}{\partial \delta} \\
&= \frac{u''(c^u) - u''(c^e)}{u''(c_0)} - \frac{u'''(c_0)}{u''(c_0)}\left(\frac{(1-\delta)u'''(c^e) + \delta u'''(c^u)}{u'''(c_0)} + \frac{(1-\delta)u''(c^e) + \delta u''(c^u)}{u''(c_0)}\right)\frac{\partial c_0}{\partial \delta}
\end{aligned} \tag{B.3}$$

where $c^u := m - c_0 + b$ and $c^e := m - c_0 + y$. At $\delta = 0$, clearly, we have $c_0 = \frac{m+y}{2}$ and $c^u = m - c_0 + b > 0$ iff $m > y - 2b$. From now on, consider only the case $m > y - 2b$. By equation (B.2) and the Implicit Function Theorem, the consumption policy c_0 is differentiable and hence continuous with respect to δ at $\delta = 0$. Then we have

$$\lim_{\delta \to 0^+} \frac{u'''(c_0)}{u''(c_0)}\left(\frac{(1-\delta)u'''(c^e) + \delta u'''(c^u)}{u'''(c_0)} + \frac{(1-\delta)u''(c^e) + \delta u''(c^u)}{u''(c_0)}\right) < \infty$$

Furthermore, note that the term $\frac{u''(c^u) - u''(c^e)}{u''(c_0)} > 0$ because $c^u < c^e$, $u''' > 0$, and $u'' < 0$. Now it suffices to show that $\lim_{\delta \to 0^+} \frac{\partial c_0}{\partial \delta} = 0$.

To compute $\frac{\partial c_0}{\partial \delta}$, differentiate the Euler equation with respect to δ:

$$\begin{aligned}
u''(c_0)\frac{\partial c_0}{\partial \delta} = \delta\big[u'(m-c_0+b) - u'(m-c_0+y)\big] \\
- \big[(1-\delta)u''(m-c_0+y) + \delta u''(m-c_0+b)\big]\frac{\partial c_0}{\partial \delta}
\end{aligned}$$

Rearrange:

$$\begin{aligned}
\frac{\partial c_0}{\partial \delta} &= \frac{\delta\big[u'(m-c_0+b) - u'(m-c_0+y)\big]}{u''(c_0) + \big[(1-\delta)u''(m-c_0+y) + \delta u''(m-c_0+b)\big]} \\
&= \delta \cdot \frac{u'(c^u) - u'(c^e)}{u''(c_0)} \cdot \frac{1}{1+\Delta}
\end{aligned}$$

We have $\lim_{\delta\to 0^+} \frac{u'(c^u)-u'(c^e)}{u''(c_0)} < \infty$ and $\lim_{\delta\to 0}\Delta < \infty$. It follows that $\lim_{\delta\to 0^+}\frac{\partial c_0}{\partial \delta} = 0$, as desired. The proof is complete. □

B.2 Proof of Proposition 2

Proof. In general, the cutoff value $\underline{m}$ is uniquely determined by the following equation:

$$c_0^*(\underline{m};\delta) = \underline{m} - \underline{a}$$

where $c_0^*(\underline{m};\delta)$ is the optimal policy without the borrowing constraint and under the risk level δ. Differentiate the equation with respect to δ:

$$\begin{aligned}
\frac{\partial c_0^*(\underline{m};\delta)}{\partial \underline{m}} \cdot \frac{\partial \underline{m}}{\partial \delta} + \frac{\partial c_0^*(\underline{m};\delta)}{\partial \delta} &= \frac{\partial \underline{m}}{\partial \delta} \\
\frac{\partial \underline{m}}{\partial \delta} &= \frac{\frac{\partial c_0^*(\underline{m};\delta)}{\partial \delta}}{1 - \frac{\partial c_0^*(\underline{m};\delta)}{\partial \underline{m}}}
\end{aligned}$$

As shown in the proof of Proposition 1, $\frac{\partial c_0^*(\underline{m};\delta)}{\partial \underline{m}} = MPC \in (0,1)$ and $\frac{\partial c_0^*(\underline{m};\delta)}{\partial \delta} < 0$. Therefore, $\frac{\partial \underline{m}}{\partial \delta} > 0$, as desired. □

B.3 Proof of Proposition 3

Proof. I first prove that the policy function takes the piecewise continuous form. Assume the "rational" preference u takes the CRRA form. Since $\lim_{c\to 0^+} u(c) = -\infty$, it's clear that $a_1 > 0$. Thus, the problem can be rewritten as

$$\max_{c_0, c_1^e, c_1^u, a_1} \; u(c_0) - \psi \mathbf{1}\{c_0 > y\}[u(c_0) - u(y)] + \psi[(1-\delta)u(c_1^e) + \delta u(c_1^u)]$$

$$\begin{aligned} s.t. \quad c_0 + a_1 &= a_0 + y \\ c_1^e &= a_1 + y \\ c_1^u &= a_1 \end{aligned}$$

Suppose $c_0 < y$. Then it must satisfy the FOC:

$$u'(c_0) = \psi[(1-\delta)u'(a_0 + 2y - c_0) + \delta u'(a_0 + y - c_0)] \tag{B.4}$$

Given that u is CRRA, equation (B.4) implicitly defines a continuously differentiable function $c_0^L(a_0)$ over the domain $(-y, \infty)$. Clearly, $c_0^L(a_0)$ is strictly increasing, $\lim_{a_0\to\infty} c_0^L(a_0) \to \infty$, and $c_0^L(0) < y$. Then by the Intermediate Value Theorem, there exists $\underline{a} \in (0, \infty)$ such that $c_0^L(\underline{a}) = y$.

Similarly, for $c_0 > y$, the FOC is

$$\begin{aligned} (1-\psi)u'(c_0) &= \psi[(1-\delta)u'(a_0 + 2y - c_0) + \delta u'(a_0 + y - c_0)] \\ u'(c_0) &= \frac{\psi}{1-\psi}[(1-\delta)u'(a_0 + 2y - c_0) + \delta u'(a_0 + y - c_0)] \end{aligned} \tag{B.5}$$

Equation (B.5) defines another continuously differentiable function $c_0^R(a_0)$ over the domain $(-y, \infty)$. Clearly, $c_0^H(a_0)$ is strictly increasing, $\lim_{a_0\to\infty} c_0^H(a_0) \to \infty$, and $c_0^H(0) < y$. Then by the Intermediate Value Theorem, there exists $\overline{a} \in (0, \infty)$ such that $c_0^H(\overline{a}) = y$.

Since $u'' < 0$, comparing the RHS of equation (B.4) and (B.5) gives $c_0^L(a_0) > c_0^R(a_0)$ for all $a_0 \in (-y, \infty)$. By monotonicity, we have $\underline{a} < \overline{a}$. Since the optimal policy c_0 must be increasing in a_0, we conclude that it takes the form:

$$c_0(a_0; y) = \begin{cases} c_0^L(a_0) & \text{if } a_0 \in (-y, \underline{a}) \\ y & \text{if } a_0 \in [\underline{a}, \overline{a}] \\ c_0^R(a_0) & \text{if } a_0 \in (\overline{a}, \infty) \end{cases}$$

Clearly, we have $MPC = \frac{\partial c_0}{\partial y} = 1$ for $a_0 \in [\underline{a}, \overline{a}]$ and $MPC < 1$ otherwise.

Now we prove the main claim. In general, the left end point of the interval $\underline{a}$ is uniquely determined by the following equation

$$u'(y) = \psi[(1-\delta)u'(\underline{a}_1 + y) + \delta u'(\underline{a}_1)]$$

Differentiate with respect to δ:

$$\begin{aligned} 0 &= \psi\left[u'(\underline{a}) - u'(\underline{a} + y) + \left[(1-\delta)u''(\underline{a}_1 + y) + \delta u''(\underline{a}_1)\right]\frac{\partial \underline{a}}{\partial \delta}\right] \\ \frac{\partial \underline{a}}{\partial \delta} &= \frac{u'(\underline{a} + y) - u'(\underline{a})}{(1-\delta)u''(\underline{a}_1 + y) + \delta u''(\underline{a}_1)} \end{aligned}$$

Note that $u'' < 0$ so the numerator is negative, so as the denominator. Thus, $\frac{\partial \underline{a}}{\partial \delta} > 0$. By the same argument, $\frac{\partial \overline{a}}{\partial \delta} > 0$. The proof is complete.

$\square$

Appendix C Alternative Models

C.1 Two asset model

The model is a straight-forward extension of the one-asset model in the main text. Households have access to another "illiquid" asset, denoted by d, that provides a higher risk-free return R^d. Following the specification in Graves (2023), I assume that adjusting the position in the illiquid asset incurs an iid random utility cost $\chi \sim U[0, \bar{\chi}]$. Also, I impose the no-borrowing constraint on the illiquid asset, i.e. $d \geq 0$. Lastly, I get rid of discount factor heterogeneity in light of the additional parameters.

Recursive formulation The household problem can be divided into two cases: adjust and not adjust. For those that do not adjust, the Bellman equation is given by:

$$
\begin{aligned}
V^{NA}(a, d, z, e) = \max_{c, a'} \frac{c^{1-\sigma}}{1-\sigma} + \beta \, \mathbb{E}\left[V(a', R^d d, z', e'; \beta) \mid z, e\right] \\
s.t. \quad c + a' = y(z, e) + Ra \\
y(z, e) = [e + (1-e) \cdot b]z \\
a' \geq \underline{a}
\end{aligned}
\tag{C.6}
$$

For those that adjust, after paying the adjustment cost, the Bellman equation is given by:

$$
\begin{aligned}
V^{A}(a, d, z, e) = \max_{c, a', d'} \frac{c^{1-\sigma}}{1-\sigma} + \beta \, \mathbb{E}\left[V(a', d', z', e'; \beta) \mid z, e\right] \\
s.t. \quad c + a' + d' = y(z, e) + Ra + R^d d \\
y(z, e) = [e + (1-e) \cdot b]z \\
a' \geq \underline{a}
\end{aligned}
\tag{C.7}
$$

Finally, the continuation value is given by

$$
V(a, d, z, e) = \int \max \left\{ V^A(a, d, z, e) - \chi, V^{NA}(a, d, z, e) \right\} dF(\chi) \tag{C.8}
$$

Parametrization I calibrate the discount factor β, the return difference $R^d - R$, and the maximum adjustment cost $\bar{\chi}$ to target 1) average liquid wealth; 2) ratio of average liquid wealth to average illiquid wealth; 3) share of hand-to-mouth. The moments are computed from SCF 2004, except the ratio which I take from Bayer et al. (2019).[28] The remaining parameters are the same as in Table 4 in the main text. Table C.9 summarizes the calibration results.

[28] My own calculation leads to a substantially higher ratio. To be consistent with the usual calibration for business-cycle models, I choose to use the value in Bayer et al. (2019).

Table C.9: Calibration of Two-asset Model

Parameter	Value	Moment	Target	Achieved
β	0.9626	Avg. liquid wealth (SCF 2004)	1.04	1.00
$R^d - R$	15.47%	Ratio of liq. to illiq. (Bayer et al. (2019))	0.09	0.09
$\bar{\chi}$	0.6612	Share of HtM (SCF 2004)	0.30	0.29

Results I repeat the same experiment as in the main text for the calibrated two-asset model. Table C.10 shows the results. The steady-state value of the MPC (untargeted) is relatively low, as is usually the case in two-asset models when calibrated to match the average wealth. When unemployment risk increases, the MPC of the employed drops by 0.01, which is larger in magnitude compared to the standard model. Yet, it is still dramatically lower than the empirical estimate of 0.03.

To understand the role of the rebalancing channel, I compute the extensive MPC using the change in consumption driven solely by portfolio adjustments. The extensive MPC is always negative, reflecting the fact that most adjusting households withdraw their illiquid assets for liquidity. Most importantly, as can be seen from Table C.10, the extensive MPC is barely affected by the unemployment risk. I conclude that the portfolio rebalancing channel is quantitatively unimportant.

Table C.10: MPC and Unemployment Risk in Two-asset Model

	Two Asset		**Standard**		**Mental Accounting**	
	Steady State	High Risk	Steady State	High Risk	Steady State	High Risk
MPC	0.142	0.132	0.200	0.195	0.200	0.173
MPC (Employed)	0.148	0.138	0.178	0.176	0.191	0.164
MPC (Extensive)	-0.063	-0.060	.	.	.	.

C.2 Borrowing spread

I extend the standard model in the main text to allow for a spread between the borrowing rate and the saving rate. Let $r^d > 0$ be the interest rate spread. The Bellman equation now reads as

$$
\begin{aligned}
V(a, z, e; \beta) = \max_{c, a'} \frac{c^{1-\sigma}}{1-\sigma} + \beta \, \mathbb{E}\left[V(a', z', e'; \beta) \mid z, e\right] \qquad \text{(C.9)} \\
s.t. \quad c + a' = y(z, e) + (1 + r + r^d \cdot \mathbf{1}\{a < 0\})a \\
y(z, e) = [e + (1 - e) \cdot b]z \\
a' \geq \underline{a}
\end{aligned}
$$

Table C.11: Calibration of Borrowing Spread Model

Parameter	Value	Moment	Target	Achieved
β^L	0.9794	Avg. MPC (Kaplan and Violante 2022)	0.20	0.17
β^H	0.9468	Avg. liquid wealth (SCF 2004)	1.04	1.05
r^d	17.92%	Share of borrowers (SCF 2004)	0.24	0.23
p^L	0.5246	Median wealth-to-income ratio (SCF 2004)	0.10	0.08

Parametrization To best capture the borrowing constraint mechanism, in addition to the two discount factors (β^L, β^H) and the spread r^d, I also calibrate the population share of the low discount-factor type p^L. The four parameters are jointly calibrated to target four moments: 1) the average liquid wealth, 2) the avergae MPC, 3) the share of borrowers, and 4) the median wealth-to-income ratio. Table C.11 summarizes the calibration results.

Results I repeat the same experiment as in the main text for the calibrated borrowing spread model. Table C.12 reports the changes in MPC in response to the heightened unemployment risk. The steady-state value of the MPC (untargeted) is relatively low, as is usually the case in two-asset models when calibrated to match the average wealth. When unemployment risk increases, the MPC of the employed drops by 0.01, which is larger in magnitude compared to the standard model. Yet, it is still dramatically lower than the empirical estimate of 0.03.

Table C.12: MPC and Unemployment Risk in Borrowing Spread Model

	Data (SCE)	Borrowing Spread	Mental Accounting	Standard
ΔMPC	-2.90	-1.91	-2.71	-0.24
ΔMPC ($a/y \leq 0$)	-3.22	-5.32	-4.17	-0.59
ΔMPC ($a/y \in (0, 0.2)$)	-3.21	0.71	**-2.80**	0.68
ΔMPC ($a/y \geq 0.2$)	-2.74	0.15	-0.16	0.14

C.3 Rationalizing mental accounting with temptation and self-control

Appendix D Details on the GE Model

D.1 Equilibrium system

Here I list the system of equilibrium equations for the HANK model in Section 5.

Household

Bellman equation

$$
\begin{aligned}
V_t(a,z,e) &= \max_{c,a'} \left\{ \frac{c^{1-\sigma}}{1-\sigma} - \mathbf{1}\{c > y_t(z,e)\} v(c, y_t(z,e)) + \beta e^{\nu_t^d} \mathbb{E}_t \left[V_{t+1}(a',z',e') | z,e \right] \right\} \\
c + \frac{a'}{R_t^n} &= y_t(z,e) + \frac{a}{\Pi_t} \\
y_t(z,e) &= (1-\tau_t)([e + (1-e)\cdot b] w_t z)^{1-\xi} + \mathcal{T}_t \\
v(c, y_t(z,e)) &= \psi \left(\frac{c^{1-\sigma}}{1-\sigma} - \frac{y_t(z,e)^{1-\sigma}}{1-\sigma} \right) \\
a' &\geq \underline{a}
\end{aligned}
$$

Solution gives aggregate consumption, asset demand, and labor supply

$$C_t = \int c_t(a,z,e)\, dF_t(a,z,e) \tag{D.1}$$

$$A_{t+1} = \int a_t'(a,z,e)\, dF_t(a,z,e) \tag{D.2}$$

$$N_t = \int ze\, dF_t(a,z,e) \tag{D.3}$$

Labor transition matrix

$$Q_t^e = \begin{bmatrix} 1-\delta+\delta f_t & \delta(1-f_t) \\ f_t & 1-f_t \end{bmatrix} \tag{D.4}$$

Goods market

Production

$$Y_t = N_t \tag{D.5}$$

NKPC

$$\log \Pi_t = \kappa_p \left(p_t^\ell - \frac{\epsilon-1}{\epsilon} \right) + \mathbb{E}_t \left[\frac{\Pi_{t+1}}{R_t^n} \cdot \frac{Y_{t+1}}{Y_t} \cdot \log \Pi_{t+1} \right] \tag{D.6}$$

Labor market

Job match value to labor agency

$$J_t = (p_t^\ell - w_t)\,\mathbb{E}[z] + (1-\delta)\,\mathbb{E}_t\left[\frac{\Pi_{t+1}}{R_t^n} J_{t+1}\right] \tag{D.7}$$

No entry condition

$$k = q_t J_t \tag{D.8}$$

Wage rule

$$w_t = w_{ss} \tag{D.9}$$

Aggregate matching function

$$\mathcal{M}_t = \frac{\mathcal{U}_t \mathcal{V}_t}{(\mathcal{U}_t^\alpha + \mathcal{V}_t^\alpha)^{\frac{1}{\alpha}}} \tag{D.10}$$

Vacancy-filling rate and job-finding rate

$$q_t = \frac{\mathcal{M}_t}{\mathcal{V}_t} \tag{D.11}$$

$$f_t = \frac{\mathcal{M}_t}{\mathcal{U}_t} \tag{D.12}$$

Government

Monetary policy

$$\log R_t^n = \max\left\{ \log R_{ss} + \phi_\pi \log \Pi_t + \phi_u(\mathcal{U}_t - \mathcal{U}_{ss}), 0\right\} \tag{D.13}$$

Government budget

$$B_{t+1} = R_t^n \left(\frac{B_t}{\Pi_t} + G_t + UI_t - T_t\right) \tag{D.14}$$

Fiscal rule

$$T_t - T_{ss} = (1-\rho_B)\left(\frac{B_t}{\Pi_t} - B_{ss} + G_t - G_{ss} + UI_t - UI_{ss}\right) \tag{D.15}$$

Tax revenue

$$T_t = w_t N_t + UI_t - (1-\tau_t)\int [e + (1-e)\cdot b] w_t z)^{1-\xi}\, dF_t(a,z,e) - \mathcal{T}_t \tag{D.16}$$

Aggregate equations

Resource constraint

$$Y_t - k\mathcal{V}_t = C_t + G_t + D_t \tag{D.17}$$

Asset market clearing

$$A_{t+1} = B_{t+1} \tag{D.18}$$

D.2 Solution method

Here I describe the algorithm for solving a rational expectation equilibrium. The algorithm is proposed by Lin and Peruffo (2024) and is built upon the Sequence-Space Jacobian method of Auclert et al. (2021).

Let $t = 0$ be the period the shock hits. In the following, the notation x_t^τ represents the value of a variable x at time t conditional on the shock dissipates at time τ.

1. Choose a truncation horizon $T \gg 0$ after which the shock dissipates for certain. In practice, I choose $T = 200$ and do not find the results change when further increasing the value.

2. Recall that the shock is first-order equivalent to an AR(1) shock. Solve for the associated perfect foresight equilibrium $(\mathbf{X}_t^{PF})_{t=0}^T$ using the quasi-Newton algorithm and the sequence-space Jacobians. In particular, compute the path of distributions $(F_t^{PF})_{t=0}^T$ and set $F_\tau^\tau = F_\tau^{PF}$ $\forall \tau > 0$.

3. For each $\tau > 0$, given the distribution F_τ^τ at the period when the shock dissipates, solve for the associated transition path to the steady state $(\mathbf{X}_t^\tau)_{t=\tau}^{\tau+T}$. Note that this step can be parallelized.

4. Use the value functions $(V_\tau^\tau)_{\tau=1}^T$ solved in step 3 to iterate backward the household Bellman equation. Compute the implied aggregate consumption, asset demand, labor supply.

5. Using the quasi-Newton algorithm and the sequence-space Jacobians, update the stochastic paths $\{(\mathbf{X}_t^\tau)_{t=0}^{\tau-1}\}_{\tau=1}^T$. Note that for all $\tau > 0$, we have

$$\mathbf{X}_t^\tau = \mathbf{X}_t^{\tau+j} \quad \forall t < \tau,\, j \geq 0$$

   In particular, compute the path of distributions $(F_\tau^\tau)_{\tau=1}^T$.

6. Repeat step 3-5 until the stochastic paths $\{(\mathbf{X}_t^\tau)_{t=0}^{\tau-1}\}_{\tau=1}^T$ converge.