Does Unemployment Risk Affect Business Cycle Dynamics?

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Abstract

In this paper, I show that the decline in consumption during unemployment depends on both liquid and illiquid wealth; that unemployment predicts illiquid asset withdrawal, primarily when households have few liquid assets; and that increased idiosyncratic unemployment risk leads to a rise in saving overall, but also to a decline in investment in illiquid assets. Motivated by these new findings, I embed endogenous unemployment risk in a two-asset heterogeneous-agent New Keynesian model. The model is consistent with the new evidence and suggests that aggregate shocks are amplified by a flight-to-liquidity when unemployment risk rises, particularly when monetary policy is constrained.

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1 Introduction

Unemployment spells are the largest source of income risk that households face. Yet the majority of household wealth is held in illiquid assets, which are not well suited to smoothing consumption during unemployment. In this paper, I study the implications of these facts in a model with endogenous unemployment risk in which households trade both liquid and illiquid assets. The combination of these features provides a propagation mechanism for aggregate shocks, driven by a "flight-to-liquidity" that occurs when households face higher unemployment risk. It also suggests that an important role for unemployment insurance is its ability to dampen this amplification by lessening the cyclicality of household income risk.

I begin by presenting new empirical evidence on the relationship between unemployment, the liquidity of asset holdings, and consumption. First, using data from the Consumer Expenditure Survey and the Panel Study of Income Dynamics, I show that the size of the decline in consumption during unemployment spells depends on both a household's liquid and illiquid asset positions. In particular, the consumption decline is smallest for households with significant liquid asset holdings, larger for households with only illiquid assets, and largest for households with few assets of either type.[1] This finding suggests that households principally use their liquid wealth to smooth consumption during unemployment, but are partially able to access their illiquid wealth if required. This is consistent with my second finding: I use data from the Survey of Consumer Finances to show that unemployment spells predict withdrawal from illiquid asset holdings, primarily when the unemployment spell is long or when the household has few liquid assets.

Taken together, the above evidence on consumption and illiquid asset adjustment during unemployment spells suggests that it is costly for households to use their illiquid wealth to smooth consumption during unemployment, and consequently that households will vary their liquid and illiquid asset holdings depending on the unemployment risk that they face. I use data from the Survey of Consumer Expectations to show that this is the case. I find that saving increases overall when idiosyncratic unemployment risk rises, but that investment in illiquid assets declines, consistent with a precautionary flight-to-liquidity mechanism.

Motivated by this empirical evidence, I study a heterogeneous-agent New Keynesian (HANK)

[1] In the terminology of Kaplan, Violante and Weidner (2014), the first group are non hand-to-mouth households, the second are the wealthy hand-to-mouth, and the third are the poor hand-to-mouth.

model in which households trade both liquid bonds and illiquid capital, and are subject to endogenous unemployment risk due to search frictions in the labor market. First, I show that this model is consistent with all the above findings. I then study the response of the economy to aggregate shocks in order to answer the following questions: How does household demand for liquid and illiquid assets change when unemployment risk rises? Does this affect business cycle dynamics? Does unemployment insurance play an important role as an automatic stabilizer?

I find that the interaction of illiquid assets and endogenous unemployment risk provides an important propagation mechanism for aggregate shocks. Higher unemployment risk triggers a flight-to-liquidity: households increase their demand for liquid assets, as these are the best suited to smoothing consumption during unemployment spells. Conversely, demand for illiquid capital declines. In the presence of sticky prices, this decline in investment leads to lower output and higher unemployment, prompting a feedback loop between unemployment risk and aggregate demand. A key feature of the model is that income risk responds endogenously to aggregate shocks through changes in the unemployment rate. I use the Current Population Survey to show that this is confirmed in the data: the cyclicality of income risk is driven by changes in unemployment risk.[2]

If there is no unemployment insurance, this propagation mechanism implies that the response of unemployment or output is around 30% larger than in a version of the model with no idiosyncratic unemployment risk. Unemployment insurance provides a source of consumption smoothing during unemployment spells, and consequently dampens the flight-to-liquidity and the feedback loop between unemployment risk and aggregate demand. Quantitatively, I find that unemployment insurance removes around half of the amplification that the flight-to-liquidity mechanism provides. Unemployment insurance is even more important when monetary policy is constrained, as the feedback loop between unemployment risk and aggregate demand is significantly strengthened at such times.

I show the importance of the flight-to-liquidity mechanism by comparing the results from this two-asset model to those from various models where households have access to one liquid asset. Even if such models are calibrated to match the same decline in consumption during unemployment as in the data, unemployment risk and unemployment insurance have little

[2] Guvenen, Ozkan and Song (2014) use Social Security Administration data to show that the skewness of the income growth distribution is strongly pro-cyclical. The role of unemployment cannot be studied in their data, as it does not include a measure of time spent employed.

effect on business cycle volatility, as they lack the flight-to-liquidity and decline in investment demand that occurs in the two-asset model.

The two-asset model can also be used to study policies that affect asset adjustment costs. I consider the effect of various policies that temporarily reduce the tax faced by individuals that make a withdrawal from their illiquid asset holdings, motivated by a policy that was included in the CARES Act in response to the COVID-19 pandemic. The model implies that the particular policy included in the CARES Act, a short-lived and quickly-reversed removal of the withdrawal tax, was contractionary: such a reduction in withdrawal costs leads to a synchronized withdrawal of illiquid assets and a significant decline in investment.

1.1 Literature Review

The empirical evidence on the consumption response to unemployment spells in this paper builds on previous work by Gruber (1997), Aguiar and Hurst (2005), Chodorow-Reich and Karabarbounis (2016), Kolsrud, Landais, Nilsson and Spinnewijn (2018) and others. These papers either estimate the average consumption decline during unemployment or focus on heterogeneity related only to liquid asset holdings. I provide evidence that illiquid asset holdings are also an important determinant of the response of household consumption to unemployment.

The evidence on illiquid asset withdrawal during unemployment spells is consistent with contemporaneous work by Coyne, Fadlon and Porzio (2022). While I use data from the SCF, they find a similar relationship between unemployment and penalized withdrawals from retirement accounts using U.S. tax records. While the SCF has drawbacks relative to such administrative data, offering a much smaller sample with more measurement error, it also has some benefits: I am able to use questions about asset holdings and the length of unemployment spells to show that the relationship between unemployment and early withdrawals from retirement accounts is primarily driven by individuals whose unemployment spell is long or whose unemployment spell occurs when they have few liquid assets.

Turning to the evidence on precautionary saving, Basten, Fagereng and Telle (2016) use Norwegian administrative data to provide evidence of an increase in saving and a shift toward safe assets in the years leading up to an unemployment spell. While they do not study the effect of unemployment risk on illiquid asset holdings, their evidence of an increase in saving overall is consistent with my results from the SCE. To the best of my knowledge, my paper is the first to provide empirical evidence of the effect of unemployment risk on precautionary saving and portfolio allocation using a direct measure of job loss expectations.

A number of recent papers have investigated the source of the pro-cyclical skewness of the income growth distribution documented by Guvenen et al. (2014). I use the Current Population Survey (CPS) to show that this is driven entirely by cyclicality in the distribution of changes in time employed. For workers that do not experience unemployment, the skewness of the income growth distribution exhibits no cyclicality. This is consistent with evidence from Italian data provided in Hoffmann and Malacrino (2019).

This paper also contributes to the literature studying the aggregate implications of unemployment risk in HANK models. Previous papers have disagreed on whether or not unemployment risk amplifies business cycle dynamics in such models. For example, Ravn and Sterk (2017) study a one-asset model without capital. Their baseline version of the model features a degenerate wealth distribution and has the feature that unemployment risk strongly amplifies business cycle fluctuations. On the other hand, Gornemann, Kuester and Nakajima (2016) study a one-asset model with capital that is calibrated to match total household wealth. In their model, where households hold a large quantity of liquid assets, business cycle volatility is unaffected by unemployment risk: unemployment risk leads to more volatile consumption but less volatile investment.

While the above results suggest that the presence of capital is the key determinant of whether or not unemployment risk amplifies the response to aggregate shocks, it is unfortunately not that simple. Challe, Matheron, Ragot and Rubio-Ramirez (2017) estimate a HANK model featuring liquid capital. They achieve tractability by assuming that risk-sharing takes place between employed households, such that the wealth distribution converges to a small number of mass points. They find that unemployment risk amplifies business cycle dynamics in response to some aggregate shocks but not others.[3] Finally, one other paper that studies unemployment risk in a model with multiple assets is Den Haan, Rendahl and Riegler (2017). The key difference between my model and theirs is that both assets in their model are liquid.[4] Whether or not unemployment risk amplifies business cycles in their model depends crucially on the degree of nominal wage stickiness.

Taken together, these papers suggest that whether or not unemployment risk amplifies busi-

[3] Cho (2023) studies an extension of their model where the liquid wealth distribution does not have finite support and finds very little amplification from unemployment risk.

[4] The two-assets in their model are bonds and equity in the firms that post vacancies in the labor market.

ness cycles depends crucially on the asset structure of the economy. In this paper, I provide a quantitative assessment of the amplification provided by unemployment risk in a model that matches the distribution of both liquid and illiquid asset holdings, as well as new evidence on the consumption response to unemployment spells, the relationship between unemployment and illiquid asset adjustment, and the relationship between unemployment risk and saving in both liquid and illiquid assets. I find that unemployment risk does significantly amplify business cycle fluctuations in this environment.

By studying a HANK model with liquid and illiquid assets, my paper is closely related to the burgeoning literature following Kaplan, Moll and Violante (2018). My paper introduces search frictions in the labor market of such models. The flight-to-liquidity mechanism in the two-asset model in my paper is related to that studied by Bayer, Lütticke, Pham-Dao and Tjaden (2019). In a two-asset model with a competitive labor market, they show that uncertainty shocks to households' idiosyncratic productivity can lead to a decline in investment and output. The mechanism in their model is operative in response to exogenous uncertainty shocks to idiosyncratic productivity. In my model, income risk is endogenous, as any shock that affects the unemployment rate also affects household income risk.

Finally, this paper contributes to the literature studying the role of unemployment insurance as an automatic stabilizer, such as Kekre (2016) and McKay and Reis (2016). The latter paper uses a one-asset HANK model and finds that automatic stabilizers have little effect on business cycle volatility when monetary policy is not constrained. My contribution to this strand of the literature is to show that unemployment insurance can affect business cycle volatility in a model with liquid and illiquid assets, through its ability to dampen the flight-to-liquidity that occurs when unemployment rises.

The rest of the paper is organized as follows. Section 2 shows that the consumption response to unemployment spells depends on both liquid and illiquid asset holdings. Section 3 documents the relationship between unemployment and the withdrawal of illiquid assets. Section 4 provides new evidence on the effect of unemployment risk on household saving behavior. Section 5 describes the two-asset model, and Section 6 shows that it is consistent with the empirical evidence. Section 7 studies the impact of an aggregate productivity shock in the two-asset model and compares this with the results from one-asset models. Section 8 studies a temporary removal of the withdrawal tax on illiquid assets, as in the CARES Act. Section 9 concludes.

2 Consumption Response to Unemployment Spells

In this section, I show that the decline in household consumption during unemployment spells depends on both liquid and illiquid asset positions.

Methodology As in Kaplan et al. (2014), I classify households as non hand-to-mouth if they have significant liquid asset holdings, wealthy hand-to-mouth if they have few liquid assets but significant illiquid asset holdings, and poor hand-to-mouth if they have few liquid or illiquid assets. I then estimate the response of consumption to unemployment spells using the following specification:

$$\log C_{i,t} = \boldsymbol{\beta X_{i,t}} + \gamma_N U_{i,t}\mathbb{1}\{\text{N-HTM}\} + \gamma_W U_{i,t}\mathbb{1}\{\text{W-HTM}\} + \gamma_P U_{i,t}\mathbb{1}\{\text{P-HTM}\} + \epsilon_{i,t} \quad (2.1)$$

where $C_{i,t}$ denotes household consumption, $U_{i,t} \in [0, 1]$ denotes the fraction of the year that the household spent unemployed, and the indicator variables denote the liquid/illiquid asset status of the household. Chodorow-Reich and Karabarbounis (2016) use the same specification to estimate the average consumption response to unemployment spells, without conditioning on asset positions. As in their specification, I include an extensive set of controls in $\boldsymbol{X_{i,t}}$: region-year fixed effects; race, education, age and age squared of the household head; family size and family size squared; housing tenure; number of cars owned by the household; rental value of the household's home (split into deciles by region and year); hand-to-mouth status; and the fraction of the year spent out of the labor force.

The coefficients γ_N, γ_W, and γ_P measure the decline in log consumption during unemployment for households that are either non-hand-to-mouth, wealthy-hand-to-mouth, or poor-hand-to-mouth. Using cross-sectional variation to identify the consumption decline during unemployment relies on the assumption that the set of control variables is large enough to eliminate any omitted variable bias coming from a correlation between unemployment spells and unobservables. As an alternative, I estimate the following panel regressions based on within-household variation in consumption:

$$\Delta \log C_{i,t} = \alpha_t + \gamma_N \Delta U_{i,t}\mathbb{1}\{\text{N-HTM}\} + \gamma_W \Delta U_{i,t}\mathbb{1}\{\text{W-HTM}\} + \gamma_P \Delta U_{i,t}\mathbb{1}\{\text{P-HTM}\} + \Delta\epsilon_{i,t} \quad (2.2)$$

Data To estimate equation 2.1, I use data from the Consumer Expenditure Survey (CEX) for the period from 1996 to 2017, restricting the sample to households whose head is between the ages of 25 and 55. I follow Chodorow-Reich and Karabarbounis (2016) and use a consumption measure that covers spending on non-durables and services. The CEX measures liquid asset holdings well, but has little information on illiquid asset holdings. I therefore use homeownership as a proxy for positive illiquid asset holdings.[5] I define households as hand-to-mouth if they are in the bottom 50% of the liquid asset distribution at the beginning of the year that they participate in the CEX.[6] I then define them as wealthy hand-to-mouth if they are also homeowners, and as poor hand-to-mouth if they are not.

To estimate equation 2.2, I use biennial data from the Panel Study of Income Dynamics (PSID) for the period from 2005 to 2017. As in the CEX, I restrict the sample to households whose head is between the ages of 25 and 55. As well as having a shorter sample than the CEX, the PSID also includes less information on consumption: the measure I use is spending on food, clothing, recreation and vacations. On the other hand, the PSID does have more accurate information on illiquid wealth holdings: I measure illiquid wealth as housing equity plus the value of retirement accounts and define households as wealthy if their illiquid wealth is greater than zero. Given the biennial nature of the PSID in this period, I group households based on their asset holdings in year $t-2$. Appendices B.1 and B.2 contain further details on the construction of the datasets.

Results The results of estimating equations 2.1 and 2.2 are shown in Table 1. The estimated consumption declines are very similar using both the cross-sectional variation in the CEX and the within-household variation in the PSID. Columns 1 and 4 show estimates of the average response of consumption to unemployment without interacting unemployment with the asset indicator variables. I find that consumption is 20-25% lower during unemployment on average, in line with previous estimates.[7]

Columns 2 and 5 show the estimates when I split households only on the basis of their liquid asset holdings. The estimated consumption decline during unemployment is strongly

[5] In Appendix B.1 I use data from the Survey of Consumer Finances to show that homeownership is a good proxy for illiquid asset holdings.

[6] Kaplan et al. (2018) report that 15% of households have negative liquid asset holdings and a further 30% of households have liquid asset holdings close to zero.

[7] A large literature has studied the average response of consumption to unemployment. Chodorow-Reich and Karabarbounis (2016) find similar estimates in both the CEX and PSID. Aguiar and Hurst (2005) use the Continuing Survey of Food Intake of Individuals (CSFII) to estimate that food expenditure falls by 19% during unemployment.

Table 1: Consumption Response to Unemployment Spells

	CEX			PSID		
	(1)	(2)	(3)	(4)	(5)	(6)
$U_{i,t}$	-0.22			-0.26		
	(0.015)			(0.051)		
$U_{i,t}\mathbb{1}\{\text{N-HTM}\}$		-0.14	-0.14		-0.14	-0.14
		(0.026)	(0.026)		(0.069)	(0.069)
$U_{i,t}\mathbb{1}\{\text{HTM}\}$		-0.26			-0.32	
		(0.019)			(0.065)	
$U_{i,t}\mathbb{1}\{\text{W-HTM}\}$			-0.23			-0.28
			(0.027)			(0.131)
$U_{i,t}\mathbb{1}\{\text{P-HTM}\}$			-0.30			-0.34
			(0.026)			(0.074)
$H0 : \gamma_N = \gamma_H$		0.00			0.02	
$H0 : \gamma_N = \gamma_W = \gamma_P$			0.00			0.11
$H0 : \gamma_W = \gamma_P$			0.06			0.71

Notes: Robust standard errors in parentheses. PSID standard errors are clustered by household head. Regressions weighted using sampling weights. The final three rows report the p-values for different Wald tests. CEX uses 31638 observations from 1996-2017. PSID uses 17892 observations from 2005-2017.

influenced by a household's liquid asset position. Non hand-to-mouth households are able to use their liquid assets to smooth consumption during unemployment, and their consumption declines by around 15% on average. Hand-to-mouth households are less able to smooth their consumption, which declines by 25-30% on average.

Columns 3 and 6 estimate the regressions in full, now splitting hand-to-mouth households into two groups on the basis of their illiquid asset holdings. When liquid asset holdings are low, illiquid asset holdings appear to significantly affect the consumption decline during unemployment: the consumption of poor hand-to-mouth households declines by at least 30%, double the decline of non hand-to-mouth households. For the wealthy hand-to-mouth, the decline is around 25%, suggesting that illiquid assets provide households with at least some ability to smooth consumption during unemployment.

To formally test the hypothesis that the size of the consumption decline depends on liquid and illiquid asset positions, Table 1 also reports the p-values of Wald tests that (1) the decline is the same for hand-to-mouth and non hand-to-mouth households, (2) the decline is the same for all three groups, and (3) that the decline for the hand-to-mouth does not depend on illiquid asset holdings. In the cross-sectional regressions using the CEX, all hypotheses can be rejected at the 10% level, confirming that both liquid and illiquid asset positions are important for determining the size of the consumption decline during unemployment. Given the smaller sample in the PSID, the second and third hypothesis cannot be rejected in the regressions using within-household variation.

One concern with the approach used here is that differences in the consumption response to unemployment spells may reflect heterogeneity in the effect of unemployment spells on household labor income, rather than heterogeneity in the effect of a given decline in labor income on household consumption. In Appendix E I show that this is not the case: I find no evidence that the effect of a given unemployment spell on household labor income differs across the three groups.

3 Illiquid Asset Response to Unemployment Spells

The findings in the previous section suggest that illiquid assets can play a role in smoothing consumption during unemployment spells. I now turn to data from the Survey of Consumer Finances (SCF) to understand the relationship between unemployment spells and illiquid asset holdings. I find that unemployment is a strong predictor of illiquid asset withdrawal, and that this effect is primarily driven by unemployment spells that are either long or occur when a household has few liquid assets.

Data I use data from the SCF from 2004 to 2019. To measure the withdrawal of illiquid assets, I focus on early withdrawals from tax-deferred individual retirement accounts (IRAs).[8] Such withdrawals are generally subject to a 10% penalty, making them a clear example of illiquid asset adjustment.[9] Along with housing equity, retirement accounts are one of the key components of illiquid asset holdings, making up around a fifth of all household wealth. I restrict the sample to households whose head is at most 55 years of age and has an IRA. More details on the sample are included in Appendix B.3.

Results Table 2 reports the annual probability of an early withdrawal for different groups

[8] The SCF question about withdrawals from retirement accounts is specifically asked in relation to IRA/Keogh accounts, and does not relate to employer-sponsored accounts such as a 401(k).

[9] For Roth IRAs this penalty applies to earnings but not contributions. I obtain very similar results if I remove households with Roth IRAs from the sample.

Table 2: Illiquid Asset Withdrawal Probabilities

	Data	95% C.I.	p-value
Full Sample	0.046	(0.039, 0.054)	
No Unemployment Spell	0.040	(0.033, 0.048)	0.000
Unemployment Spell	0.105	(0.073, 0.138)	
Short Unemployment Spell	0.058	(0.026, 0.096)	0.007
Long Unemployment Spell	0.159	(0.103, 0.220)	
Unemployment Spell & Non-HTM	0.048	(0.010, 0.096)	0.007
Unemployment Spell & HTM	0.134	(0.084, 0.190)	

Notes: Probabilities constructed using sampling weights from households in the 2004 to 2019 waves of the SCF. I define an unemployment spell as short for households whose head was unemployed for 12 weeks or less. I define a household as hand-to-mouth if they have less than the median level of liquid assets. The first three sections use a sample of 4863 households. The last section uses a sample of 3649 households. Bootstrapped confidence intervals in parentheses. p-values calculated using Fisher's exact test.

of households. The first row shows that between four and five percent of households make an early withdrawal from their retirement account in a given year. The next two rows split the sample depending on whether or not the household head experienced an unemployment spell that year. Households whose head had an unemployment spell are between two and three times as likely to have made an early withdrawal from their retirement account as those whose head was employed for the whole year. This provides evidence that the withdrawal of such illiquid assets is an important way that many households smooth their consumption in the face of unemployment shocks.

Next, I further divide the sample of households whose head was unemployed into two groups, based on the length of the unemployment spell. Households whose head was unemployed for more than 12 weeks were nearly three times as likely to make an early withdrawal than those whose head was unemployed for 12 weeks or less.

Finally, I split the sample of unemployed households based on their liquid asset holdings. As in Section 2, I define households as being hand-to-mouth if they are in the bottom 50% of the liquid asset distribution. The last two rows of Table 2 show that households with low liquid asset holdings were almost three times as likely to make an early withdrawal than those who had high liquid asset holdings if their head had an unemployment spell. Overall, these results are consistent with the idea that liquid assets are the primary source of consumption smoothing for unemployed households, but that illiquid assets are also used when households have depleted their liquid asset holdings.

The second column of Table 2 provides bootstrapped confidence intervals for each of these probabilities, while the third column reports the p-value for tests that the probability of withdrawal does not depend on employment status, the length of the unemployment spell, or liquid asset holdings. In all cases, the null hypothesis that withdrawal probabilities are the same across the two groups can be rejected at the 1% level.

The withdrawal probabilities in Table 2 do not control for other observable variables that may be correlated with an individual's employment status and their withdrawal probability. In Appendix D I show that the results are unaffected by the addition of controls for age, education, race, family size and year.

4 Precautionary Response to Unemployment Risk

The evidence in the previous two sections shows that illiquid assets provide some ability for households to smooth consumption during unemployment spells, and that households turn to these assets primarily when they have exhausted their liquid asset holdings. I now turn to considering how unemployment risk affects household behavior during employment rather than unemployment.

The findings in Sections 2 and 3 suggest that both the level of saving and the choice of which assets to save in should be closely related to expectations about the risk of becoming unemployed. To assess this, I use data from Survey of Consumer Expectations (SCE) administered by the Federal Reserve Bank of New York. Importantly for my purposes, this survey contains data on individual's perceptions of the unemployment risk that they face.

I find that consumption spending declines significantly when a household head's unemployment risk rises. This suggests that households respond to higher unemployment risk by increasing their precautionary saving. I then show that an increase in unemployment risk decreases the amount of their income that household heads plan to invest in their retirement accounts, an important form of illiquid wealth, as discussed in Section 3. Thus, households both increase their saving overall, and decrease their saving in illiquid assets, in response to higher unemployment risk. Overall, this is consistent with a precautionary flight-to-liquidity motive when unemployment risk rises.

Data I use data from the SCE from 2014 to 2019. The survey occurs monthly, and interviews roughly 1,300 households heads each month. Respondents participate in the survey for up to twelve months. In addition to the main survey, which is fielded monthly, I use data from the Household Spending supplement, which is fielded every four months, as well as the Household Finance supplement, which was fielded once a year between 2014 and 2019.

From the main survey, I obtain estimates of perceived unemployment risk: employed household heads are asked every month to report their estimate for the probability that they will lose their job in the following 12 months. I denote this $\mathbb{E}_{i,t}[s^i_{t,t+12}]$. I am interested in understanding how household consumption and saving decisions are affected by unemployment risk, both in terms of the level of saving overall and also in terms of how unemployment risk affects household portfolio decisions. Consequently, from the Household Spending supplement I obtain data on household consumption. Respondents are first asked whether their current consumption spending is higher or lower than it was 12 months ago. They are then asked a second question to put the change in consumption spending in percentage terms. I use an indicator, $\mathbb{1}\{c^i_t \geqslant c^i_{t-12}\}$, to denote that individual i reports consumption spending that is "about the same or higher" than 12 months ago. I denote the percentage change in consumption from 12 months ago by $\frac{c^i_t - c^i_{t-12}}{c^i_{t-12}}$.[10]

Finally, from the Household Finance supplement, I obtain data on household asset allocation. Specifically, respondents who report having Defined Contribution pension accounts are asked whether they expect to increase, decrease, or leave unchanged the proportion of their earnings that they contribute to this pension account in the next 12 months, relative to the last 12 months. I summarize this by an indicator, $\mathbb{1}\{\mathbb{E}_{i,t}[P^i_{t,t+12} > P^i_{t-12,t}]\}$, which denotes that individual i expects to increase their pension contributions in the next year.

Using this data, I run regressions of the following form:

$$Y_{i,t} = \boldsymbol{\beta X_{i,t}} + \gamma \Delta_9 \mathbb{E}_{i,t}[s^i_{t,t+12}] + \epsilon_{i,t} \tag{4.1}$$

$Y_{i,t}$ is the outcome of interest: one of the measures of consumption changes or the expected change in pension contributions. $\Delta_9 \mathbb{E}_{i,t}[s^i_{t,t+12}]$ is the change in the perceived job loss probability over the past 9 months, and $\boldsymbol{X_{i,t}}$ is a vector of control variables: time fixed effects;

[10] A very small number of individuals report extreme values when asked to put a percentage value on their annual change in consumption. Thus, I winsorize the 0.5% largest values of this variable.

Table 3: Precautionary Response to Unemployment Risk

	(1)	(2)	(3)
	$\mathbb{1}\{c_t^i \geqslant c_{t-12}^i\}$	$\frac{c_t^i - c_{t-12}^i}{c_{t-12}^i}$	$\mathbb{1}\{\mathbb{E}_{i,t}[P_{t,t+12}^i > P_{t-12,t}^i]\}$
$\Delta_9 \mathbb{E}_{i,t}[s_{t,t+12}^i]$	-0.28	-0.038	-0.31
	(0.07)	(0.014)	(0.14)
Observations	946	942	260

Notes: Estimates from estimating equation 4.1. Dependent variable shown in the second row. c_t^i denotes household consumption of individual i in month t. $\mathbb{1}\{\mathbb{E}_{i,t}[P_{t,t+12}^i > P_{t-12,t}^i]\}$ is an indicator denoting that individual i expects to increase the proportion of earnings contributed to their Defined Contribution pension over the next year. $\Delta_9 \mathbb{E}_{i,t}[s_{t,t+12}^i]$ denotes the change in the perceived annual job loss probability of individual i from month $t-9$ to t. Robust standard errors in parentheses. Regressions weighted using sampling weights. In column (2) I winsorize to remove the most extreme 0.5% of consumption growth observations. Data from the Survey of Consumer Expectations from 2014 to 2019.

age, age squared, gender and education of the household head; and the household's SCE income group. I use the 9-month change in job loss expectations in order to investigate the effect of a persistent change in perceived unemployment risk while preserving the size of the sample.

As in the SCF, I restrict the sample to households whose head is at most 55 years of age. I also only include individuals who report having been employed in the same job for at least one year. This bolsters my confidence that the results on changes in consumption expenditure are due to changes in precautionary saving, rather than changes in household income. More details are included in Appendix B.4. In Appendix F, I show the robustness of my results to using the 10- or 11-month change instead.[11]

Results Table 3 provides the results of estimating equation 4.1 with three different dependent variables. First, in column (1), the dependent variable is the indicator for household consumption spending being higher than a year before. I find that an increase in perceived unemployment risk significantly lowers the probability that household consumption spending has increased. The standard deviation of the 9-month change in perceived unemployment

[11]Using the 11-month change shrinks the sample by roughly two-thirds relative to the 9-month change. The small size of the SCE sample is particularly notable for the regression using the Household Finance supplement, given that this was only administered annually for six years.

risk is 20%. Thus, a one standard deviation increase in perceived unemployment risk is associated with a roughly 6 percentage point lower likelihood that household spending has increased.[12]

In column (2) the dependent variable is the reported percentage change in consumption spending. Using this measure, I am able to quantify the decline in spending when unemployment risk rises. The estimated coefficient implies that a 20% rise in perceived unemployment risk is associated with a 0.7-0.8% decline in consumption spending.

Thus, the results in column (1) and column (2) provide evidence that households cut back their consumption spending, and thus increase their saving, when unemployment risk rises. To understand whether households increase their liquid or illiquid asset holdings, in column (3) the dependent variable is an indicator that is equal to one if the individual expects to invest a higher proportion of their earnings in their pension in the next year, relative to the previous year. The estimated coefficient implies that a 20% rise in perceived unemployment risk leads to a 6 percentage point decline in the probability that the individual expects to increase their pension contributions. Roughly 30% of individuals report that they expect to increase the proportion of their earnings that they contribute on average, so this suggests that higher perceived unemployment risk leads to a quantitatively significant decline in illiquid asset investment.

In conclusion, evidence from the SCE shows that households respond to increased unemployment risk by saving more overall, but by saving less in illiquid forms of wealth. This is consistent with the evidence from the previous sections, which suggested that liquid assets are preferable for consumption smoothing during unemployment spells.

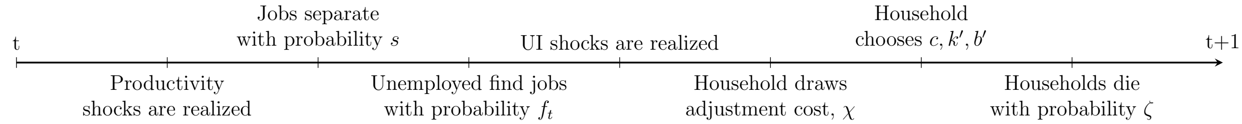
5 A Two-Asset Model with Unemployment

Motivated by the empirical evidence in the previous sections, I now study the role of endogenous unemployment risk in a heterogeneous-agent New Keynesian model with both liquid and illiquid assets. As in Kaplan et al. (2018), households trade both liquid assets (nominal bonds) and illiquid assets (physical capital).[13] Search frictions in the labor market render

[12] On average, individuals report a 14% chance that they will lose their job in the next year. 80% of individuals report consumption being "about the same or higher" than a year before.

[13] I follow Kaplan et al. (2018) in calibrating the model assuming that housing, business equity, and durables are illiquid assets. In an earlier version of this paper, Graves (2020), I showed that the main results are the same if the illiquid asset in the model is housing rather than productive capital.

Figure 1: Model Timeline



unemployment, and consequently income risk, endogenous to aggregate shocks.

In the model, households face a trade-off when choosing their asset portfolio. Bond holdings can be adjusted without cost, but offer a low rate of return. Capital offers a higher return, but is costly to adjust. As bonds are liquid, they are well suited to smoothing consumption in response to transitory income shocks, such as unemployment spells. The key mechanism in this model is that a household's optimal asset portfolio depends on the level of unemployment risk in the economy, leading to a time-varying preference for holding liquid assets.

Households Time is discrete. There is a continuum of infinitely-lived households that supply labor inelastically, derive utility from consumption, and trade both liquid and illiquid assets. Households' idiosyncratic labor productivity follows an exogenous Markov process. Households are also subject to shocks to their employment status. In each period, households that choose to adjust their illiquid asset position pay a random adjustment cost, described in more detail below. In order to study the effect of the CARES Act, which reduced the tax on early withdrawals from retirement accounts, I also assume that households that withdraw from their illiquid asset holdings are required to pay a tax, τ_k. At the end of each period, a fraction ζ of households dies and is replaced by new households with zero wealth.[14] The government receives the assets of the dying households, effectively levying a 100% estate tax. Within a period, the timing of events is shown in Figure 1.

For households that choose to adjust their illiquid asset holdings, the recursive problem is:

$$V_t^A(b,k,z,e) = \max_{c,b',k'} \frac{c^{1-\gamma}}{1-\gamma} + \beta(1-\zeta)\mathbb{E}_{e',z'} V_{t+1}(b',k',z',e') \tag{5.1}$$

subject to

$$k' + b' + c + \tau_k \mathbb{1}\{k' < k\}(k - k') = \mathbb{1}\{e = E\} w_t z(1-\tau_l) + \mathbb{1}\{e = U\} w_t \phi(z)(1-\tau_l) + R_t^b(b)b + R_t^k k + T_t$$

[14]As in Kaplan et al. (2018), this assumption helps the model to match the wealth distribution in the data.

$$b' \geqslant -\underline{\mathrm{b}}$$
$$k' \geqslant 0$$
$$z' = \Gamma(z)$$

where b and k denote bond and capital holdings, z is the household's idiosyncratic productivity, and $e \in \{E, U, N\}$ is the household's employment status, equal to E if employed, U if unemployed and receiving unemployment insurance, or N if unemployed and not receiving unemployment insurance. If employed, the household receives wage w_t per unit of labor productivity. If unemployed and receiving unemployment insurance, $e = U$, households receive benefits equal to $w_t\phi(z)$ per unit of labor productivity. Both sources of labor income are subject to a linear tax, τ_l. If unemployed and not receiving unemployment insurance, $e = N$, the household received no labor income. However, T_t denotes a lump-sum transfer which is received by all households.

Households face borrowing constraints on their holdings of both liquid bonds and illiquid capital. Illiquid asset holdings must be non-negative. Household are able to borrow up to $\underline{\mathrm{b}}$ units of the liquid asset. However, there is an exogenous wedge, κ, between the borrowing and lending rates on the liquid asset:[15]

$$R^b(b) = \begin{cases} \frac{1+i_t}{\Pi_t} & \text{if } b \geqslant 0 \\ \frac{1+i_t}{\Pi_t} + \kappa & \text{if } b < 0 \end{cases} \tag{5.2}$$

where i_t is the nominal interest rate set by the central bank, and Π_t is the gross rate of inflation. The return on the illiquid asset is derived from supplying capital services to the intermediate good producers at rate r_t^k. Capital services provided are the product of the utilization rate, u_t, and the household's holding of the illiquid asset, k. The rate of depreciation of capital is increasing in the utilization rate, as in Greenwood, Hercowitz and Huffman (1988).[16] Thus, the rate of return on the illiquid asset is:

$$R_t^k = 1 + r_t^k u_t - \delta_0 u_t^{\delta_1} \tag{5.3}$$

[15] This assumption helps to ensure a realistic distribution of liquid asset holdings: a large mass of households with close to zero liquid assets, and a share of around 15% of households with negative liquid asset holdings.

[16] Without variable capital utilization, the marginal product of labor, and thus the wage, would rise after a negative productivity shock that leads to a decline in employment and a consequent rise in the capital-labor ratio.

If the household doesn't adjust their illiquid asset holdings, their problem is:

$$
\begin{aligned}
V_t^{NA}(b,k,z,e) = \max_{c,b'} \frac{c^{1-\gamma}}{1-\gamma} + \beta(1-\zeta)\mathbb{E}_{z',e'}V_{t+1}(b',k,z',e') \qquad (5.4)\\
\text{subject to}\\
k + b' + c = \mathbb{1}\{e=E\}w_t z(1-\tau_l) + \mathbb{1}\{e=U\}w_t\phi(z)(1-\tau_l) + R_t^b(b)b + R_t^k k + T_t\\
b' \geqslant -\underline{\mathrm{b}}\\
z' = \Gamma(z)
\end{aligned}
$$

Illiquid Asset Adjustment Costs Each period, household's draw an iid adjustment cost, χ, from the uniform distribution on $[0,\bar{\chi}]$, denominated in units of utility. They then decide whether or not to adjust their capital holdings. Consequently, the value of the household's problem, conditional on a draw of χ is:

$$
V_t(b,k,z,e;\chi) = \max\{V_t^A(b,k,z,e) - \chi, V_t^{NA}(b,k,z,e)\} \qquad (5.5)
$$

The value before the draw of χ is:

$$
V_t(b,k,z,e) = \mathbb{E}_\chi V_t(b,k,z,e;\chi) \qquad (5.6)
$$

Such random adjustment costs have been used in the household context by Bayer et al. (2019) and in the firm context by Khan and Thomas (2008). When calibrating the model, I discipline the size of these adjustment costs using data on liquid and illiquid wealth holdings.

Idiosyncratic Shocks Households face idiosyncratic shocks to their employment status and to their productivity. Each period, employed households are separated to unemployment with exogenous probability s. Unemployed households find employment with endogenous probability f_t. If unemployed, the probability that households receive unemployment insurance is independent across periods and equal to ξ.[17] I assume that households whose employment is terminated may immediately re-enter employment.

[17] I assume that recipiency is random as there is no evidence in the SCF that recipiency is related to liquid asset holdings: 48% of households that have unemployment spells report receiving unemployment insurance, while the proportion is 50% for households with low liquid asset holdings and 45% for households with high liquid asset holdings.

Previous research has shown that having a realistic income process is crucial if models are to generate a realistic wealth distribution. A key feature of the data is the high level of kurtosis of the income growth distribution. By introducing infrequent large income changes, idiosyncratic unemployment risk helps to provide high kurtosis of income growth. However, to match the level seen in the data, I also assume that idiosyncratic productivity shocks are infrequent. Specifically:

$$\log z' = (1-\rho_z)\mu_z + \rho_z \log z + \epsilon_z \tag{5.7}$$

$$\epsilon_z = \begin{cases} N(0, \sigma_z^2) & \text{with prob } \lambda_z \\ 0 & \text{with prob } 1-\lambda_z \end{cases} \tag{5.8}$$

I introduce the normalization μ_z to ensure that the mean value of idiosyncratic productivity is equal to 1.

Final Good Producers There is a representative final good producer, which aggregates a continuum of intermediate goods according to the production function:

$$Y_t = \left(\int_0^1 y_{j,t}^{\frac{\epsilon-1}{\epsilon}} dj\right)^{\frac{\epsilon}{\epsilon-1}} \tag{5.9}$$

Their profit maximization problem leads to the following demand curve for intermediate goods:

$$y_{j,t}(p_{j,t}) = \left(\frac{p_{j,t}}{P_t}\right)^{-\epsilon} Y_t \tag{5.10}$$

$$P_t = \left(\int_0^1 p_{j,t}^{1-\epsilon} dj\right)^{\frac{1}{1-\epsilon}} \tag{5.11}$$

Intermediate Good Producers Intermediate goods are produced using both capital services, $k_{j,t}$, and labor, $n_{j,t}$, using the production function:

$$y_{j,t} = A_t k_{j,t}^{\alpha} n_{j,t}^{1-\alpha} \tag{5.12}$$

where A_t is the level of aggregate productivity. Intermediate good producers rent capital from households at rate r_t^k and labor from a representative labor agency at rate h_t. Their cost minimization problem implies the following value for their marginal cost of production:

$$m_t = \frac{1}{A_t}\left(\frac{r_t^k}{\alpha}\right)^{\alpha}\left(\frac{h_t}{1-\alpha}\right)^{1-\alpha} \tag{5.13}$$

I assume that intermediate good producers are owned by risk-neutral entrepreneurs who consume all profits each period. In Appendix J, I show that the results are similar if instead profits are distributed lump-sum to households. Price adjustment is subject to quadratic costs.[18] Given these assumptions, the recursive form of their price-setting problem is:

$$V_t^I(p_{j,t-1}) = \max_{p_{j,t}} Y_t\left\{\left(\frac{p_{j,t}}{P_t} - m_t\right)\left(\frac{p_{j,t}}{P_t}\right)^{-\epsilon} - \frac{\theta_P}{2}\log\left(\frac{p_{j,t}}{p_{j,t-1}}\right)^2\right\} + \beta V_{t+1}^I(p_{j,t}) \tag{5.14}$$

where θ_P governs the size of price adjustment costs. The solution to this problem implies the following New Keynesian Phillips Curve:

$$\log(\Pi_t) = \beta\frac{Y_{t+1}}{Y_t}\log(\Pi_{t+1}) + \frac{\epsilon}{\theta_P}(m_t - m^*) \tag{5.15}$$

where $m^* = \frac{\epsilon-1}{\epsilon}$ is the inverse of the steady-state mark-up and $\Pi_t = \frac{P_t}{P_{t-1}}$.

Labor Agency Intermediate good producers hire labor from a representative labor agency. This agency hires households in a frictional labor market by posting vacancies. I assume that the labor agency is also owned by risk-neutral entrepreneurs. The labor agency's recursive problem is:

$$J_t(N) = \max_{N',V} (h_t - w_t)N' - cV + \beta J_{t+1}(N') \tag{5.16}$$

$$\text{subject to}$$

$$N' = (1-s)N + q(\theta_t)V$$

where N is the number of employed households, V is the number of vacancies, c is the cost of posting a vacancy, $q(\theta_t)$ is the job-filling probability, and $\theta_t \equiv \frac{V_t}{U_t}$ is labor market tightness.

[18] As in Rotemberg (1982).

There are two wages in the model: h_t is the wage paid by intermediate good producers to the labor agency, and w_t is the wage paid by the labor agency to employed households. Due to the search frictions in the model, there is a range of household wages that is between the reservation wages of households and the labor agency. I assume the following wage rule, which implies that the wage paid to households responds to the wage paid to the labor agency with elasticity ϵ_w:[19]

$$w_t = \bar{w}\left(\frac{h_t}{\bar{h}}\right)^{\epsilon_w} \tag{5.17}$$

Labor Market The labor market is characterized by search and matching frictions. Given U_t unemployed households and V_t vacancies, $M(U_t, V_t)$ new employment relationships are formed according to the following matching function:[20]

$$M(U_t, V_t) = \frac{U_t V_t}{(U_t^l + V_t^l)^{\frac{1}{l}}} \tag{5.18}$$

The job-finding and job-filling rates are functions of labor market tightness:

$$f(\theta_t) = (1 + \theta_t^{-l})^{-\frac{1}{l}} \tag{5.19}$$

$$q(\theta_t) = (1 + \theta_t^{l})^{-\frac{1}{l}} \tag{5.20}$$

Fiscal and Monetary Policy The central bank sets nominal interest rates according to the following Taylor rule:

$$i_{t+1} = \bar{r}^b + \psi \log(\Pi_t) \tag{5.21}$$

Unemployment insurance provides a replacement rate ϕ_0 and is capped at a fraction ϕ_1 of the average wage:

$$\phi(z) = \min\{\phi_0 z, \phi_1\} \tag{5.22}$$

The government receives revenue from the labor income tax, the illiquid asset withdrawal tax, and the estate tax. It distributes unemployment insurance and the lump-sum transfer, issues nominal bonds, and undertakes government spending. The government budget constraint

[19] The complexity of the problem precludes a Nash bargaining solution for wages. Similar wage rules are used in Gornemann et al. (2016) and Den Haan et al. (2017). In Appendix J.4, I show that the main results of the paper are robust to a wide range of values of ϵ_w.

[20] As in Den Haan, Ramey and Watson (2000). This matching function ensures that job-finding and job-filling rates are well-defined for any value of $\theta_t > 0$.

is:

$$G_t + r_t^b B_t^g + T_t + \xi(1-N_t)w_t \int \phi(z) d\mu_t = \tau_l N_t w_t + \tau_l \xi (1-N_t) w_t \int \phi(z) d\mu_t \tag{5.23}$$
$$+ \tau_k \int \mathbb{1}\{k' < k\}(k-k') d\mu_t$$
$$+ \zeta \int (R_t^b(b) b + R_t^k k) d\mu_t$$

Equilibrium An equilibrium in this model consists of paths for household decision rules $\{c_t, b_t, k_t, u_t\}_{t=0}^{\infty}$, firm decision rules $\{L_t, K_t, N_t, V_t\}_{t=0}^{\infty}$, prices and returns $\{w_t, h_t, r_t^b, r_t^k\}_{t=0}^{\infty}$, inflation $\{\Pi_t\}_{t=0}^{\infty}$, the job finding rate $\{f_t\}_{t=0}^{\infty}$, fiscal variables $\{G_t, T_t, B_t\}_{t=0}^{\infty}$, and the distribution of households $\{\mu_t\}_{t=0}^{\infty}$ such that:

1. Decision rules solve household and firm problems, taking as given aggregate variables
2. The government budget constraint holds
3. The distribution satisfies aggregate consistency conditions
4. All markets clear

Market Clearing The following market clearing conditions must hold in equilibrium:

1. Bonds:
$$B_t^g = B_t^h = \int b \, d\mu_t \tag{5.24}$$
2. Capital:
$$K_t = K_t^h = u_t \int k \, d\mu_t \tag{5.25}$$
3. Labor:
$$L_t = N_t = \int \mathbb{1}\{e = E\} \, d\mu_t \tag{5.26}$$
4. Goods:
$$Y_t = C_t + I_t + G_t + \Theta_t + \kappa \int \max\{-b, 0\} \, d\mu_t + cV_t \tag{5.27}$$

The goods market clearing condition takes into account price adjustment costs, Θ_t, as well as the borrowing costs and costs of posting vacancies.

5.1 Calibration

Table 4 summarizes the calibration of the model. The model period is one quarter. Below, I provide further details on the calibration process.

Labor Market The quarterly job separation rate is 0.1, in line with the Job Openings and Labor Turnover Survey (JOLTS). I target a steady-state unemployment rate of 6%, and a quarterly job-filling rate of 0.71, as in Den Haan et al. (2000). These values imply a matching function elasticity of $l = 1.68$. I set the vacancy cost equal to 5% of the quarterly wage. Combined with the job-filling probability, this implies a hiring cost per worker of around 7% of the quarterly wage, as in Christiano, Eichenbaum and Trabandt (2016). With this assumption, I calibrate the steady-state wage to generate an unemployment rate of 6%. I set ϵ_w to 0.45, the elasticity of wages to labor productivity estimated by Hagedorn and Manovskii (2008).[21]

Income Process I set the values of ρ_Z, σ_Z, and λ_Z in order to target the variance and kurtosis of the annual income growth distribution, as well as the variance of the level of income. Table 5 reports these moments in the model and the data. While the high kurtosis of the income growth distribution implies that idiosyncratic productivity shocks occur infrequently, unemployment spells provide income shocks that are both more frequent and more transitory.

Wealth Distribution The key parameters affecting the liquid and illiquid wealth distributions are the coefficient of relative risk aversion, the death rate, the discount factor, the borrowing wedge, and the parameter governing the degree of illiquid asset adjustment costs. I set the coefficient of relative risk aversion, γ, to 2 and the quarterly death probability, ζ, to $\frac{1}{180}$, as in Kaplan et al. (2018), implying that households live for 45 years on average. I calibrate the other parameters to target the total quantity of liquid and illiquid assets relative to

[21] Due to movements in the mark-up, this calibration leads to wages that are more responsive to labor productivity than in the data. This ensures that the results of the model are not driven by the stickiness of real wages, as further shown in Appendix J.4.

output, as well as the fraction of households with negative liquid asset holdings, as reported by Kaplan et al. (2018). Table 5 provides various moments of the wealth distribution.[22]

The model matches the Gini coefficient for total wealth inequality. The model is also close to matching the proportion of hand-to-mouth households, defined as those with liquid asset holdings close to zero. The bottom two panels of Table 5 provide further details on the share of the liquid and illiquid wealth distributions held by different quantiles. The model slightly fails to match the wealth holdings of the top 1% of households, and instead over-predicts the share of wealth held by the rest of the top 10% of the distribution. In terms of adjustment probabilities, 3% of employed households and 11% of unemployed households adjust their illiquid asset holdings each period. The total adjustment costs that households pay are equivalent to 0.7% of aggregate output.[23]

Fiscal and Monetary Policy The particular details of unemployment insurance vary across US states. I set the cap on unemployment insurance, ϕ_1, to two-thirds of the average wage, and the replacement rate, ϕ_0, to 50%. These values are the most common across states, as reported in Department of Labor (2018). The parameter ξ governs the probability that unemployed households receive unemployment insurance. Figure 11 in Appendix A shows that a large fraction of unemployed individuals do not actually receive unemployment insurance, even if their unemployment spell is short enough to qualify for benefits. I set ξ equal to 0.45, the average UI recipiency rate for the short-term unemployed. I set the illiquid asset withdrawal tax to 10%, equal to the standard penalty for early withdrawals from retirement accounts. I set the linear income tax to 30%, and the value of the transfer to 0.04, such that it is equal to around 1% of GDP, as in McKay and Reis (2016). I set the steady-state real return on bonds to 1% on an annual basis. I assume that the Taylor rule coefficient on inflation is 1.5.

Remaining Parameters I calibrate the remaining parameters of the model to standard values in the New Keynesian literature. The coefficient on capital in the intermediate good production function is set to 0.33. I choose δ_0 such that the depreciation rate on capital

[22]The target for liquid assets to output is notably lower than the ratio of government debt to GDP in the data. However, it is close to the level of government debt held by private domestic agents, which is the appropriate comparison for the model.

[23]See Appendix I.4 for the derivation of this value. Kaplan et al. (2018) report that illiquid asset adjustment costs in their model total less than 4% of GDP.

Table 4: Parameter Values

Parameter		Value	Source/Target
Separation Rate	s	0.1	JOLTS
Vacancy Cost	c	0.11	5% of Quarterly Wage
Steady-state Wage	$\bar{w}$	2.1	6% Unemployment Rate
Wage Elasticity	ϵ_w	0.45	Hagedorn and Manovskii (2008)
Matching Function Elasticity	l	1.68	Quarterly Job-Filling Probability
Prod. Persistence	ρ_z	0.964	Variance of Annual Income
Prod. Variance	σ_z	3.2	Variance of Annual Income Growth
Prod. Shock Probability	λ_z	0.007	Kurtosis of Annual Income Growth
Risk Aversion	γ	2	Standard value
Discount Factor	β	0.982	Illiquid Assets/Output
Death Probability	ζ	$\frac{1}{180}$	Kaplan et al. (2018)
Adjustment Cost Limit	$\bar{\chi}$	1	Liquid Assets/Output
Borrowing Limit	$\underline{b}$	1	50% of Average Quarterly Labor Income
Borrowing Wedge	κ	0.019	% Negative Liquid Assets
UI Replacement Rate	ϕ_0	0.5	Department of Labor (2018)
UI Cap	ϕ_1	0.67	Department of Labor (2018)
UI Probability	ξ	0.45	Employment & Training Administration
Income Tax	τ_l	0.3	Kaplan et al. (2018)
Withdrawal Tax	τ_k	0.1	IRA Withdrawal Penalty
Transfer	T	0.04	McKay and Reis (2016)
Return on Liquid Assets	$\bar{r}^b$	0.0025	1% Annual Rate of Return
Taylor Rule Coefficient	ψ	1.5	Kaplan et al. (2018)
Capital Share	α	0.33	Standard value
Steady-State Depreciation Rate	δ_0	0.014	6% Annual Rate of Depreciation
Depreciation Elasticity	δ_1	2.02	Steady-State Utilization Rate of 1
Elasticity of Substitution	ϵ	20	Mark-up of 5%
Price Adjustment Cost	θ_P	250	Slope of New Keynesian Phillips Curve

Notes: This Table reports the baseline calibration of the two-asset model with unemployment insurance. The calibration is described in Section 5.1.

Table 5: Income and Wealth Distributions

Moment	Data	Model
Variance: Annual Log Earnings	0.70	0.71
Variance: 1-year change	0.23	0.23
Kurtosis: 1-year change	17.8	18.3
Liquid Assets to Output	0.26	0.29
Illiquid Assets to Output	2.92	2.88
% Poor Hand-to-Mouth	0.10	0.05
% Wealthy Hand-to-Mouth	0.20	0.20
% Negative Liquid Assets	0.15	0.14
Gini Coefficient (Total Wealth)	0.81	0.82
Top 1% share (Liquid)	47	34
Top 1%-10% share (Liquid)	39	52
Top 10%-50% share (Liquid)	18	15
Bottom 50% share (Liquid)	-4	-2
Top 1% share (Illiquid)	33	19
Top 1%-10% share (Illiquid)	37	55
Top 10%-50% share (Illiquid)	27	24
Bottom 50% share (Illiquid)	3	2

Notes: Income moments are based on Social Security Administration data on male earnings, reported by Guvenen, Karahan, Ozkan and Song (2015). Wealth moments are from the 2004 SCF, reported by Kaplan et al. (2018). Moments from the model are calculated by simulating 1 million households in the steady-state of the model and aggregating income to an annual frequency. In the model, I define household as hand-to-mouth if the absolute value of their liquid asset holdings is less than 10% of the average quarterly wage. I define households as wealthy if their illiquid asset holdings exceed 60% of average quarterly labor earnings.

is 6% at an annual frequency and δ_1 such that the steady-state utilization rate is equal to 1. I set the elasticity of substitution, ϵ, to 20, implying a steady-state mark-up of 5%. I choose a low mark-up to ensure that profits are small, given that I assume that all profits are consumed by risk-neutral entrepreneurs. I then set the value of the price-adjustment cost, θ_P, to 250, which implies that the slope of the New-Keynesian Phillips curve is 0.08. If price-adjustment was of the Calvo form, this would be equivalent to prices lasting four quarters on average.

6 Model Validation

Before turning to the effect of aggregate shocks in the model, I start by checking that the model is consistent with the empirical findings in Sections 2 and 3. To do this, I simulate a large panel of households in the steady-state of the model and aggregate to an annual frequency. Using this panel, I run the same consumption regressions as in Section 2, and calculate illiquid asset withdrawal probabilities as in Section 3. I then consider the effect of idiosyncratic shocks to expected job separation probabilities, as in Section 4.

6.1 Consumption Response to Unemployment Spells

Table 6 compares the regression results in the model and the data. Column (4) shows that the average consumption decline during unemployment in the model is close to, but slightly smaller than, that estimated in the data. Columns (5) and (6) show that the model matches well the ranking seen in the data, including the important role for illiquid asset holdings within the hand-to-mouth group.

To understand how the two-asset model is able to generate these patterns, Figure 2 plots the log difference between the consumption of unemployed and employed households across the liquid wealth distribution. I hold illiquid wealth constant at its mean level, so the figure shows the consumption decline during unemployment for wealthy hand-to-mouth or non hand-to-mouth households.

For households that do not adjust their illiquid asset holdings, the figure shows that the consumption decline during unemployment varies strongly with a household's liquid asset position. Thus, if their liquid asset holdings are low, the consumption decline for wealthy hand-to-mouth households can be large.

Table 6: Consumption Response to Unemployment Spells

	Data (CEX)			Two-Asset Model		
	(1)	(2)	(3)	(4)	(5)	(6)
$U_{i,t}$	-0.22 (0.015)			-0.18		
$U_{i,t}\mathbb{1}\{\text{N-HTM}\}$		-0.14 (0.026)	-0.14 (0.026)		-0.08	-0.08
$U_{i,t}\mathbb{1}\{\text{HTM}\}$		-0.26 (0.019)			-0.26	
$U_{i,t}\mathbb{1}\{\text{W-HTM}\}$			-0.23 (0.027)			-0.23
$U_{i,t}\mathbb{1}\{\text{P-HTM}\}$			-0.30 (0.026)			-0.27

Notes: Robust standard errors in parentheses. Regressions weighted using CEX sampling weights, with 31638 observations from 1996 to 2017. In both the model and the data, households are defined as hand-to-mouth if their liquid asset holdings are below the median. In the CEX I define households as wealthy if they are homeowners. In the model, I define households as wealthy if their illiquid asset holdings exceed 60% of average quarterly labor earnings.

On the other hand, if wealthy hand-to-mouth households do adjust their illiquid asset holdings, then their consumption decline during unemployment is negligible. In this case, the consumption decline during unemployment is largely independent of a household's liquid wealth.

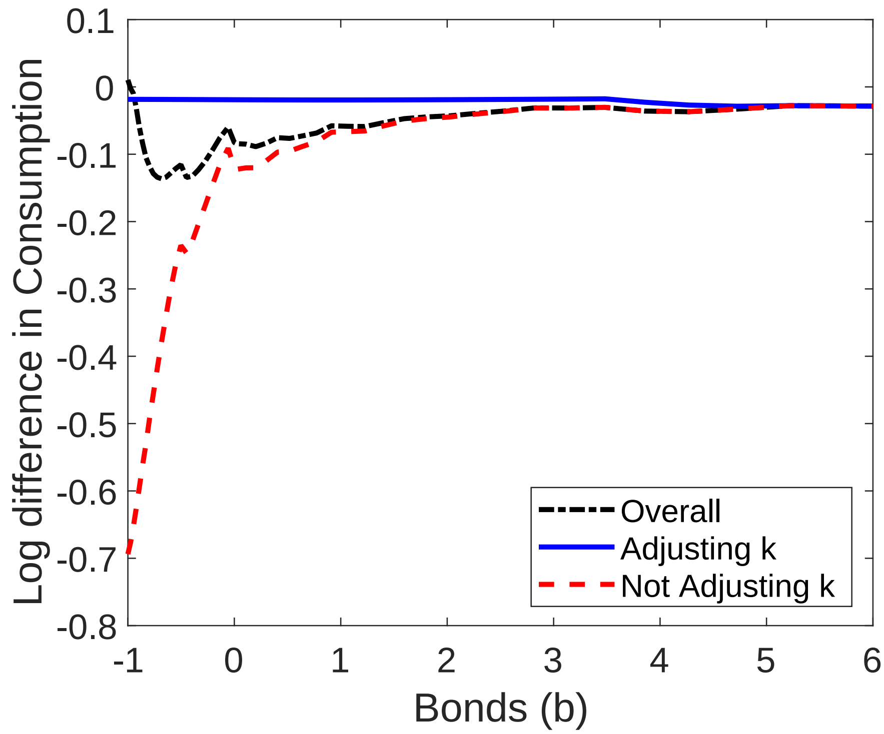
Overall, the model is able to generate a realistic consumption decline for wealthy hand-to-mouth households because only a small fraction of wealthy hand-to-mouth households choose to liquidate capital during unemployment. This implies that the average consumption decline for the wealthy hand-to-mouth is between the large decline of the poor hand-to-mouth and the small decline of the non hand-to-mouth, as it in the data.

6.2 Illiquid Asset Response to Unemployment Spells

Table 7 compares the illiquid asset withdrawal probabilities in the model and the data. As individual retirement accounts are only one type of illiquid asset, there is no direct comparability between the levels of the withdrawal probabilities in the model and the data.[24]

[24] Also, household decisions regarding retirement accounts are intimately tied up with life-cycle considerations, from which the model abstracts.

Figure 2: Consumption Declines and Illiquid Asset Adjustment



Notes: This figure plots the log difference in consumption between unemployed and employed households at the median level of idiosyncratic productivity and mean level of illiquid asset holdings. The mean (median) value of k in the steady-state of the model is 34 (6). The mean (median) value of b is 3.4 (0.5).

The true withdrawal probabilities in the data are higher when including withdrawals from other illiquid assets, such as housing.[25] However, it is possible to validate the model by considering the relative effect of unemployment and liquid asset holdings on withdrawal probabilities.

The model matches the patterns seen in the data. In the model, the withdrawal probability for households who experienced an unemployment spell is significantly higher than that for households who did not. As in the data, this is driven particularly by households who experienced long unemployment spells and those who became unemployed when they had few liquid assets.

Figure 3 plot illiquid asset withdrawal probabilities across the liquid wealth distribution to highlight the relationship between employment status and illiquid asset adjustment in the model. The withdrawal probability for employed households has a modest negative rela-

[25] For example, Bhutta and Keys (2016) find that an average of 11% of households extracted equity from their home each year between 1999 and 2010.

Table 7: Illiquid Asset Withdrawal Probabilities

	SCF Data	Model
Full Sample	0.046	0.079
No Unemployment Spell	0.040	0.058
Unemployment Spell	0.105	0.185
Short Unemployment Spell	0.058	0.115
Long Unemployment Spell	0.159	0.325
Unemployment Spell & Non-HTM	0.048	0.071
Unemployment Spell & HTM	0.134	0.290

Notes: Probabilities constructed using sampling weights from the 2004 to 2019 waves of the SCF. The first three sections use a sample of 4863 households. The last section uses a sample of 3649 households. I define an unemployment spell as short for households whose head was unemployed for 12 weeks or less. I define a household as hand-to-mouth if they have less than the median level of liquid assets.

tionship with liquid asset holdings: Employed households would like to make a withdrawal from their illiquid asset holdings when their liquid wealth is low, in order to balance their portfolios and improve their ability to smooth consumption during unemployment. However, they only do so if they receive a favorable draw of the illiquid asset adjustment cost.

Relative to employed households, unemployed households are much more likely to withdraw from their illiquid asset holdings when their liquid asset holdings are low. This is consistent with Figure 2 which show that such households would experience a large drop in consumption if they did not draw down upon their illiquid wealth.

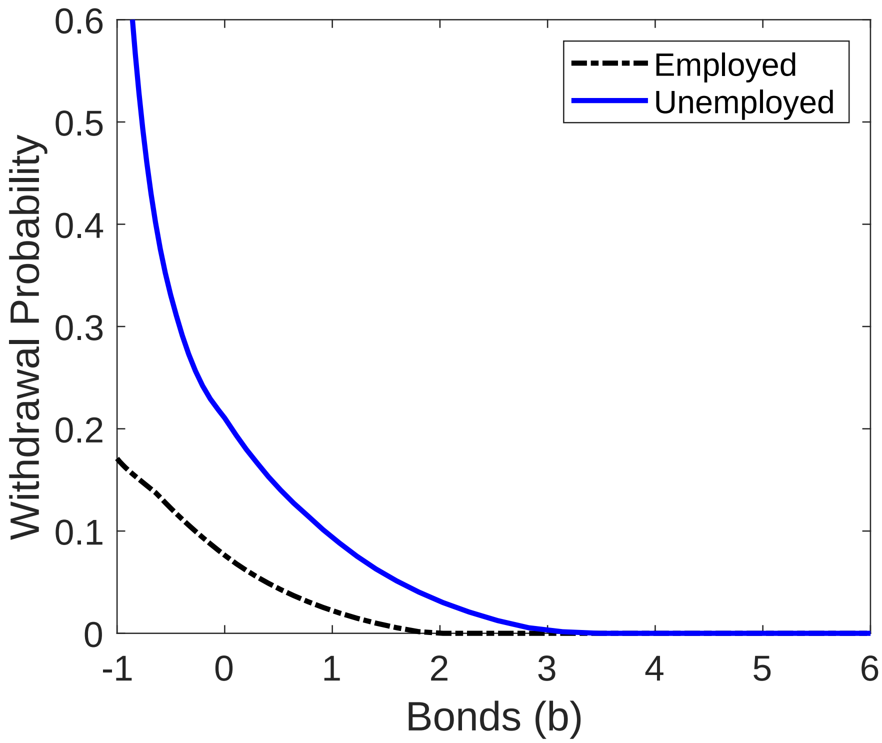
6.3 Precautionary Response to Unemployment Risk

Finally, I consider the effect of idiosyncratic shocks to expected job separation probabilities. As the model does not include shocks to the job separation rate, I consider the effect of a one-time unexpected shock to the job separation rate such that the expected job loss probability over the next year rises by 20%, which I found to be the standard deviation of the change in the expected job separation rate in the SCE data in Section 4.[26]

Figure 4 plots the average response of consumption as well as liquid and illiquid asset holdings

[26] I do this by raising the quarterly separation rate from 0.1 to 0.21, and letting it decline back to its steady-state value as an AR(1) process with a quarterly persistence of 0.8.

Figure 3: Adjustment Probabilities and Employment Status

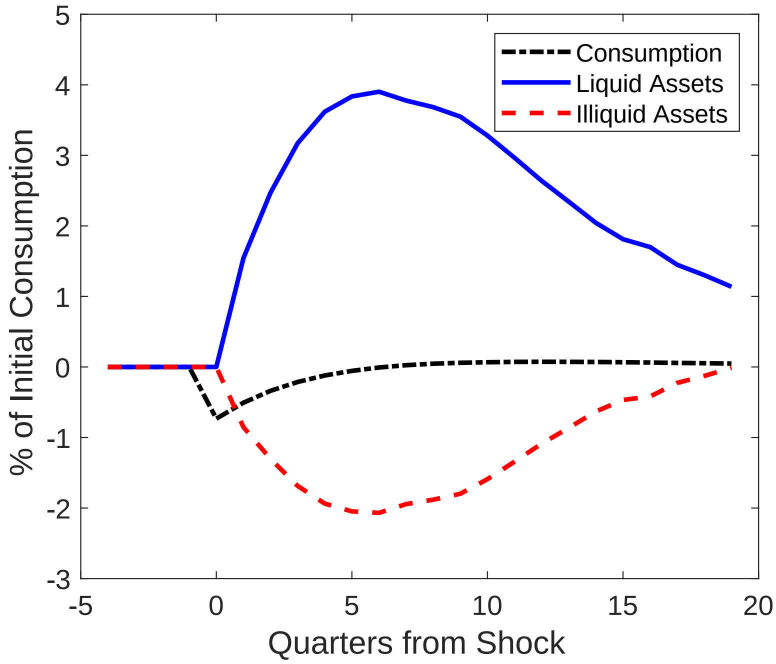


Notes: This figure plots illiquid asset withdrawal probabilities for employed and unemployed households at the median level of idiosyncratic productivity and mean level of illiquid asset holdings. The mean (median) value of k in the steady-state of the model is 34 (6). The mean (median) value of b is 3.4 (0.5).

to such a shock, relative to the paths that would have occurred with no shock to the expected job loss probability.[27] As in the data, I consider a panel of individuals that are constantly employed. There are two main results. First, I find that consumption declines on impact by around 0.75% in response to a shock that raises the expected job loss probability over the next year by 20%. This is almost exactly in line with the magnitude of the consumption response found in the first column of Table 3. Second, I find that illiquid asset holdings fall, despite the increase in precautionary saving implied by the decline in consumption. As the model has no notion of regular contributions to a retirement account, it is not possible to quantitatively compare the decline in illiquid asset investment in the model and the data. Thus, the model is consistent both with the quantitative magnitude of the decline in consumption in response to a rise in unemployment risk, and with the fact that this increase in precautionary saving is accompanied by a shift in portfolios towards liquid wealth. In the

[27] I consider the effect of idiosyncratic shocks by holding all prices fixed, consistent with the use of time fixed effects in the regressions in Section 4.

Figure 4: A Shock to the Expected Job Separation Rate



Notes: This figure plots the response of consumption and liquid/illiquid asset holdings to an unexpected shock to the job separation rate, such that the expected job loss probability over the next year rises by 20% on impact. Responses are plotted for continuously employed individuals relative to a path with no such shock. See the text for full details.

model, both the decline in consumption and the decline in illiquid asset holdings contribute roughly equally to a sharp rise in liquid wealth.

7 Response of the Economy to Aggregate Shocks

Having shown that the two-asset model is consistent with the new empirical evidence, I now study the response of the economy to an unanticipated negative shock to aggregate productivity.[28] To understand whether or not unemployment risk affects business cycle dynamics, and if unemployment insurance is an important automatic stabilizer, I compare the impulse responses of three different versions of the model: (1) the baseline model, (2) a model with no unemployment insurance, and (3) a model in which households pool their idiosyncratic unemployment risk perfectly. In this version with pooled unemployment risk,

[28] I consider a shock which lowers aggregate productivity by 0.1% on impact, and has a quarterly persistence equal to 0.9.

I assume that there is no unemployment insurance. Thus, all households receive labor income of $N_t w_t z(1-\tau_l)$, regardless of whether or not they are working. Note, in this model, households still face income risk due to idiosyncratic productivity shocks. They simply do not face additional income risk due to unemployment.

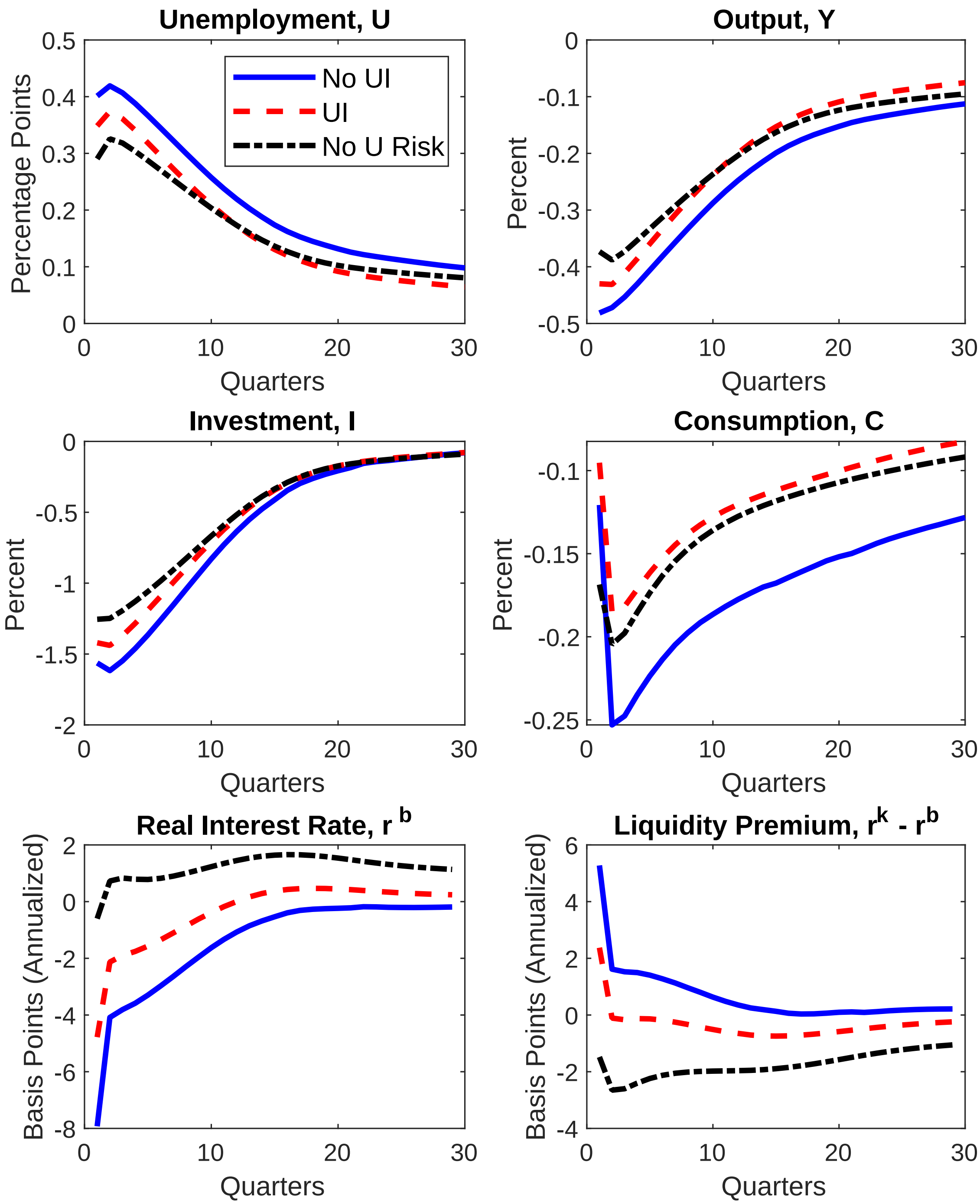
In these alternate versions of the model, I adjust $\bar{w}$ so that the unemployment rate remains at 6% in the original steady-state. I also assume that the steady-state real interest rate remains at 1% in each version of the model. Table 8 in Appendix A shows that the steady-state wealth distributions are similar in all three versions of the model, highlighting the relatively limited role that unemployment risk plays in determining the steady-state wealth distribution. In response to the aggregate shock, I assume that government spending adjusts to balance the government's budget constraint each period. In Appendix J, I show that results are similar with an alternative fiscal policy in which the lump-sum transfer adjusts.

By comparing the response to the shock in the model with no unemployment insurance and in the model with pooled unemployment risk, I am able to assess the impact of unemployment risk on aggregate fluctuations. Between these extreme scenarios, the baseline model then shows the degree to which unemployment insurance is able to mitigate any amplification due to idiosyncratic unemployment risk. Figure 5 plots the impulse response of key variables to the aggregate productivity shock in each version of the model.

In all versions of the model, the decline in aggregate productivity causes a decline in vacancy posting and a rise in the unemployment rate. In response to an increase in unemployment risk, there is a flight-to-liquidity: demand for liquid assets increases, as these are best-suited to smoothing consumption during unemployment spells. Investment in capital falls, as employed households postpone investing in illiquid assets, and unemployed households withdraw from their illiquid asset holdings. In the presence of nominal rigidities, this decline in investment demand lowers aggregate output, raises unemployment, and initiates a feedback loop between unemployment risk and aggregate demand in the economy.

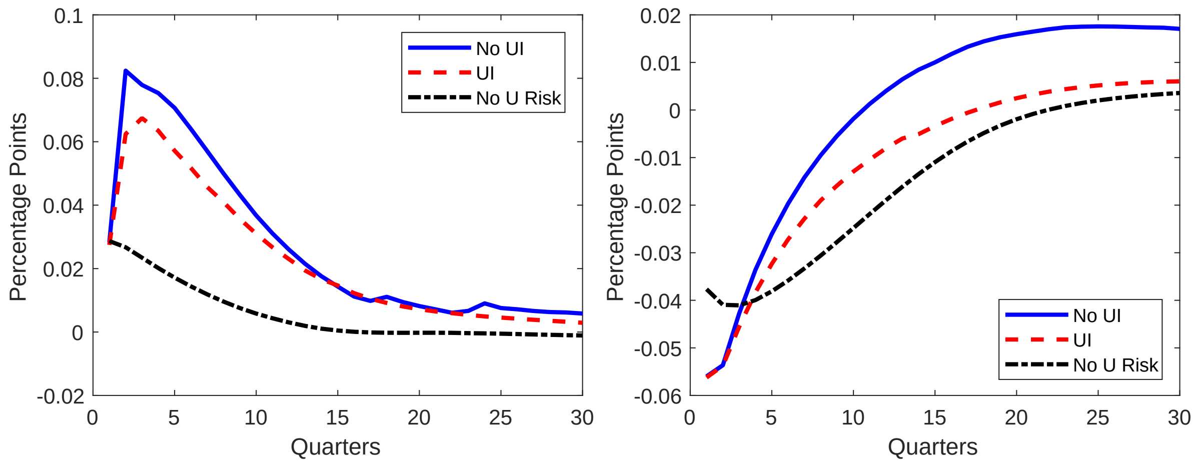
This mechanism is not operative if unemployment risk is pooled, and it is dampened if households have access to unemployment insurance. By providing a source of income during unemployment spells, unemployment insurance lessens the need for holding liquid assets to smooth consumption during such times. Figure 6 shows the response of illiquid asset adjustment probabilities in each version of the model. The key difference is that without unemployment insurance there is a much larger increase in the probability of illiquid asset

Figure 5: Response to an Aggregate Productivity Shock



Notes: This figure shows the response of the economy to a negative aggregate productivity shock. "No UI" refers to the model without unemployment insurance. "UI" refers to the baseline model with unemployment insurance. "No U Risk" refers to the model in which households pool unemployment risk. See the text for full details.

Figure 6: Response of Illiquid Asset Adjustment Probabilities



(a) Withdrawing from Illiquid Asset **(b) Investing in Illiquid Asset**

Notes: This figure shows the response of illiquid asset adjustment probabilities following a negative aggregate productivity shock. "No UI" refers to the model without unemployment insurance. "UI" refers to the baseline model with unemployment insurance. "No U Risk" refers to the model in which households pool unemployment risk. See the text for full details.

withdrawal in comparison to the other two versions of the model.

The quantitative significance of this mechanism can be seen in Figure 5. The main result is that the unemployment rate rises by around 30% more in the version without unemployment insurance than in the version with no unemployment risk, and that unemployment insurance removes around half of this amplification. The more unemployment risk that households face, the larger is the decline in investment, and the sharper is the decline in the real interest rate. The bottom-right panel of Figure 5 plots the liquidity premium, the spread between the rate of return on capital and the real interest rate. This spread is counter-cyclical when households face unemployment risk, and particularly so if there is no unemployment insurance.

7.1 Robustness

In Appendix J, I undertake a number of robustness exercises. The amplification implied by unemployment risk is robust to heterogeneous job separation rates, assuming that transfers rather than government spending adjust to balance the government's budget constraint, a Taylor rule featuring interest-rate smoothing, assuming that profits are distributed directly to households, a wide range of values for the responsiveness of wages, and an alternative wage rule in which wages respond to unemployment risk.[29] I also show that amplification is not confined to aggregate productivity shocks: I find similar amplification when studying a shock to the marginal efficiency of investment. This is significant, as such shocks have been shown to play an important role in business-cycle fluctuations in estimated DSGE models.

7.2 The Endogenous Response of Income Risk

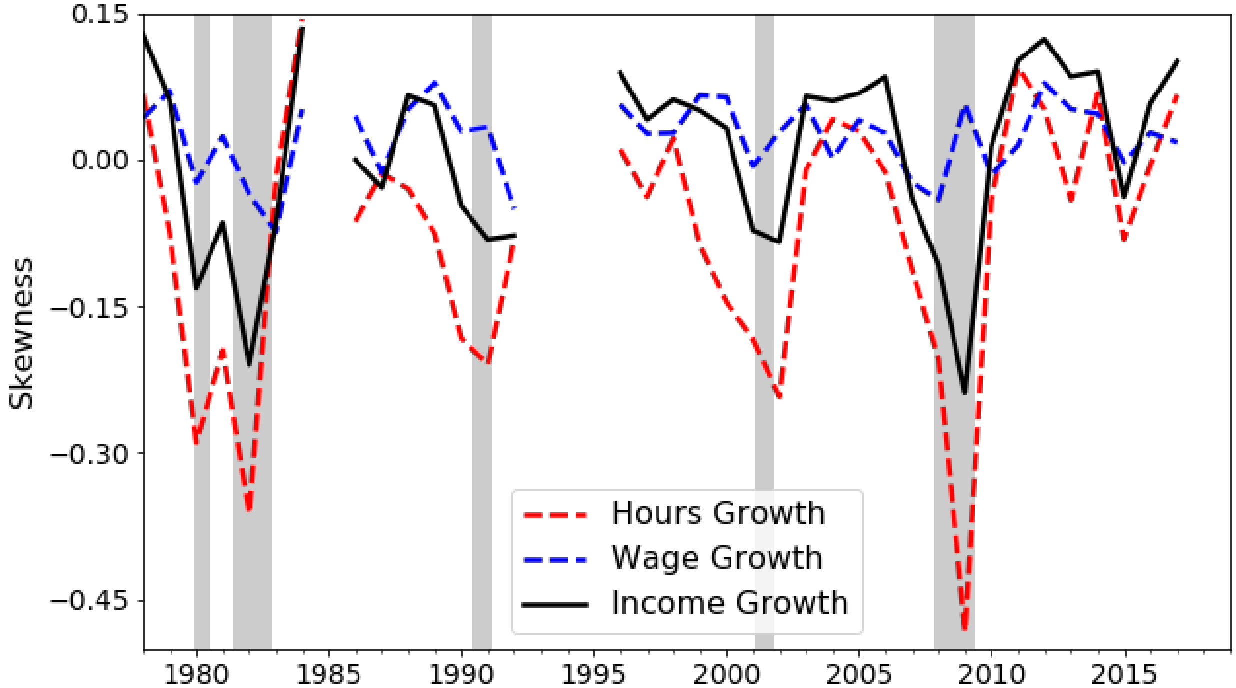
In this section, I show that the endogenous response of income risk to the aggregate shock in the model is consistent with empirical evidence from the CPS. Guvenen et al. (2014) use Social Security Administration data to show that the skewness of the income growth distribution is strongly pro-cyclical: recessions are times when large negative income changes become much more likely. Using data from the March supplement of the CPS, I am able to break down income growth into hours growth and wage growth. Figure 7 shows that the pro-cyclical skewness of income growth is entirely driven by the pro-cyclical skewness of hours growth, while the distribution of hourly wage growth doesn't vary over the business cycle. Thus, large negative income changes in recessions become more likely due to an increased likelihood of a large decline in hours worked, i.e. an unemployment spell. In Appendix G I provide more detail on the CPS data and additional evidence that the cyclicality of income growth is driven by the extensive margin, specifically the cyclicality of unemployment risk.

Figure 8 shows the effect of the aggregate shock on the skewness of the hours growth, wage growth and income growth distributions in the model. As in the data, the skewness of income growth is pro-cyclical, and it is driven entirely by the skewness of hours growth, which is around twice as volatile as the skewness of income growth. In the model, the skewness of the wage growth distribution is acyclical by construction, as it depends only on the exogenous stochastic process for idiosyncratic productivity.

Figure 8 is also useful for understanding why the flight-to-liquidity mechanism is not operative in the version of the model where unemployment risk is pooled. In this version of the model, the only source of income risk comes from idiosyncratic productivity shocks, so

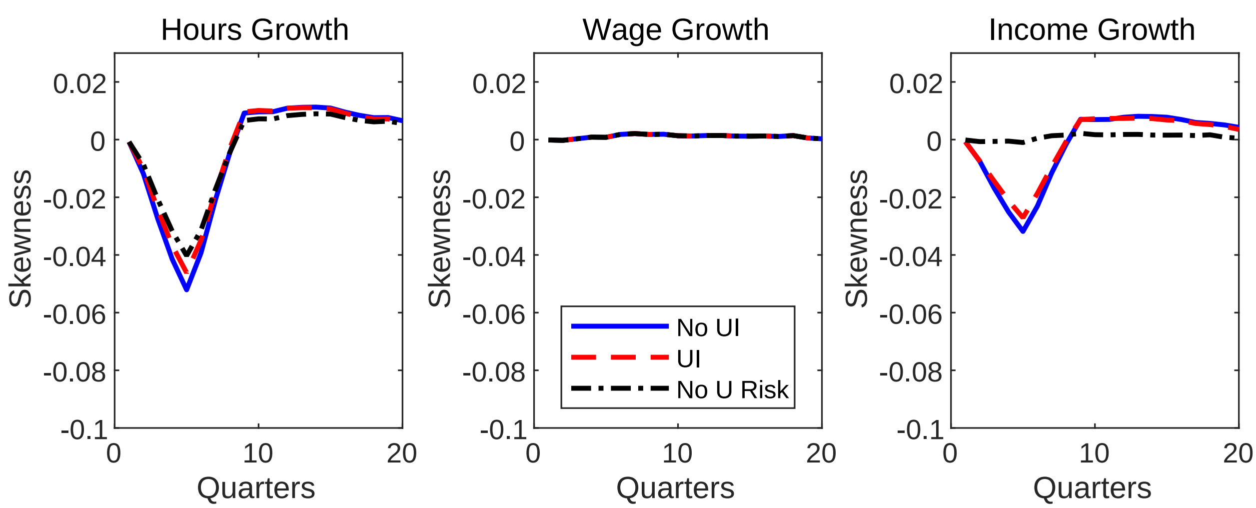
[29] It would be interesting to extend the model to allow for varying search effort on the part of unemployed agents, for an hours choice on the intensive margin. I have not undertaken these extensions due to the computational complexity of the current model without these extra decisions on behalf of households. The same is true of an extension to accurately capture the earnings cost of job loss. Huckfeldt (2022) shows that such a cost is concentrated among individuals who change occupation. I believe that studying how such occupation choice interacts with liquid and illiquid asset holdings is an interesting topic for future research.

Figure 7: Breakdown of Income Growth Skewness in the Data



Notes: Data from the Current Population Survey. Skewness measured using Pearson's second skewness coefficient (median skewness). Gaps in the data occur due to periods in which it is not possible to link individuals in the CPS over time.

Figure 8: Model Response of Income Risk



Notes: This figure shows the response of income risk to a negative productivity shock. "No UI" refers to the model without unemployment insurance. "UI" refers to the baseline model with unemployment insurance. "No U Risk" refers to the model in which households pool unemployment risk. See the text for full details. Skewness measured using Pearson's second skewness coefficient (median skewness).

the skewness of the income growth distribution is unaffected by changes in the job-finding rate.

7.3 The Importance of Unemployment Insurance at the ZLB

I now consider how the importance of unemployment insurance as an automatic stabilizer depends on the responsiveness of monetary policy. I consider the response of the economy to the same aggregate productivity shock considered previously. However, I now assume that there is an exogenous lower bound on the nominal interest rate, such that monetary policy follows a truncated Taylor rule:

$$i_t = \max\{\bar{r}^b + \psi \log(\Pi_t), \underline{\mathrm{i}}\} \tag{7.1}$$

I set $\underline{\mathrm{i}}$ such that monetary policy is constrained for 2 quarters in the baseline version of the model.[30] Figure 9 compares the impulse response functions of the baseline model with those from the versions of the model without unemployment insurance or without unemployment risk.

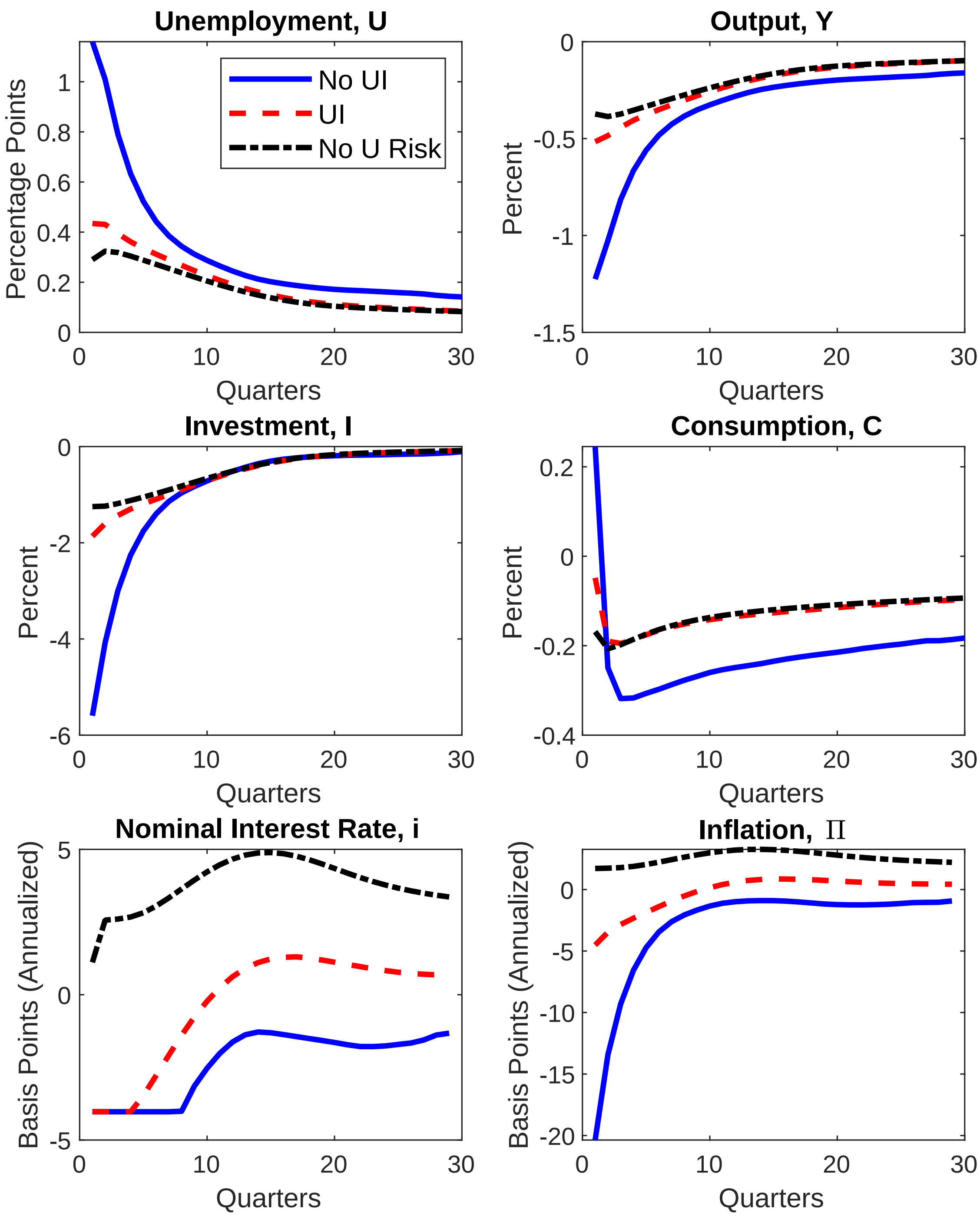
When monetary policy is constrained, the decline in investment demand that follows the increase in unemployment risk is not offset by lower interest rates. This strengthens the feedback loop between aggregate demand and unemployment risk, and increases the amplification coming from the flight-to-liquidity mechanism. Unemployment insurance plays a much more important role than in normal times: without unemployment insurance, unemployment rises by more than twice as much as in the baseline model. Monetary policy is constrained for longer, and both investment and inflation decline significantly more than with the baseline level of unemployment insurance.

7.4 A Comparison with One-Asset Models

The previous sections have provided a quantitative assessment of the amplification provided by unemployment risk in a model which matches both liquid and illiquid wealth distributions. In order to understand the source of this amplification, I now briefly compare the results

[30] The standard method for engineering a ZLB episode in New Keynesian models is a temporary rise in the discount factor, β. This does not work in this model due to the presence of capital and labor market frictions. Increasing the discount factor leads to a decline in unemployment, both because of an increase in the capital stock, which increases labor productivity, but also because a higher discount factor raises the value of a filled vacancy to the labor agency.

Figure 9: Response to Shock with Constrained Monetary Policy



Notes: This figure shows the response of the economy to a negative productivity shock in the presence of a lower bound on the nominal interest rate. "No UI" refers to the model without unemployment insurance. "UI" refers to the baseline model with unemployment insurance. "No U Risk" refers to the model in which households pool unemployment risk. See the text for full details.

from Section 7 with those from various models in which households only trade one (liquid) asset. The full results are provided in Appendix H.

In the first one-asset model, I remove bonds from the model and assume that households trade capital with no adjustment costs. Aside from these changes, I keep the parameterization as described in Section 5.1. In such a model, households are well insured against unemployment risk, and consequently the decline in consumption during unemployment is smaller than documented in Section 2. When studying the response of the economy to the aggregate productivity shock in this model, I find no amplification from unemployment risk. My findings are consistent with Gornemann et al. (2016). In such a model, while it increase the volatility of consumption, unemployment risk decreases the volatility of investment, and leaves the volatility of output or unemployment broadly unchanged.[31]

In the second one-asset model, I keep the liquid capital framework but lower the calibrated discount factor, β, from 0.982 to 0.96, in order to match the estimated consumption decline during unemployment. Here I find that unemployment risk actually *dampens* business cycle fluctuations slightly. A rise in unemployment risk leads to an increase in precautionary saving in capital. This dampens the decline in investment sufficiently such that output and employment actually fall less with unemployment risk than without. In the language of Challe et al. (2017), the stabilizing "aggregate supply" channel of unemployment risk dominates in this setting.

Finally, I also consider a one-asset model in which I remove capital. Thus, households only trade liquid bonds, and the potential stabilizing effect of unemployment risk operating through capital is absent. As in the models with liquid capital, I stick as close as possible to the calibration of the two-asset model. Here I find that, if the discount factor, β, is calibrated to match the consumption decline during unemployment seen in the data, there is only a small amount of amplification from unemployment risk.

Overall, studying these alternative one-asset models suggests that the inclusion of illiquid wealth and the flight-to-liquidity motive is key in generating the amplification seen in the two-asset model in Section 7.

[31] These results also consistent with Cho (2023) who shows that time-varying unemployment risk has little effect on business cycle volatility in an estimated HANK model without illiquid assets.

8 Temporary Tax-Free Illiquid Asset Withdrawals

In response to the COVID-19 pandemic, the CARES Act removed the 10% early withdrawal penalty on retirement accounts until the end of 2020 for individuals that experience adverse financial consequences due to the pandemic. The two-asset model in this paper is a useful laboratory for studying the effect of such a policy.

In this section, I investigate the implications of variations of this policy in the baseline calibration of the model. I consider three alternative implementations. First, and most similar to the CARES Act, I assume that the withdrawal tax on illiquid assets is reduced unexpectedly and immediately from 10% to 5% for three quarters for individuals that are unemployed. It then returns immediately to 10%. I do not remove the tax entirely as in reality retirement accounts are only a fraction of total illiquid asset holdings. Second, I consider a variation where after three quarters the withdrawal tax returns to 10% much more slowly.[32] Third, I consider a variation where the reduction in the withdrawal tax is pre-announced by one year. As in the second case, the tax is then cut to 5% for three quarters and returns to 10% only gradually. For simplicity, I assume that these tax cuts occur in the steady-state of the model, rather than layering them on top of an additional aggregate shock to mimic the COVID-19 recession.

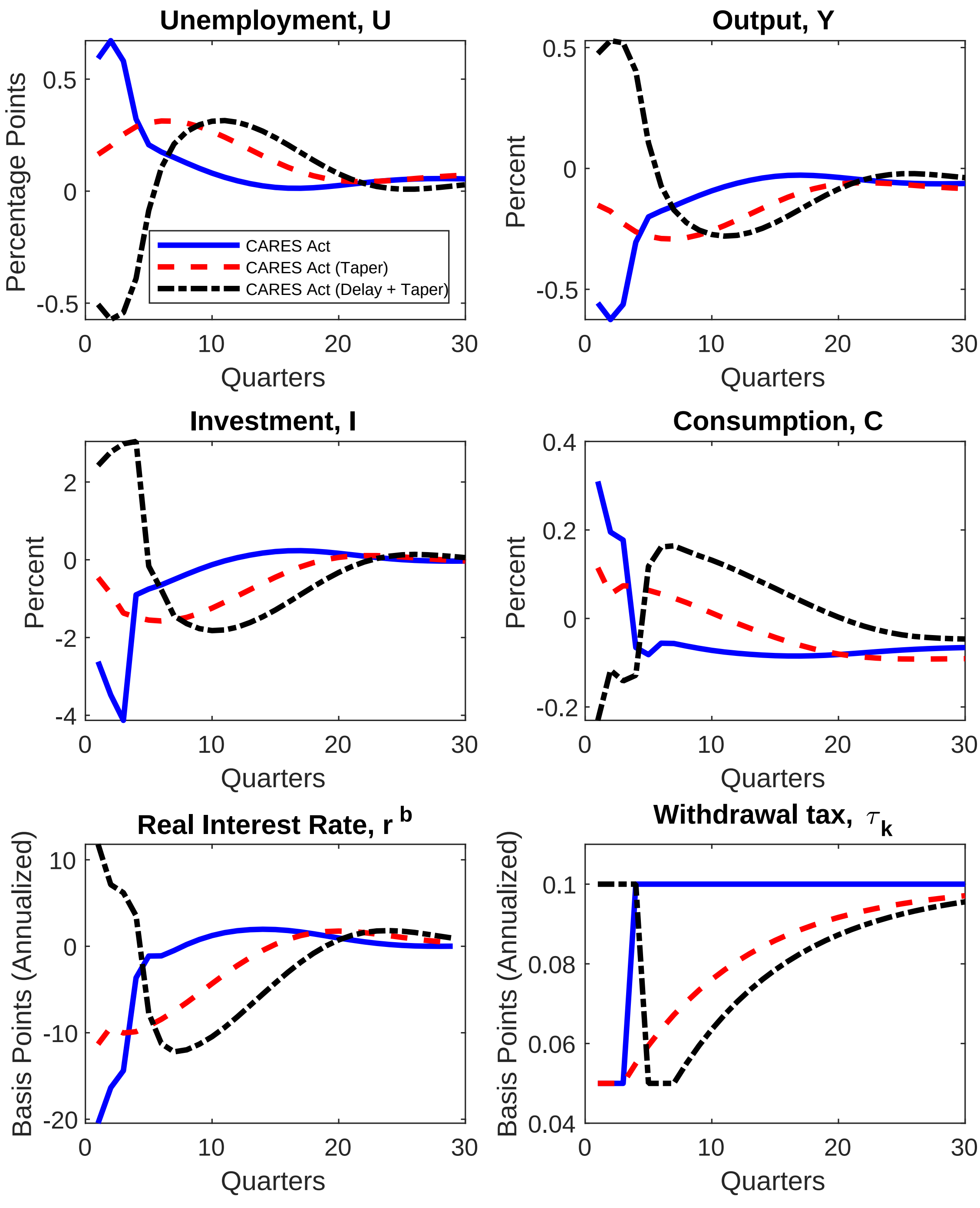
Figure 10 shows the results of these policies. The three alternate paths of the withdrawal tax are shown in the bottom-right panel. Starting with the first scenario, labelled "CARES Act", in which the tax is cut immediately and then returns to 10% after three quarters, we see that while the policy helps unemployed individuals smooth their consumption, it actually has a sharp contractionary effect. The policy leads to a synchronized withdrawal of illiquid assets, and consequently a significant decline in investment in capital. This is only partially offset by an increase in consumption. The overall effect is a decline in aggregate demand, a fall in the equilibrium interest rate, and consequently a rise in unemployment.

By considering the second case, labelled "CARES Act (Taper)", we see that allowing the tax cut to last longer significantly lowers the peak rise in unemployment, or the decline in output on impact. This occurs as such an implementation avoids the synchronized withdrawal of illiquid assets that occurs when the tax cut is known to only last for three quarters.

Finally, the third case, labelled "CARES Act (Delay + Taper)" shows that both pre-

[32] Specifically, following an AR(1) process with a quarterly persistence of 0.9.

Figure 10: Response to Temporary Reductions of Withdrawal Tax



Notes: This figure shows the response to various temporary reductions of the illiquid asset withdrawal tax. The path of the withdrawal tax in each case is shown in the bottom-right panel. See the text for full details.

announcing the policy and tapering its withdrawal actually leads to an expansion in the short-run. Knowing that the withdrawal tax will be lower in the future, households significantly increase their investment in illiquid assets in the first year, causing an expansion in output and a reduction in unemployment.

9 Conclusion

This paper shows that the combination of endogenous unemployment risk and the presence of illiquid assets provides an important propagation mechanism for aggregate shocks: higher unemployment risk leads to a flight-to-liquidity and initiates a feedback loop between unemployment risk and aggregate demand. Unemployment insurance plays an important role as an automatic stabilizer, particularly if monetary policy is constrained.

The two-asset model is consistent with new empirical evidence on the relationship between unemployment, the liquidity of asset holdings and consumption. Using data from the Consumer Expenditure Survey, I find that the consumption decline during unemployment is largest for poor hand-to-mouth households, smaller for the wealthy hand-to-mouth, and smallest for the non hand-to-mouth. The two-asset model is able to match this finding due to the costs associated with adjusting illiquid asset holdings. Some wealthy hand-to-mouth households pay these adjustment costs, and consequently are able to smooth their consumption as well as the non hand-to-mouth, while others do not pay the adjustment costs and are unable to smooth their consumption, like poor hand-to-mouth households.

In the model, unemployed households do not need to withdraw from their illiquid asset holdings until they have first run down their liquid asset holdings. However, when their liquid asset holdings are depleted, they are then likely to withdraw from their illiquid asset holdings. Consequently, unemployed households are more likely to make a withdrawal from their illiquid asset holdings than employed households, particularly if their unemployment spell is long or their liquid asset holdings are low. Using data from the Survey of Consumer Finances, I show that these patterns are confirmed in the data.

I also provide evidence in favor of the flight-to-liquidity mechanism that is central to the model's response to aggregate shocks: using data from the Survey of Consumer Expectations I show that consumption declines when idiosyncratic unemployment risk rises, consistent with a rise in precautionary saving, but that investment in illiquid assets declines, consistent with a shift in portfolios towards liquid assets. This pattern also occurs in the model.

The model suggests that an important role for unemployment insurance is its ability to dampen aggregate fluctuations by lessening the flight-to-liquidity that occurs when unemployment risk is heightened. However, the model has abstracted from search effort on the part of unemployed workers, or a mechanism by which unemployment insurance affects the level of wages. Such features would imply that there is an important trade-off between the effect of unemployment insurance on the volatility of the unemployment rate and the effect on the average level of unemployment. I leave an investigation of this trade-off to future work.

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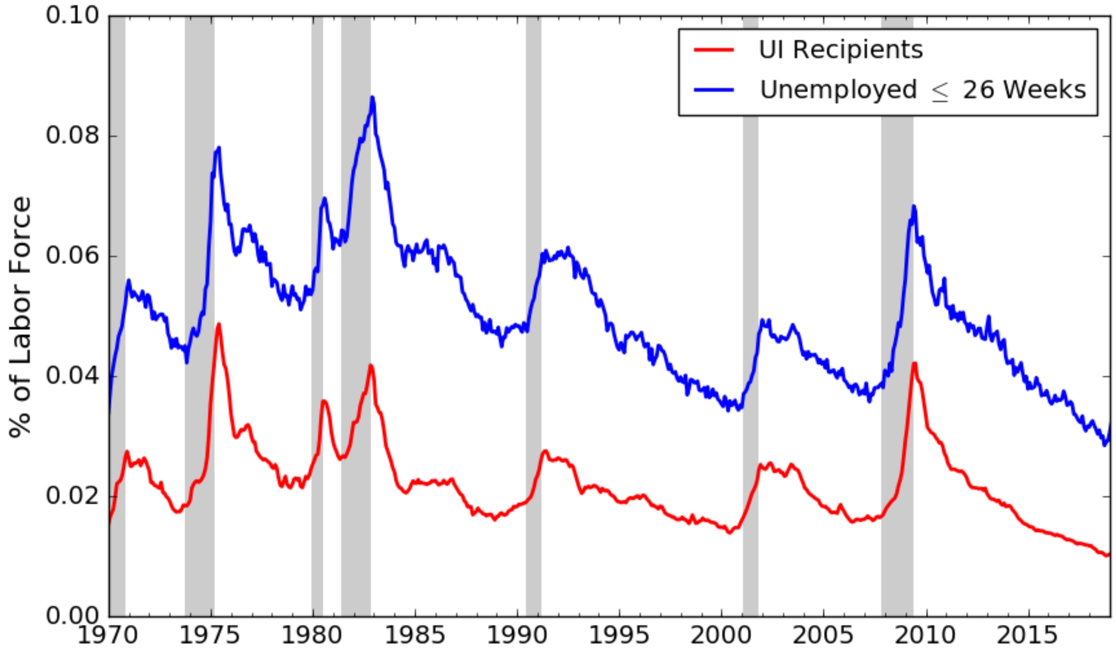
Appendices

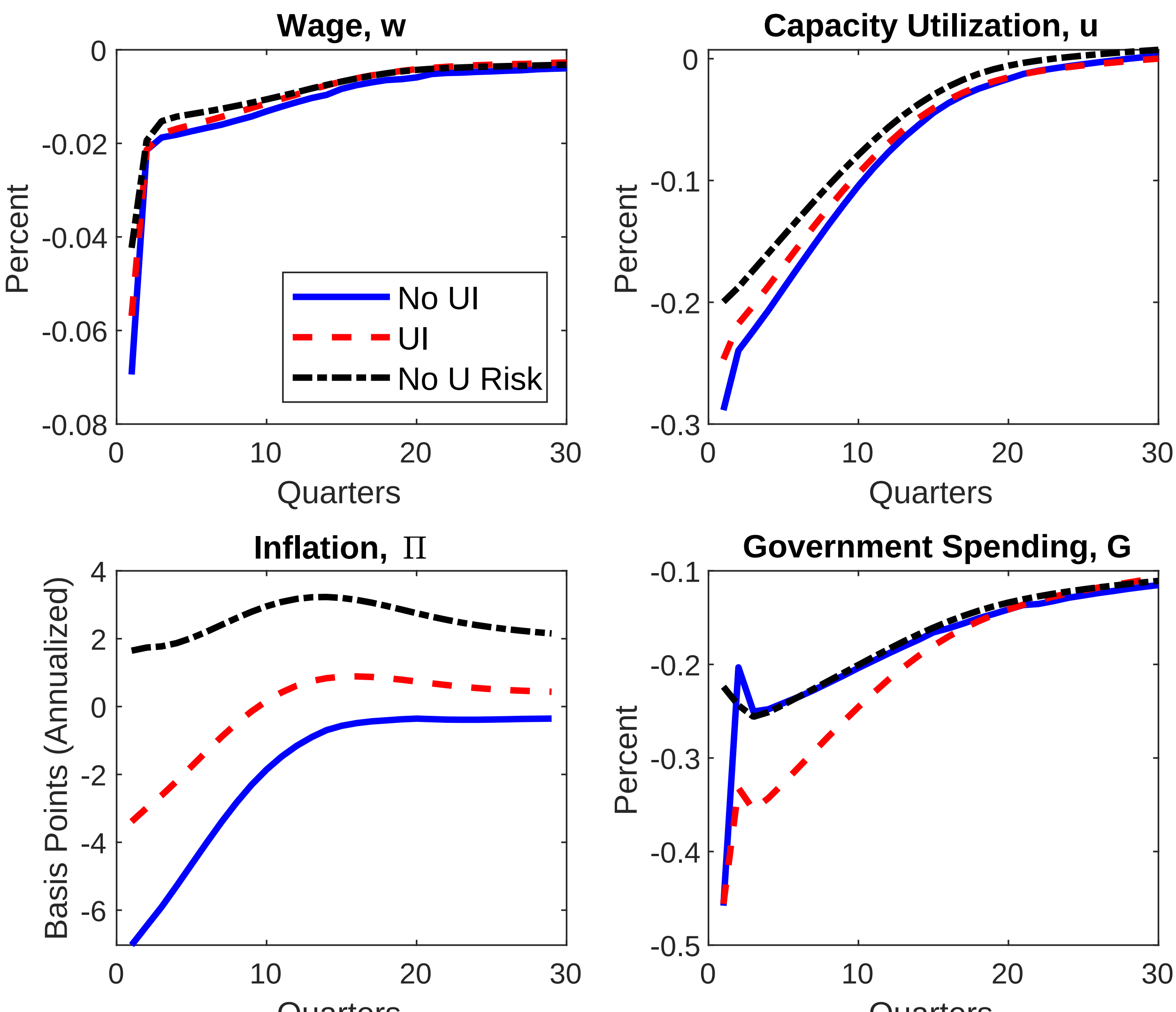
A Additional Figures and Tables

Figure 11: Low Recipiency of Unemployment Insurance



Notes: Data from the Bureau of Labor Statistics and the Employment and Training Administration.

Figure 12: Response to an Aggregate Productivity Shock



Notes: Figure shows the response of further variables to the negative aggregate productivity shock in the three versions of the two-asset model.

Table 8: Wealth Distributions in Alternative Models

Moment	Data	Baseline Model	No UI Model	No U Risk Model
Liquid Assets to Output	0.26	0.29	0.31	0.27
Illiquid Assets to Output	2.86	2.88	2.88	2.88
% Poor Hand-to-Mouth	0.1	0.05	0.05	0.04
% Wealthy Hand-to-Mouth	0.2	0.2	0.14	0.41
% Negative Liquid Assets	0.15	0.14	0.12	0.16
Gini Coefficient (Total Wealth)	0.81	0.82	0.81	0.83
Top 1% share (Liquid)	47	34	33	41
Top 1%-10% share (Liquid)	39	52	51	51
Top 10%-50% share (Liquid)	18	15	16	11
Bottom 50% share (Liquid)	-4	-2	0	-3
Top 1% share (Illiquid)	33	19	19	19
Top 1%-10% share (Illiquid)	37	55	55	55
Top 10%-50% share (Illiquid)	27	24	24	24
Bottom 50% share (Illiquid)	3	2	2	2

Notes: Data moments are from Guvenen et al. (2015) and Kaplan et al. (2018). Moments from the model are calculated by simulating 1 million households until the steady-state of the model is reached, and aggregating income to an annual frequency. In the model I define household as hand-to-mouth if the absolute value of their liquid asset holdings is less than 10% of the average quarterly wage.

B Data Sources

B.1 Consumer Expenditure Survey (CEX)

I construct the CEX sample using the microdata files provided by the BLS. Following the previous literature on the relationship between household consumption and unemployment, I restrict attention to the consumption of non-durables and services. From total expenditure, I exclude spending on housing, health care, education, cash contributions, personal insurance, and automobiles. This is close to the definition of non-durables and services used by Chodorow-Reich and Karabarbounis (2016).

I select households whose head is between the ages of 25 and 55. As in Chodorow-Reich and Karabarbounis (2016), I drop households whose head or spouse work in farming, forestry, or the armed services.

The measurement of liquid asset holdings has changed over time in the CEX. For the most recent years, I use the variable LIQUDYRX, which measures the value of checking, savings, and money market accounts, as well as CDs, one year ago. Before 2013 this variable was not available, and I construct a similar measure using CKBKACTX (which measures the current value of checking accounts, brokerage accounts, and other similar accounts) and COMPCKGX which measures the change in checking account balances over the previous year. Thus, I am able to measure liquid asset holdings immediately before the year in which the households report their employment status and consumption. In all years, I define households as hand-to-mouth if their liquid asset holdings are below the median value in that given year.

The CEX contains little information on a household's illiquid asset holdings. Consequently, I use housing tenure as a proxy for illiquid asset holdings. I define households as wealthy (poor) hand-to-mouth if they are hand-to-mouth by the above definition and they are homeowners (renters). Table 9 reports some descriptive statistics about the CEX sample and compares it to households from the SCF, where liquid and illiquid asset holdings are measured more accurately.

In both the CEX and SCF, poor hand-to-mouth households are slightly younger, less likely to have a college degree, and more likely to be unemployed than either non hand-to-mouth or wealthy hand-to-mouth households. Table 9 also shows that housing status is a good proxy for illiquid asset holdings: 70% of wealthy hand-to-mouth households in the SCF

Table 9: Descriptive Statistics Across Asset Groups

	Full Sample		N-HTM		W-HTM		P-HTM	
	CEX	SCF	CEX	SCF	CEX	SCF	CEX	SCF
% of Households	1	1	0.51	0.50	0.29	0.31	0.20	0.19
Average Age	41.2	39.6	41.8	40.5	41.8	40.8	38.7	35.5
% College Degree	0.45	0.39	0.59	0.53	0.37	0.30	0.22	0.17
% Homeowners	0.71	0.59	0.84	0.74	1.00	0.70	0.00	0.06
Average $U_{i,t}$	0.08	0.06	0.06	0.04	0.09	0.08	0.12	0.12
Median Income (000's)	50	54	69	80	44	48	23	23

Notes: SCF data is from Kaplan et al. (2018) for the 2004 survey. In both surveys I define households as hand-to-mouth if their liquid asset holdings are below the median level. In the SCF, I define households as wealthy if their illiquid asset holdings are above the 25th percentile. The CEX sample uses households in the survey between 2003 and 2005. All statistics are calculated using sampling weights.

are homeowners, compared to only 6% of poor hand-to-mouth households. By construction these values are 100% and 0% in the CEX.

I measure employment at the household level using the number of weeks worked by the household head or spouse. I classify individuals who do not work during the year as unemployed if they report having looked for a job and out of the labor force if not. For individuals who worked for less than 52 weeks, I measure the fraction of the year that they were unemployed as 1 - weeks worked/52.

B.2 Panel Study of Income Dynamics (PSID)

A broad measure of consumption expenditures is only available in the PSID from 2005 onwards. Consequently, I use data from the surveys between 2005 and 2017. As in the CEX, I restrict the sample to households whose head is between the ages of 25 and 55.

The measure of liquid asset holdings that I use in the PSID is the value of checking or savings accounts, money market funds, certificates of deposit, government savings bonds, or Treasury bills. The measure of illiquid asset holdings is the value of housing equity and retirement accounts. As the PSID occurs every other year, for the purposes of estimating equation 2.2 I group households based on their asset holdings in year $t-2$. Finally, the measure of consumption is food, clothing, recreation and vacation expenditures.

B.3 Survey of Consumer Finances (SCF)

I use microdata from the SCF for the following survey years: 2004, 2007, 2010, 2013, 2016, and 2019. 2004 was the first year that the survey asked about withdrawals from individual retirement accounts.

The SCF uses a multiple imputation approach, given the low response rate to certain questions in the survey. To avoid any problems that could be introduced by this imputation, I restrict the sample to households who have no imputed data on the age of the household head, their weeks of unemployment in the previous 12 months, their ownership of any individual retirement accounts (IRAs), and the presence of any withdrawals from their IRA in the past year.

Generally, withdrawals from retirement accounts that occur before the age of 59.5 are subject to a 10% tax penalty. Consequently, I restrict the sample to households whose head is at most 55 years of age, consistent with the sample I use for the CEX in Section 2. I further restrict the sample to households where the household head reports having an IRA. This leaves 4863 households across the 6 survey waves. Overall, 24% of households in the SCF report ownership of an IRA.

Measurement of liquid asset holdings in the SCF requires a trade-off. On the one-hand, the survey contains questions on a relatively large number of assets that could be considered liquid. On the other hand, given my decision to not use imputed data, the larger the set of assets included, the smaller will be my final sample size. Consequently, I measure liquid asset holdings using only checking account balances. Even with this relatively crude measure, the sample size declines to 3649 households once I have removed households for whom checking account data is imputed.

B.4 Survey of Consumer Expenditures (SCE)

I use SCE data from 2014 to 2019. As in the SCF, I restrict the sample to households whose head is at most 55 years of age. This is important when considering contributions to retirement accounts, for the same reason as in the SCF.

Given the focus on idiosyncratic job loss risk, I drop self-employed respondents. I also restrict the sample to household heads that have been continuously employed for more than one year. I do this by using the response to two questions in the survey. The first (Q37) is asked only to new respondents, and asks respondents to identify their job tenure using five bins. The second (DSAME) asks repeat respondents whether they are still employed at the same job.

B.5 Current Population Survey (CPS)

In Section 7.2 and Appendix G, I document the central role of unemployment risk in explaining cyclical changes in the income growth distribution. This is based on microdata from the March supplement of the IPUMS CPS dataset between 1976 and 2018. Following Guvenen et al. (2014), I restrict the sample to men between the ages of 25 and 60, and I drop individuals who report either no weeks of work or no income in a particular year. The remaining sample size fluctuates between around 5000 and 9000 individuals per year.

I measure annual income using the IPUMS variable INCWAGE, which measures wage and salary income. I measure annual hours worked using the product of WKSWORK1, which measures the number of weeks worked during the year, and UHRSWORKLY, which measures the usual number of hours worked per week.

C Consumption Response to Unemployment Spells

In this section, I provide further evidence on the consumption response to unemployment spells. Column (1) of Table 10 repeats the average response shown in Table 1. The second column removes the control variables to show their importance. Without the control variables, the consumption response to unemployment is biased due to a correlation between unemployment and other demographic characteristics that predict lower consumption. For example, even when employed, the consumption of wealthy and poor hand-to-mouth households is around 10% and 20% lower than that of non hand-to-mouth households, respectively. Finally, columns (3) to (8) repeat the basic regressions in the various one-asset models studied in Section H.

D Illiquid Asset Response to Unemployment Spells

In this section, I show that the results in Section 3 are unaffected by the addition of control variables. Table 11 shows the results of estimating a linear probability model with an indicator for IRA withdrawal as the dependent variable. I provide results both with and

Table 10: Consumption Response to Unemployment Spells

	Data (CEX)		K Model (High β)		K Model (Low β)		B Model	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$U_{i,t}$	-0.22	-0.31	-0.13		-0.20		-0.19	
	(0.015)	(0.017)						
$U_{i,t}\mathbb{1}\{\text{N-HTM}\}$				-0.05		-0.07		-0.07
$U_{i,t}\mathbb{1}\{\text{HTM}\}$				-0.20		-0.32		-0.28
Fixed effects	✓	✓						
Control variables	✓							

Notes: Robust standard errors in parentheses. Regressions weighted using CEX sampling weights, with 31638 observations from 1996 to 2017. K Model refers to the one-asset model with capital, described in Appendix H.1. B Model refers to the one-asset model with bonds, described in Appendix H.2. In both the model and the data households are defined as hand-to-mouth if their liquid asset holdings are below the median.

without controls for age, family size, education, race and year. The first and second columns estimate the overall effect of unemployment on the withdrawal probability. The third and fourth columns split unemployed households into two on the basis of the number of weeks spent unemployed. The fifth and sixth columns split unemployed households into two on the basis of liquid asset holdings.

The first, third, and fifth columns are equivalent to Table 2 in that they measure the increase in withdrawal probabilities relative to households that do not experience unemployment, with no controls. The second, fourth, and sixth columns add the control variables. The estimates are unaffected by the addition of control variables.

E Income Response to Unemployment Spells

To estimate whether or not a household's asset status is related to the size of the labor income decline that they experience during an unemployment spell, I estimate equations 2.1 and 2.2 using household wage and salary income as the dependent variable. To focus on households whose primary source of labor income is wages and salaries, I restrict the sample to households whose wage and salary income is at least $7000 in 2017 prices. Table 12 reports the estimated coefficients for the three versions of the regression used in Section 2. I find that there is no significant difference in the impact of unemployment on labor income across the three groups.

Table 11: Illiquid Asset Response to Unemployment Spells

	(1)	(2)	(3)	(4)	(5)	(6)
$\mathbb{1}\{U_{i,t} > 0\}$	0.064	0.062				
	(0.018)	(0.017)				
$\mathbb{1}\{U_{i,t} \leqslant 12 \text{ weeks}\}$			0.018	0.017		
			(0.018)	(0.018)		
$\mathbb{1}\{U_{i,t} > 12 \text{ weeks}\}$			0.119	0.116		
			(0.030)	(0.030)		
$\mathbb{1}\{U_{i,t} > 0 \text{ \& N-HTM}\}$					0.007	0.007
					(0.022)	(0.022)
$\mathbb{1}\{U_{i,t} > 0 \text{ \& HTM}\}$					0.092	0.087
					(0.027)	(0.027)
Control variables		✓		✓		✓
Observations	4863	4863	4863	4863	3649	3649

Notes: Dependent variable is an indicator for IRA withdrawal. Robust standard errors in parentheses. Regressions weighted using SCF sampling weights using data from 2004 to 2019. Control variables include age and family size as well as fixed effects for education, race, and year.

As an alternative to the above, I have used data from the Displaced Worker Supplement of the CPS to estimate how the log change in weekly earnings or length of an unemployment spell after a job displacement vary with education, homeownership, and age. On average, weekly earnings decline by 7.9% after a job displacement and individuals spend 12.2 weeks unemployed before finding a new job. Table 13 shows that there is no significant effect of education or homeownership on either of the dependent variables. The one characteristic which is associated with both longer unemployment spells and larger earnings declines, is age.

Given that poor hand-to-mouth households tend to be younger than either the non hand-to-mouth or wealthy hand-to-mouth, this suggests that, if anything, the long-term impact of unemployment spells is smallest for the poor hand-to-mouth. Consequently, this cannot explain the finding that the consumption response is largest for this group.

F Precautionary Saving: Robustness

Table 14 replicates Table 3 using alternative lag lengths for calculating the change in idiosyncratic unemployment risk. For clarity, I do not include the percentage change in consumption

Table 12: Income Response to Unemployment Spells

	CEX			PSID		
	(1)	(2)	(3)	(4)	(5)	(6)
$U_{i,t}$	-0.75			-0.82		
	(0.029)			(0.044)		
$U_{i,t}\mathbb{1}\{\text{N-HTM}\}$		-0.74	-0.74		-0.81	-0.81
		(0.044)	(0.044)		(0.070)	(0.070)
$U_{i,t}\mathbb{1}\{\text{HTM}\}$		-0.76			-0.84	
		(0.038)			(0.053)	
$U_{i,t}\mathbb{1}\{\text{W-HTM}\}$			-0.75			-0.84
			(0.052)			(0.091)
$U_{i,t}\mathbb{1}\{\text{P-HTM}\}$			-0.76			-0.83
			(0.055)			(0.064)
H_0: $\gamma_N^U = \gamma_H^U$		0.83			0.74	
H_0: $\gamma_N^U = \gamma_W^U = \gamma_P^U$			0.97			0.95

Notes: Robust standard errors in parentheses. PSID standard errors are clustered by household head. Regressions weighted using sampling weights. Final three rows of the table report the p-values for different Wald tests. CEX uses 23218 observations from 1996-2017. PSID uses 22672 observations from 2005-2017.

Table 13: Effect of Job Displacement in the CPS

	Δ log Weekly Earnings	Weeks Unemployed
Intercept	0.23***	3.61***
	(0.04)	(1.20)
$\mathbb{1}\{\text{High School}\}$	-0.004	-1.26
	(0.02)	(0.78)
$\mathbb{1}\{\text{Some College}\}$	-0.010	-0.77
	(0.02)	(0.79)
$\mathbb{1}\{\text{College}\}$	0.017	-0.33
	(0.02)	(0.80)
$\mathbb{1}\{\text{Homeowner}\}$	-0.004	-0.49
	(0.01)	(0.45)
Age_i	-0.008***	0.25***
	(0.001)	(0.03)

Notes: Robust standard errors in parentheses. Asterisks denote statistical significance at the ***1 percent, **5 percent, and *10 percent levels. The sample is restricted to men between the ages of 25 and 55. Regressions use sampling weights, with 7094 observations from 1990 to 2018.

Table 14: Robustness of Precautionary Response to Unemployment Risk

	$\mathbb{1}\{c_t^i \geqslant c_{t-12}^i\}$			$\mathbb{1}\{\mathbb{E}_{i,t}[P_{t,t+12}^i > P_{t-12,t}^i]\}$		
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta_9\mathbb{E}_{i,t}[s_{t,t+12}^i]$	-0.28			-0.31		
	(0.07)			(0.14)		
$\Delta_{10}\mathbb{E}_{i,t}[s_{t,t+12}^i]$		-0.24			-0.24	
		(0.10)			(0.18)	
$\Delta_{11}\mathbb{E}_{i,t}[s_{t,t+12}^i]$			-0.17			-0.18
			(0.12)			(0.40)
Observations	946	633	313	260	184	92

Notes: Estimates from estimating equation 4.1. Dependent variable shown in the first row. Robust standard errors in parentheses. Regressions weighted using sampling weights. c_t^i denotes household consumption of individual i in month t. $\mathbb{E}_{i,t}\mathbb{1}\{(P_{t,t+12}^i > P_{t-12,t}^i)\}$ is an indicator denoting that individual i expects to increase the proportion of earnings contributed to their Defined Contribution pension over the next year. $\Delta_x\mathbb{E}_{i,t}[s_{t,t+12}^i]$ denotes the change in the perceived annual job loss probability of individual i from month $t-x$ to t. Data from the Survey of Consumer Expectations from 2014 to 2019.

as a dependent variable.

It is clear in Table 14 that moving from the 9th to the 10th lag shrinks the sample by around a third, while moving from the 10th to the 11th lag shrinks the sample by half. This occurs because the Household Finance supplement and the Household Spending supplement are fielded infrequently. For example, as the Household Finance supplement was only fielded in one month each year, using the 9th lag allows us to include individuals who were in their 10th, 11th or 12th interview at the time of the supplement. If we use the 11th lag, we are only able to include individuals who were in their 12th interview at the time of the supplement.

Estimates are broadly similar using the 10th lag, although slightly attenuated and with larger standard errors. This pattern is exacerbated using the 11th lag, for which the available sample shrinks considerably.

G Unemployment and Income Risk

In this section, I explain the details behind the decomposition of income growth into hours growth and wage growth used in Section 7.2. I also show that income risk responds endogenously to identified macroeconomic shocks through the effect that these shocks have on unemployment.

The March supplement of the CPS contains annual data on income and hours worked. Using this data, I can decompose income into hours worked and hourly earnings as follows:

$$y_{i,t} = \underbrace{\left(\frac{y_{i,t}}{h_{i,t}}\right)}_{w_{i,t}} h_{i,t} \tag{G.1}$$

where $y_{i,t}$ is the income of individual i in year t, and $h_{i,t}$ is the number of hours worked by individual i in year t. Consequently, $w_{i,t}$ is a measure of hourly earnings. Taking log differences, income growth can then be decomposed into wage growth and hours growth:

$$\Delta y_{i,t} = \Delta w_{i,t} + \Delta h_{i,t} \tag{G.2}$$

Figure 7 shows a measure of the skewness of the income growth, wage growth, and hours growth distributions over time.[33] It is clear that the skewness of hours growth drives that of income growth, while the skewness of wage growth changes little over the business cycle. Income growth becomes negatively skewed in recessions because it becomes much more likely to experience a large decline in hours, i.e. to become unemployed. Meanwhile, for those who remain employed, the skewness of the wage growth distribution is unaffected by business cycles.[34]

To show that it is the extensive margin rather than the intensive margin that drives these results (i.e. unemployment rather than average hours worked) Figure 13 plots the income growth distribution in 2006 and 2009 for two groups of individuals: those who experienced unemployment spells in either of the two years used to measure income growth, and those who did not. It is clear from these densities that the decline in the skewness of the income growth

[33] Due to the 4-8-4 structure of the CPS, individuals that are in the March survey for the first time in one year should also be interviewed in the March survey in the following year. There are two breaks in my skewness measures, which correspond to periods where the CPS identifiers are not consistent across the two interview spells.

[34] Hoffmann and Malacrino (2019) shows similar results using Italian data.

distribution between these two years comes entirely from those households who experienced unemployment spells. In 2009 such households were far more likely to see a large decline in income than in 2006.

Figure 14 plots the skewness of income growth for the entire sample of individuals, as well as the sub-samples of individuals that either did or did not experience an unemployment spell. This confirms that the group of individuals with unemployment spells drives the cyclicality of the skewness of the income growth distribution. Finally, Figure 15 plots the skewness of income growth measured in the CPS against the equivalent measure from Guvenen et al. (2014), which uses Social Security Administration data. There is a close correlation between the two series, although the skewness of income growth declines by more in the Social Security Administration data in the past two recessions.

H Three Different One-Asset Models

In this section, I consider three different one-asset models. In the first, I remove bonds from the model and assume that households trade capital with no adjustment costs. Aside from these changes, I keep the parameterization as described in Section 5.1. In the second, I keep the liquid capital framework but lower the calibrated discount factor, β, in order to match the estimated consumption decline during unemployment. In the third, I remove capital and assume that households only trade liquid bonds.

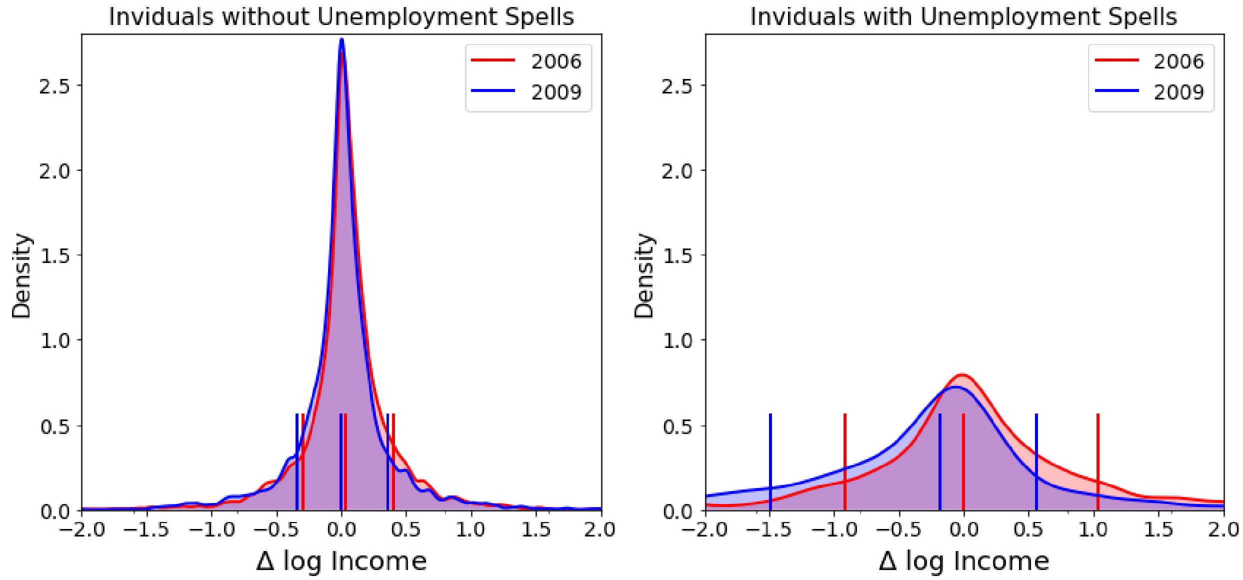
H.1 A One-Asset Model with Liquid Capital

In the model with liquid capital and without bonds, the household's problem simplifies to:

$$\begin{aligned} V_t(k,z,e) &= \max_{c,k'} \frac{c^{1-\gamma}}{1-\gamma} + \beta(1-\zeta)\mathbb{E}_{e',z'}V_{t+1}(k',z',e') \qquad \text{(H.1)} \\ &\text{subject to} \\ k' + c &= \mathbb{1}\{e=E\}w_t z(1-\tau_l) + \mathbb{1}\{e=U\}w_t\phi(z)(1-\tau_l) + R_t^k k + T_t \\ k' &\geqslant 0 \\ z' &= \Gamma(z) \end{aligned}$$

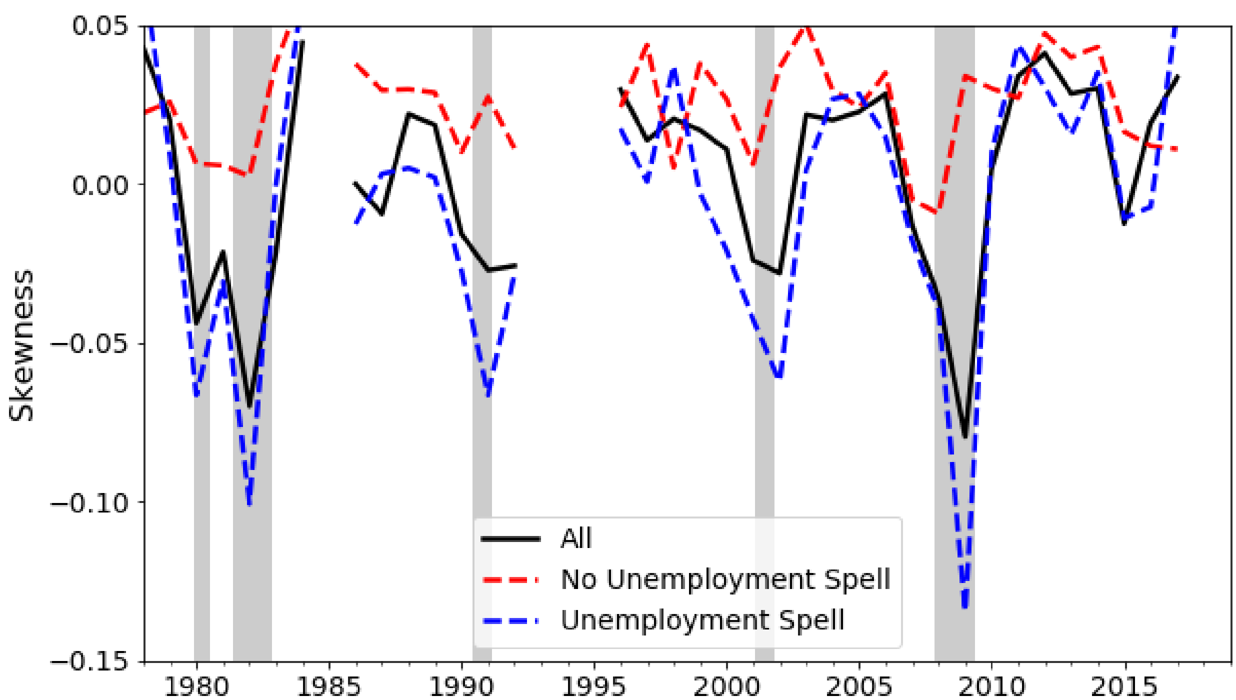
As in Gornemann et al. (2016), I use a cashless limit assumption, implying that the expected

Figure 13: Income Growth Densities and Unemployment Spells



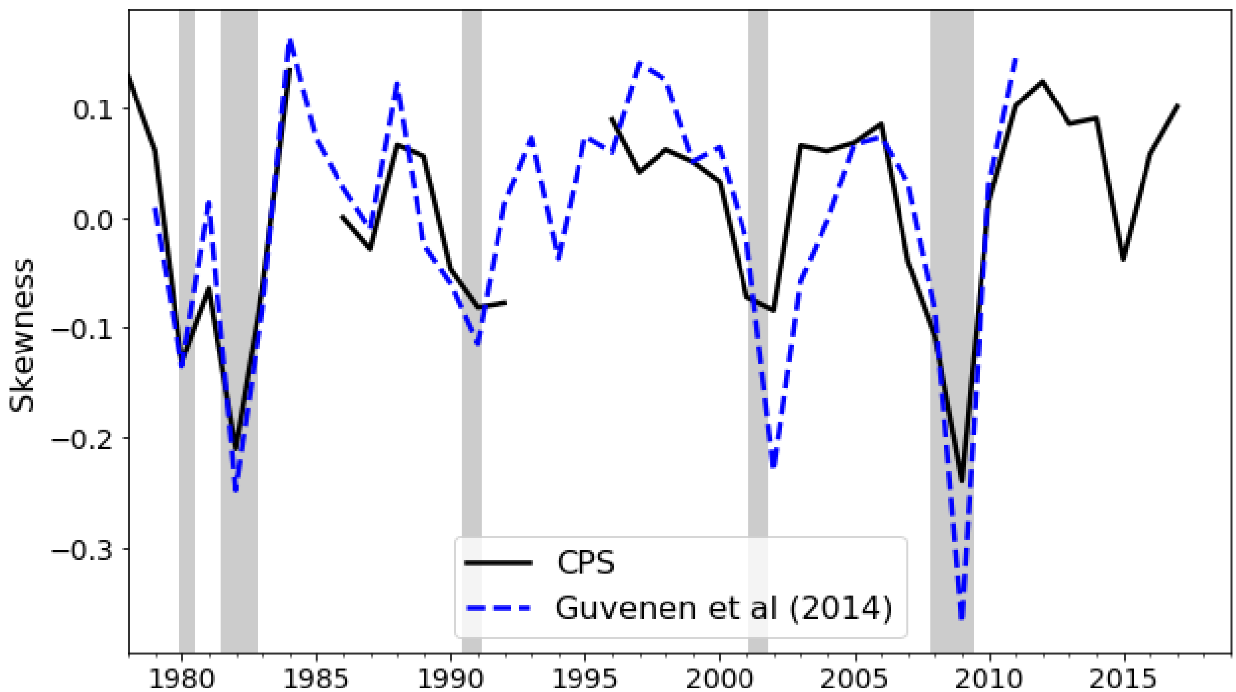
Notes: The vertical lines denote the 10th, 50th, and 90th percentiles of the distribution.

Figure 14: Unemployment Drives Skewness of Income Growth



Notes: Skewness measured using Pearson's second skewness coefficient (median skewness).

Figure 15: Income Skewness: CPS vs. Social Security Data



Notes: Skewness measured using Pearson's second skewness coefficient (median skewness).

return on nominal bonds must be equal to that on capital.

In the first calibration of this one asset model with capital, I keep the parameterization as described in Section 5.1. In such a model, households are well insured against unemployment risk, and consequently the decline in consumption during unemployment is smaller than documented in Section 2. This is shown in Table 10, which reports the consumption declines during unemployment for each of the one-asset models in this section. Figure 16 shows the response of the economy to the aggregate productivity shock in this model: I find no amplification from unemployment risk. As in Gornemann et al. (2016), I find that unemployment risk raises the volatility of consumption but lowers the volatility of investment. Overall, it has almost no effect on the response of unemployment or output.

In the second calibration of this one-asset model with capital, I lower the calibrated discount factor, β, from 0.982 to 0.96, in order to match the estimated consumption decline during unemployment. Figure 17 shows the response of the economy to the aggregate productivity shock in this model: I find that unemployment risk actually *dampens* business cycle fluctuations slightly. A rise in unemployment risk leads to an increase in precautionary saving in capital. This dampens the decline in investment sufficiently such that output and employment actually fall less with unemployment risk than without. In the language of Challe et al. (2017), the stabilizing "aggregate supply" channel of unemployment risk dominates in this setting. In Section J.2 I show that these results also hold in response to a shock to the marginal efficiency of investment.

H.2 A One-Asset Model with Liquid Bonds

In the model in which households trade bonds and there is no capital, the production function for the intermediate good producers is:

$$y_{j,t} = A_t n_{j,t} \tag{H.2}$$

Their marginal cost is equal to $m_t = \frac{h_t}{A_t}$. Given this, the New Keynesian Phillip's Curve is unchanged. The household's problem simplifies to:

$$V_t(b, z, e) = \max_{c,b'} \frac{c^{1-\gamma}}{1-\gamma} + \beta(1-\zeta)\mathbb{E}_{e',z'} V_{t+1}(b', z', e') \tag{H.3}$$

subject to

$$
\begin{aligned}
b' + c &= \mathbb{1}\{e = E\} w_t z (1 - \tau_l) + \mathbb{1}\{e = U\} w_t \phi(z)(1 - \tau_l) + R_t^b(b) b + T_t \\
b' &\geqslant \underline{\text{b}} \\
z' &= \Gamma(z)
\end{aligned}
$$

The rest of the model: the labor agency's problem and fiscal and monetary policy rules are exactly as in the two-asset model. I leave the calibration as close to the two-asset model as possible. I lower the discount factor, β, to 0.98, to match the estimated consumption decline during unemployment. I leave all other parameters unchanged except the following: I adjust the mean wage $\bar{w}$ to keep the unemployment rate at 6% in the steady state and then lower the values of the vacancy cost c, the transfer T, and the borrowing limit $\underline{\text{b}}$ such that they remain the same relative to $\bar{w}$ or output.

Figure 18 plots the response of key variables to the aggregate productivity shock in all three versions of the one-asset model with liquid bonds. The main result is that there is little amplification of the shock due to unemployment risk in this framework. Despite the fact that this is a calibration in which consumption responds strongly to unemployment, idiosyncratic unemployment risk has little effect on business cycle dynamics in this model, and unemployment insurance plays no role as an automatic stabilizer.

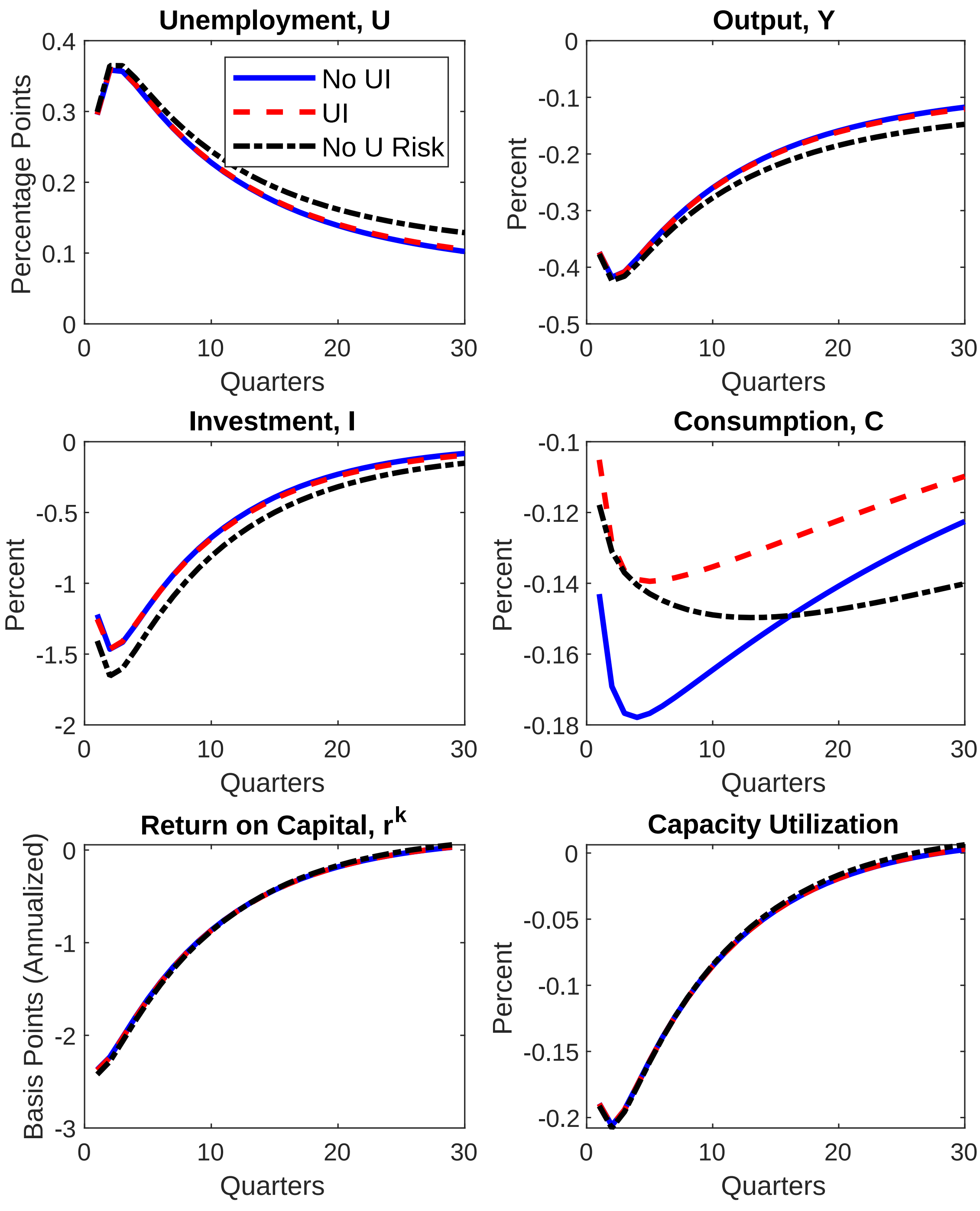
H.2.1 Amplification in the One-Asset Model with Liquid Bonds

In this section, I consider alternative calibrations of the one-asset model in which households trade bonds to understand the difference between the results above and those in Ravn and Sterk (2017).

Their paper assesses the role of unemployment risk in a one-asset HANK model and finds large amplification. The key difference is the assumption that they make about the liquid asset distribution. In particular, they assume that agents hold no assets in equilibrium. The path of the real interest rate is determined by employed households, whose Euler equation holds with equality, while unemployed households are borrowing constrained. These assumptions imply that the only force affecting the path of the real interest rate in their economy is the consumption smoothing motive of the employed households, as unemployed households are unable to borrow.

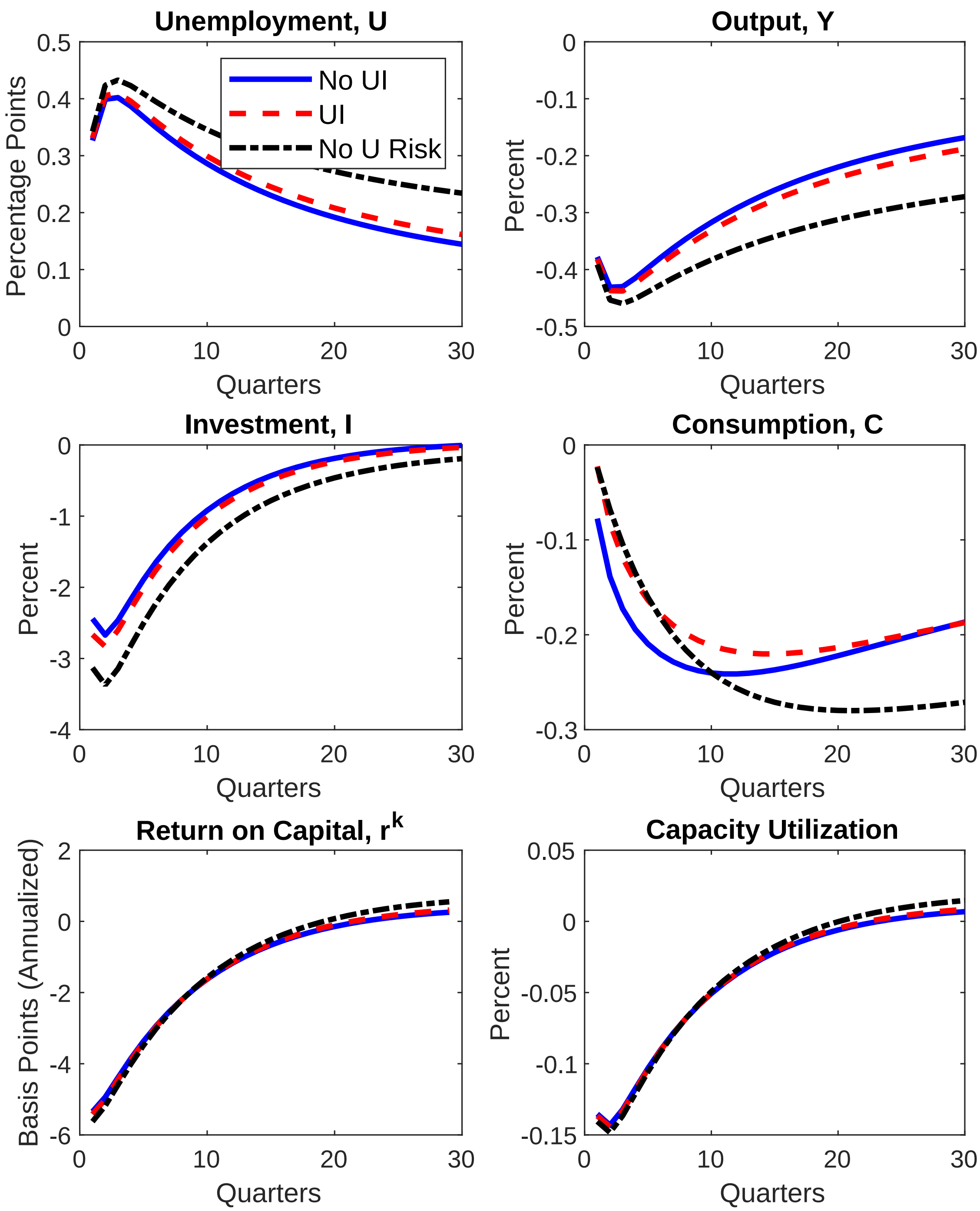
In Figure 19, I show the effect of varying β in the one asset model between 0.99 and 0.945. When β is close to 0.945, the model does display significant amplification, as in Ravn and

Figure 16: Aggregate Shock (One-Asset Model: Capital, High β)



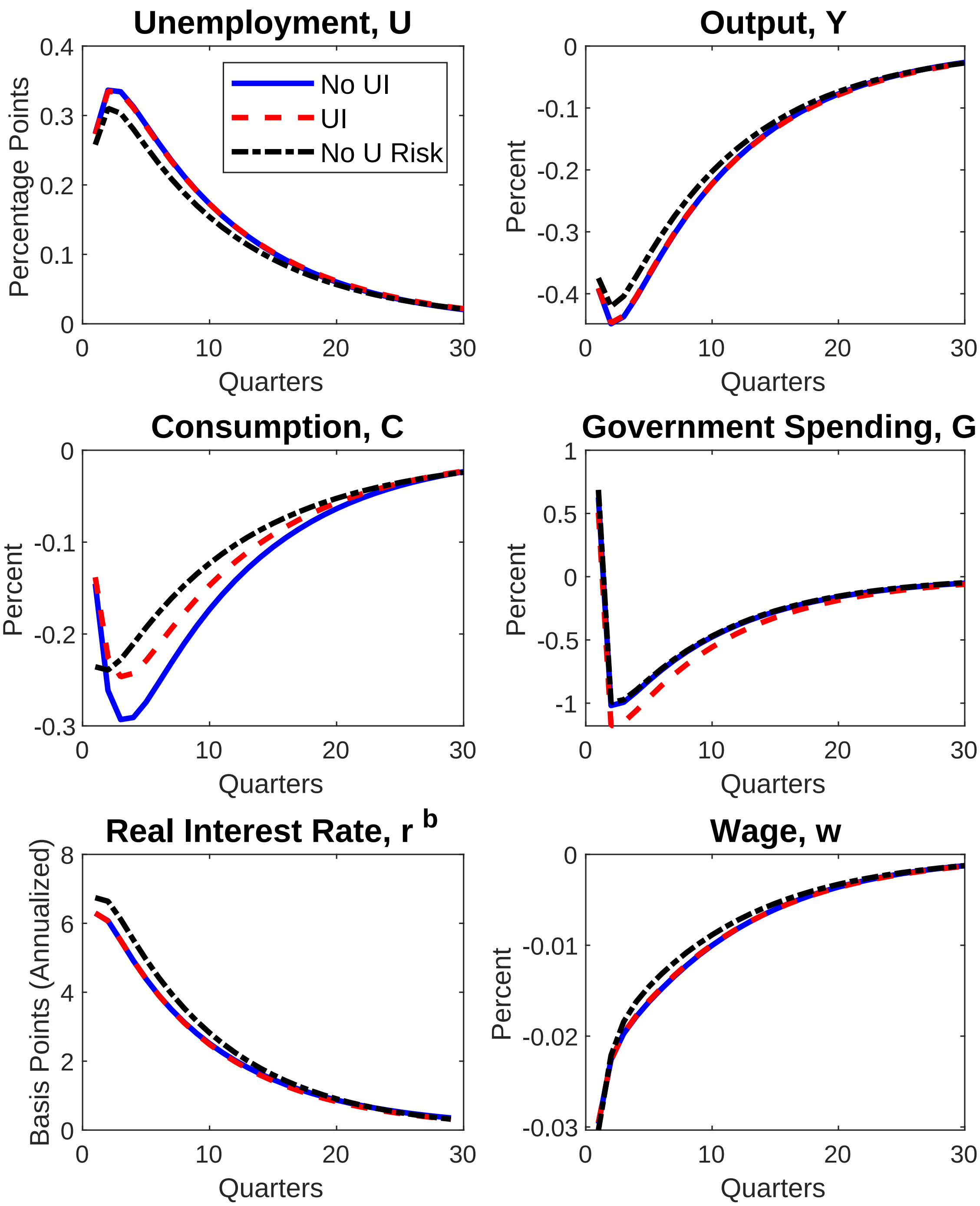
Notes: This figure shows the response of the economy to a negative productivity shock. "No UI" refers to the model without unemployment insurance. "UI" refers to the baseline model with unemployment insurance. "No U Risk" refers to the model in which households pool unemployment risk. See the text for full details.

Figure 17: Aggregate Shock (One-Asset Model: Capital, Low β)



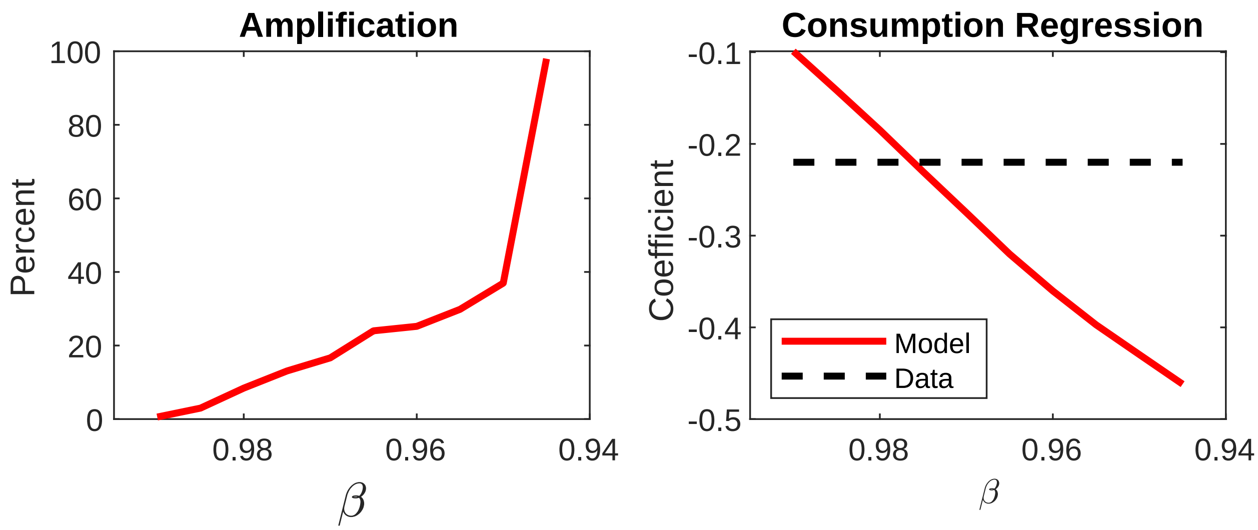
Notes: This figure shows the response of the economy to a negative productivity shock. "No UI" refers to the model without unemployment insurance. "UI" refers to the baseline model with unemployment insurance. "No U Risk" refers to the model in which households pool unemployment risk. See the text for full details.

Figure 18: Aggregate Shock (One-Asset Model: Bonds)



Notes: This figure shows the response of the economy to a negative productivity shock. "No UI" refers to the model without unemployment insurance. "UI" refers to the baseline model with unemployment insurance. "No U Risk" refers to the model in which households pool unemployment risk. See the text for full details.

Figure 19: Varying β in the One-Asset Model



Notes: Amplification measured as the maximum change in unemployment in the version of the model with no unemployment insurance relative to the maximum change in the version of the model with no unemployment risk.

Sterk (2017). However, in such a calibration, the consumption decline during unemployment is much larger than in the data.

I Solving the Two-Asset Model

I.1 Solving the Household Problem

Solving equation 5.1 numerically involves a significantly higher computational burden than the corresponding problem when the household does not adjust their illiquid asset holdings, as the household has a two-dimensional maximization problem (rather than a one-dimensional problem that can easily be solved using the golden-section search method).

A robust but slow method for solving equation 5.1 is a nested golden-section search algorithm, in which the maximization over one asset is done in an outer loop, and the maximization over the other asset is done in an inner loop. However, this method is too slow for calculating the response of the economy to aggregate shocks, which requires solving a modified version of equation 5.1 for a large number of periods, multiple times.

A faster method is to break equation 5.1 down into two simpler problems. Specifically, I first solve the problem for households that choose not to adjust their illiquid asset holdings, shown in equation 5.4.

It is then possible to solve the full problem in equation 5.1 by solving the following one-dimensional maximization:

$$V_t^A(b,k,z,e) = \max_{k'} V_t^{NA}(b^*,k',z,e) \tag{I.1}$$

$$\text{subject to}$$

$$b^* = \frac{R_t^b(b)b + R_t^k(k-k') - \tau_k \mathbb{1}\{k'<k\}(k-k')}{R_t^b(b^*)}$$

To see why this works, consider the budget constraint of the problem given by $V_t^{NA}(b^*,k',z,e)$:

$$k' + b' + c = \mathbb{1}\{e=E\}w_t z(1-\tau_l) + \mathbb{1}\{e=U\}w_t\phi(z)(1-\tau_l) + T_t + R_t^b(b^*)b^* + R_t^k k' \tag{I.2}$$

Now, substitute in the value of b^* given in equation I.1:

$$\begin{aligned} k' + b' + c &= \mathbb{1}\{e=E\}w_t z(1-\tau_l) + \mathbb{1}\{e=U\}w_t\phi(z)(1-\tau_l) + T_t + R_t^b(b^*)b^* + R_t^k k' \\ &= \mathbb{1}\{e=E\}w_t z(1-\tau_l) + \mathbb{1}\{e=U\}w_t\phi(z)(1-\tau_l) + T_t + R_t^b(b)b + R_t^k(k-k') - \tau_k\mathbb{1}\{k'<k\}(k-k') + R_t^k k' \\ &= \mathbb{1}\{e=E\}w_t z(1-\tau_l) + \mathbb{1}\{e=U\}w_t\phi(z)(1-\tau_l) + T_t + R_t^b(b)b + R_t^k k - \tau_k\mathbb{1}\{k'<k\}(k-k') \end{aligned}$$

Thus, the problem in equation I.1 satisfies the household's budget constraint, regardless of the choice of k'. The adjustment to liquid asset holdings in b^* takes into account all effects of the capital adjustment on the household's budget constraint. As equation 5.4 and equation I.1 are relatively simple one-dimensional maximization problems, this significantly increase the speed of solving the full problem in equation 5.1.

I.2 Solving for the Steady-State of the Model

Since I assume that the equilibrium real interest rate is 1% on an annual basis, and that the steady-state unemployment rate must be 6%, the algorithm for finding the steady-state is as follows:

1. Guess the equilibrium level of capital, K.

2. The equilibrium unemployment rate implies an equilibrium labor-market tightness, θ, and value of h. Find the steady-state wage that is consistent with this, using the

steady-state FOC for the labor agency:

$$\beta \left(h - \bar{w} + \frac{c}{q(\theta)}(1-s) \right) = \frac{c}{q(\theta)} \tag{I.3}$$

(Taking into account the calibrated relationship between c and $\bar{w}$.)

3. Given this wage and the job-finding probability, solve the household's problem.

4. Use non-stochastic simulation to find the equilibrium distribution of households.

5. Update the guess of K and return to Step 2.

I.3 Solving the Response to an Aggregate Shock

In Section 5, I solve the response of the model to an unanticipated aggregate productivity shock. The algorithm for solving for the equilibrium path in response to this shock is described below:

1. Guess paths for the real interest rate and capital stock: $\{r_t^b\}_{t=1}^T$ and $\{K_t\}_{t=1}^T$ (where T is large enough that the economy has returned to the steady-state).

2. Use the Taylor rule and Fisher relation to find the implied path of inflation and the nominal interest rate.

3. Guess a path of employment

   (a) Given the path of employment, calculate the path output using the production function.

   (b) Using output and inflation, calculate the path of the mark-up using the New Keynesian Phillips curve.

   (c) Using the path of the mark-up, calculate the path of wages.

   (d) Using the path of wages, calculate the path of the job-finding rate from the labor agency's Euler equation. Update the guess of the path of employment and return to step 3(a).

4. Given the implied paths of the job-finding rate, wage, the real interest rate, and the return on capital, solve the household's problem backwards from $t = T - 1$ to 1.

5. Simulate the household distribution forwards from $t = 1$ to T.

6. Use the implied paths of liquid asset holdings, $\{B^h\}_{t=1}^T$, and capital holdings, $\{K_t^h\}_{t=1}^T$, to update the guessed path of the real interest rate and capital stock and return to step 2.

I.4 Consumption-Equivalent Size of Adjustment Costs

In this section, I calculate the consumption-equivalent size of the utility costs of illiquid asset adjustment cost in the steady-state of the model. A household that pays adjustment cost χ and has consumption C would be willing to lower their consumption to C^* which satisfies the following equation in order to avoid the adjustment cost:

$$\frac{C^{*(1-\gamma)} - 1}{1-\gamma} = \frac{C^{1-\gamma} - 1}{1-\gamma} - \chi \tag{I.4}$$

Solving for C^*:

$$C^* = \left[C^{1-\gamma} - (1-\gamma)\chi\right]^{\frac{1}{1-\gamma}} \tag{I.5}$$

In the calibrated version of the model, $\gamma = 2$, so this simplifies to:

$$C^* = \frac{1}{C^{-1} + \chi} \tag{I.6}$$

As the adjustment costs are random, the average level of C^* for a household with consumption C whose maximum adjustment cost is χ^* is as follows:

$$\begin{aligned} C^* &= \frac{1}{\bar{\chi}} \int_0^{\chi^*} \frac{1}{C^{-1} + \chi} d\chi + \frac{1}{\bar{\chi}} \int_{\chi^*}^{\bar{\chi}} \frac{1}{C^{-1}} d\chi \\ &= \frac{1}{\bar{\chi}} \left[\log(C^{-1} + \chi^*) - \log(C^{-1})\right] + C \frac{\bar{\chi} - \chi^*}{\bar{\chi}} \end{aligned} \tag{I.7}$$

Integrating across households, the total size of adjustment costs in terms of consumption is $\int (C - C^*) d\mu$, which is equal to 0.6% of total consumption or 0.4% of total output.

There is also a second, easier to quantify, adjustment cost, which is the illiquid asset withdrawal tax. The steady-state value of illiquid asset withdrawal tax payments is 0.3% of total output.

J Robustness

In this section, I undertake a number of robustness exercises. I show that the main results of the paper are robust to different aggregate shocks (specifically a shock to the marginal efficiency of investment), a Taylor rule featuring interest rate smoothing, a wide range of values of the wage elasticity ϵ_w, robust to different assumptions about the distribution of profits, and that amplification relies on price stickiness. I also show that unemployment insurance is a somewhat less effective automatic stabilizer if the lump-sum transfer adjusts to balance the government's budget constraint (rather than government spending).

J.1 A Shock to the Marginal Efficiency of Investment

In this section, I show that the amplification in the two-asset model due to unemployment risk is also present in response to other aggregate shocks.

Specifically, I study the response to a shock to the "marginal efficiency of investment". This is one of the "demand shocks" that explain most of the variance in output in the short-run in Smets and Wouters (2007), a finding that is corroborated by Justiniano, Primiceri and Tambalotti (2010). Bayer, Born and Luetticke (2020) show that such shocks remain important in estimated HANK models.

This shock varies the efficiency with which the final good can be transformed into physical capital. I assume that the marginal efficiency of investment declines by 0.3% unexpectedly and then returns to its steady-state value (of 1) following an AR(1) process with a quarterly persistence of 0.85.[35] I denote the path of its inverse by ν_t. This shock affects the household's budget constraint, which is now:

$$\begin{aligned}\nu_t k' + b' + c + \tau_k \mathbb{1}\{k' < k\}(k - k') = {} & \mathbb{1}\{e = E\} w_t z (1 - \tau_l) \\ & + \mathbb{1}\{e = U\} w_t \phi(z)(1 - \tau_l) + R_t^b(b) b + R_t^k k + T_t \end{aligned} \tag{J.1}$$

[35] This magnitude generates a similar rise in unemployment in the baseline model to the productivity shock in Section 7.

where

$$R_t^k = r_t^k u_t + (1 - \delta_0 u_t^{\delta_1})\nu_t \tag{J.2}$$

This shock raises ν_t and thus discourages households from investing in illiquid capital. Figure 21 shows the response to this shock in the three versions of the model. The amplification that occurs due to unemployment risk, and the dampening that occurs due to the introduction of unemployment insurance, are both similar to that seen in Section 7.

J.2 A Shock to the Marginal Efficiency of Investment in the One Asset Model

In this section, I show that the *lack of* amplification in the one-asset model is also present in response to a shock to the marginal efficiency of investment.

I study the same shock as in the previous subsection in the two calibrations of the one-asset model with capital from Section H.1. Figures 22 and 23 show the response to this shock in the two one-asset models. In each case, there is a slight dampening of the aggregate shock due to unemployment risk. As in Bayer et al. (2020), the effect of a shock to the marginal efficiency of investment is both significantly smaller and significantly more persistent in one-asset models relative to a two-asset model.[36]

J.3 A Taylor Rule with Smoothing

In the main paper, I study the response to aggregate shocks with a very simple Taylor rule. I now consider whether amplification is affected by this assumption, by considering a Taylor rule with interest-rate smoothing:

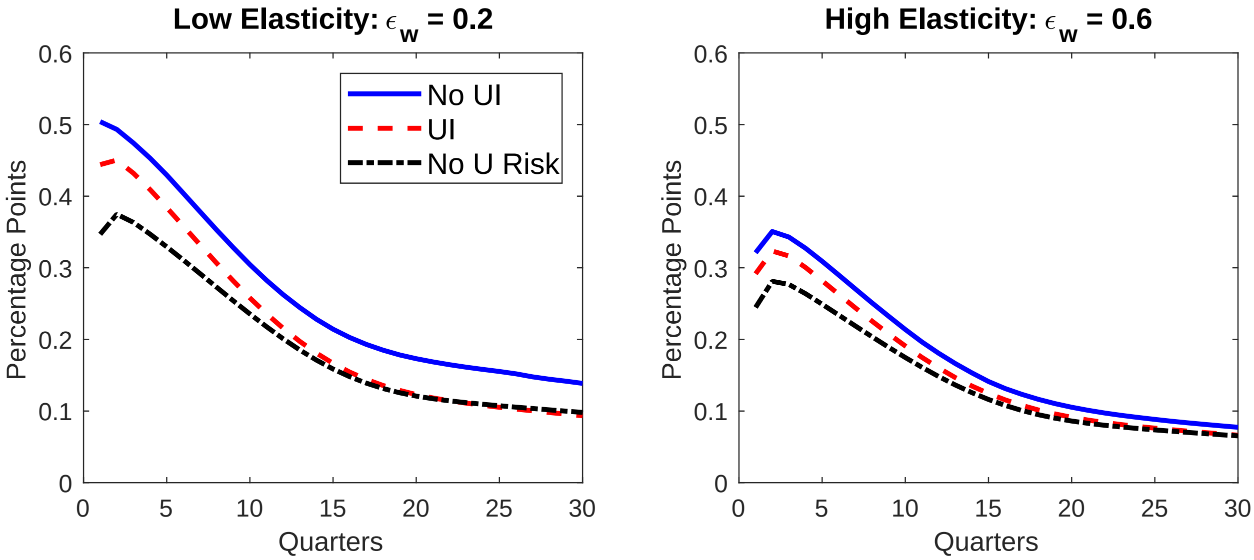
$$i_{t+1} = \rho_i i_t + (1 - \rho_i)(\bar{r}^b + \psi(\Pi_t - 1)) \tag{J.3}$$

I set $\rho_i = 0.7$, in line with recent estimates such as Carvalho, Nechio and Tristao (2021) and leave ψ (and all other parameters) unchanged.

Figure 24 shows the response to the aggregate productivity shock with this alternative monetary policy rule. I find that the amplification due to unemployment risk is significantly increased with this more sluggish response of monetary policy.

[36] In their case, the one-asset model is a RANK model.

Figure 20: Robustness to different values of ϵ_w



Notes: This figure shows the response of unemployment to a negative aggregate productivity shock under alternative calibrations of the wage rule.

J.4 Stickier or More Flexible Wages

Due to the complexity of the household problem, it is not possible to use a bargaining solution to determine the equilibrium wage in the models used in this paper. Consequently, I use a wage rule whereby the wage that households receive responds with elasticity ϵ_w to the wage that the labor agency receives from the intermediate good producers.

For the calibration in the main paper, I set ϵ_w to 0.45 (based on the elasticity of real wages to labor productivity documented by Hagedorn and Manovskii (2008)). In this section, I show that the main result of the paper, that unemployment risk significantly amplifies aggregate shocks in the two-asset model, is robust to a wide range of values of ϵ_w.

Figure 20 plots the response of unemployment to the aggregate productivity shock when ϵ_w is set to either 0.2 or 0.6. When the wage that households receive is more flexible, the overall effect of the shock is smaller, as the labor agency is able to pass through more of the decline in wages to households, and consequently the decline in vacancy posting is lessened. However, the amplification that comes from unemployment risk remains: in both cases, the response of unemployment is significantly larger in the model without unemployment insurance when compared to the model with unemployment insurance.

J.5 Wages Responding to Unemployment

In the model, and in the above subsection, I use a wage rule in which the wage that households receive responds with elasticity ϵ_w to the wage that the labor agency receives from the intermediate good producers.

In this section, I propose a different wage rule, assuming that the wage responds instead to the level of employment (or unemployment):

$$w_t = \bar{w} \left(\frac{N_t}{\bar{N}} \right)^{\epsilon_U} \tag{J.4}$$

This alternative wage rule ties wages more closely to the unemployment risk that households face. I set $\epsilon_U = 0.1$, such that the response of wages to the aggregate productivity shock is of a similar magnitude to that in the baseline calibration.

Figure 25 shows the response of each of the three versions of the model to the aggregate productivity shock with this alternate wage rule. The amplification implied by the model is similar to that seen with the baseline wage rule.

J.6 Profits Distributed to Households

In the baseline version of the model, I assume that profits are consumed by risk-neutral entrepreneurs. In this section, I consider an alternative assumption where profits are distributed evenly to the households in the model. I assume that the government issues a lump-sum tax such that the steady-state of the model is unchanged.

Figure 26 shows the response of each of the three versions of the model to the aggregate productivity shock in this case. The amplification implied by the model is increased under this assumption on the distribution of profits.

J.7 Heterogeneous Job Separation Rates

In this section, I assume that an individual's job separation rate varies exogenously with their labor productivity. I assume that:

$$s(z) = s_0 + s_1 \log(z) \tag{J.5}$$

I leave s_0 at the original calibration of 0.1, and I set s_2 to -0.01. This implies that the least productive individuals have a job separation rate that is around two times higher than the most productive.

In this version of the model, the average productivity of unemployed households will now vary over time, complicating the problem of the representative labor agency. Consequently, I replace it with an unlimited mass of potential entrepreneurs that are able to post vacancies in the labor market. The free-entry condition for such entrepreneurs is:

$$\mathbb{E}_z[J_t(z)] = \frac{c}{q(\theta_t)} \tag{J.6}$$

where $J_t(z)$ solves the following recursion:

$$J_t(z) = (h_t - w_t) + \beta(1 - (s_0 + s_1 \log(z)))\mathbb{E}_{z'}[J_{t+1}(z')] \tag{J.7}$$

Note, the expectation in the free-entry condition is over the productivity of an unemployed worker, which potentially varies over time. The remainder of the model is unchanged.

Figure 27 shows the response to the productivity shock in the three versions of the model. The introduction of heterogeneous job separation rates leaves the amplification of the model unchanged.

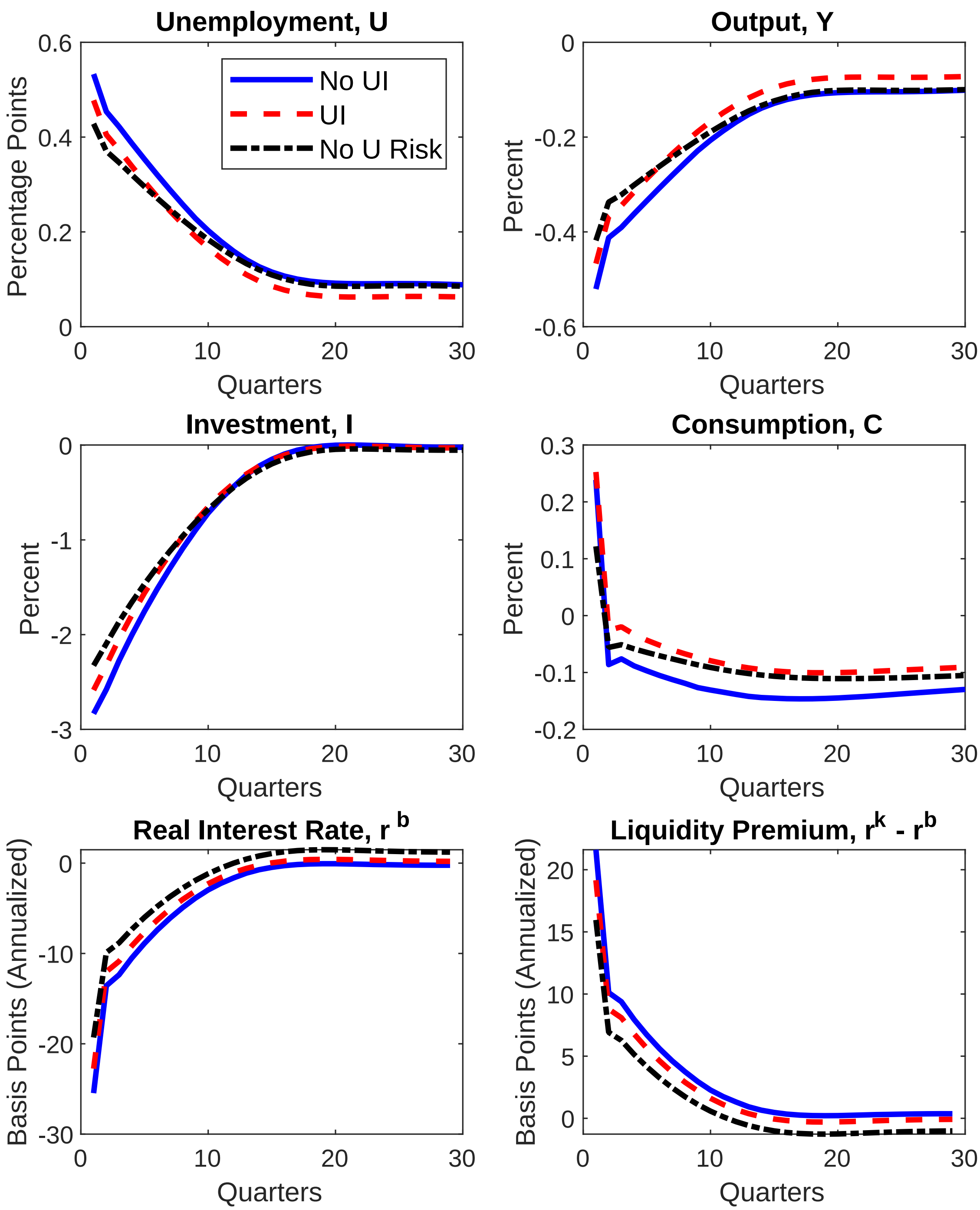
J.8 Flexible Prices

Figure 28 plots the response of the three versions of the model in an economy with flexible prices. If prices are flexible, the effect of the decline in aggregate demand initiated by the rise in unemployment risk is accommodated entirely in prices rather than quantities, and the feedback loop between unemployment risk and aggregate demand is neutralized. Consequently, price rigidity is required for idiosyncratic unemployment risk to lead to business cycle amplification in this model.

J.9 Alternative Fiscal Policy Rules: Adjusting T_t Not G_t

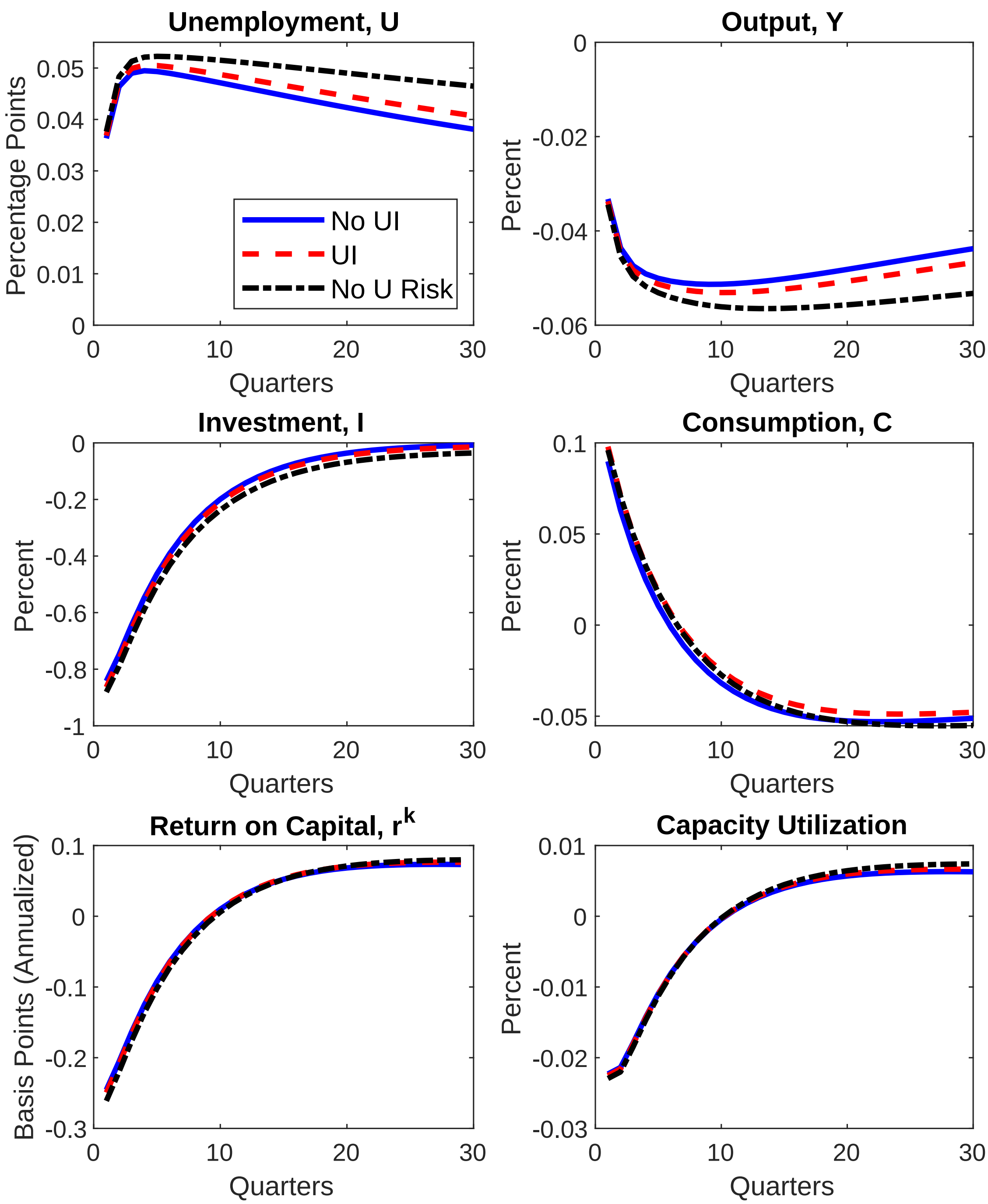
In the experiments considered in Section 7, I assume that government spending adjusts to balance the government's budget constraint each period. In this section, I assume instead that government spending is held constant at its steady-state level, and that the lump-sum transfer adjusts. Figure 29 plots the response of the three versions of the model to the aggregate productivity shock under this assumption. By comparing the versions of the model with no unemployment insurance and no unemployment risk, it is clear that the overall degree of amplification is broadly unchanged under this assumption.

Figure 21: Shock to Marginal Efficiency of Investment



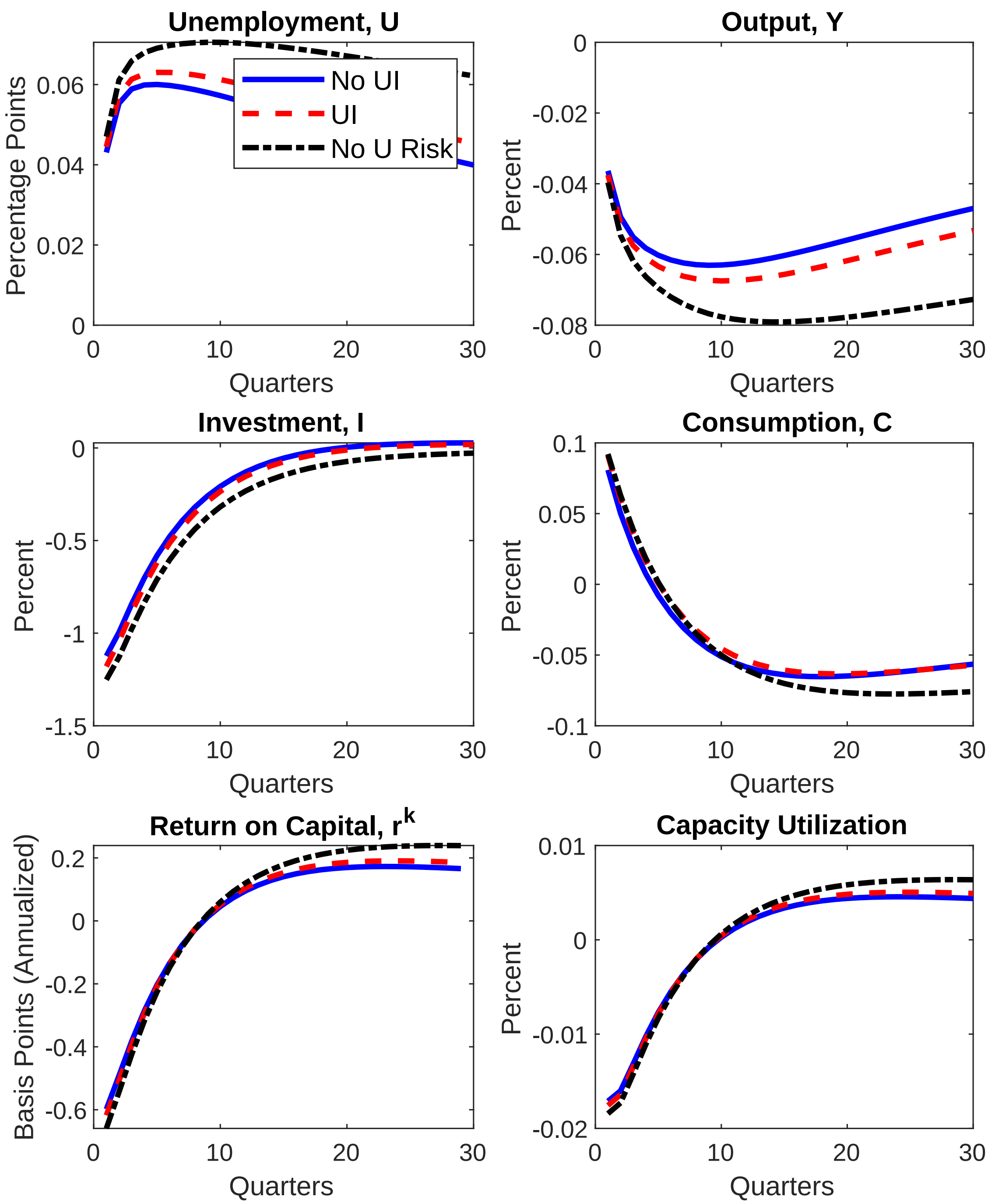
Notes: This figure shows the response of the economy to a shock to the marginal efficiency of investment. "No UI" refers to the model without unemployment insurance. "UI" refers to the baseline model with unemployment insurance. "No U Risk" refers to the model in which households pool unemployment risk. See the text for full details.

Figure 22: Shock to MEI in One-Asset Model (High β)



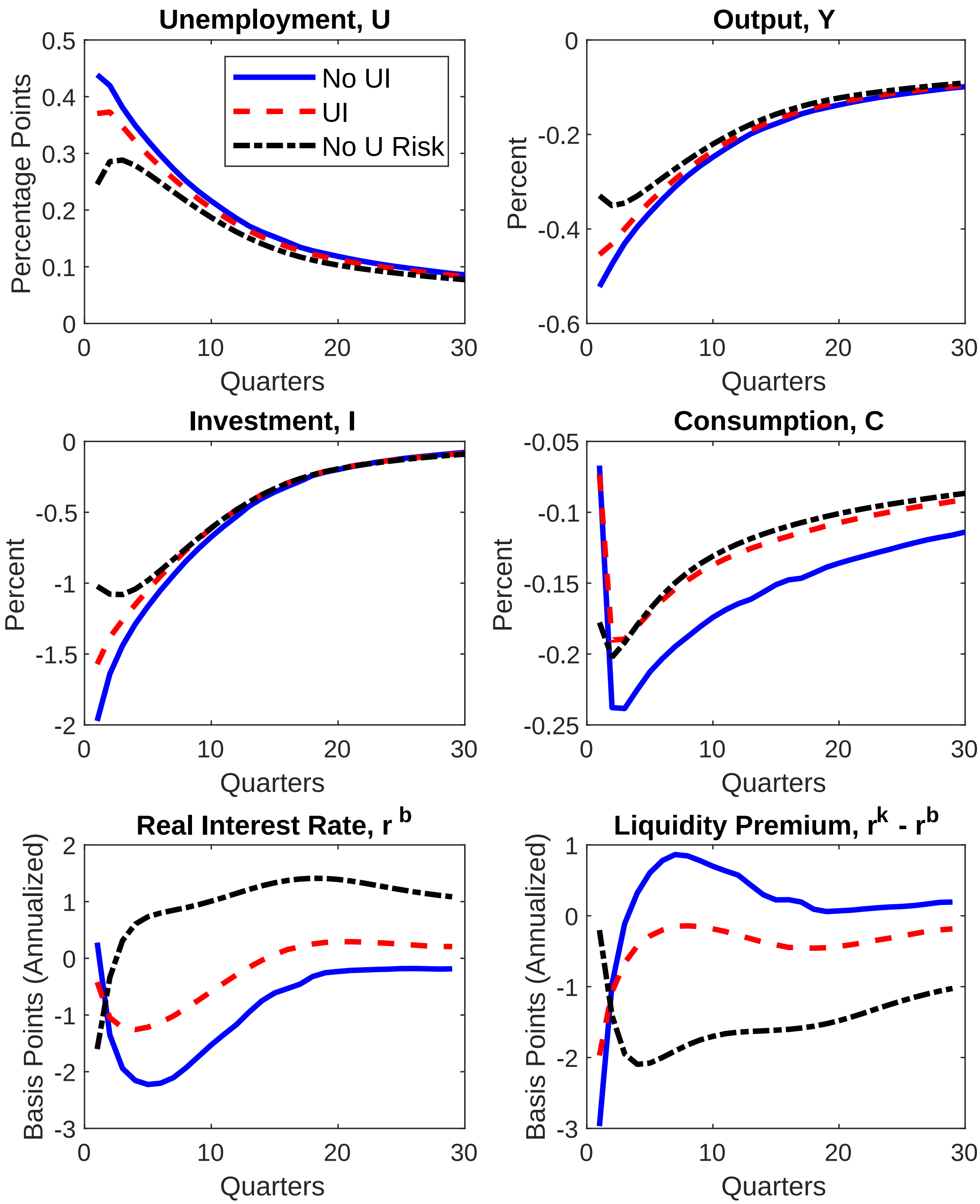
Notes: This figure shows the response of the economy to a shock to the marginal efficiency of investment. "No UI" refers to the model without unemployment insurance. "UI" refers to the baseline model with unemployment insurance. "No U Risk" refers to the model in which households pool unemployment risk. See the text for full details.

Figure 23: Shock to MEI in One-Asset Model (Low β)



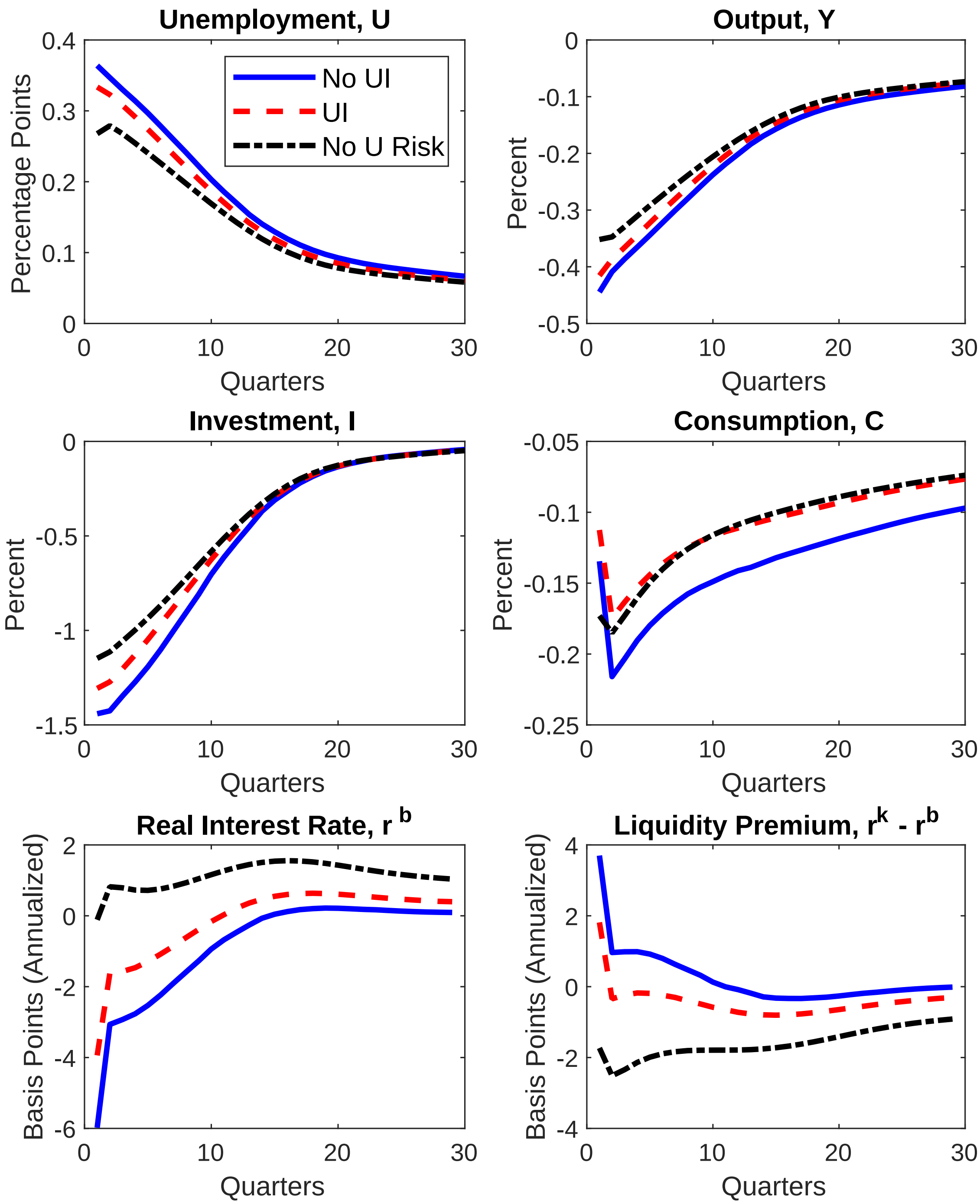
Notes: This figure shows the response of the economy to a shock to the marginal efficiency of investment. "No UI" refers to the model without unemployment insurance. "UI" refers to the baseline model with unemployment insurance. "No U Risk" refers to the model in which households pool unemployment risk. See the text for full details.

Figure 24: Robustness: Taylor Rule with Interest Rate Smoothing



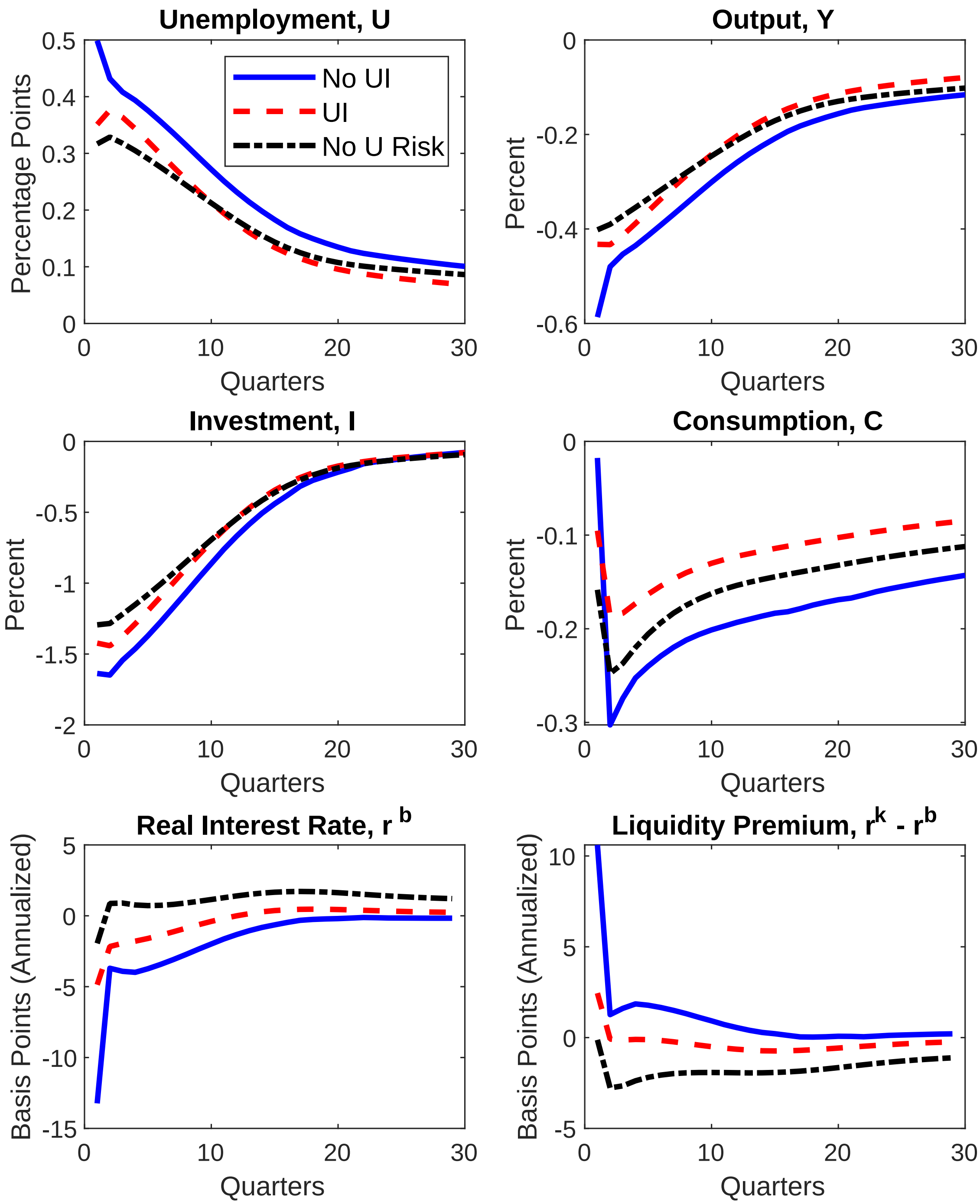
Notes: This figure shows the response of the economy to a negative aggregate productivity shock. "No UI" refers to the model without unemployment insurance. "UI" refers to the baseline model with unemployment insurance. "No U Risk" refers to the model in which households pool unemployment risk. See the text for full details.

Figure 25: Robustness: Wage Depends on Unemployment Rate



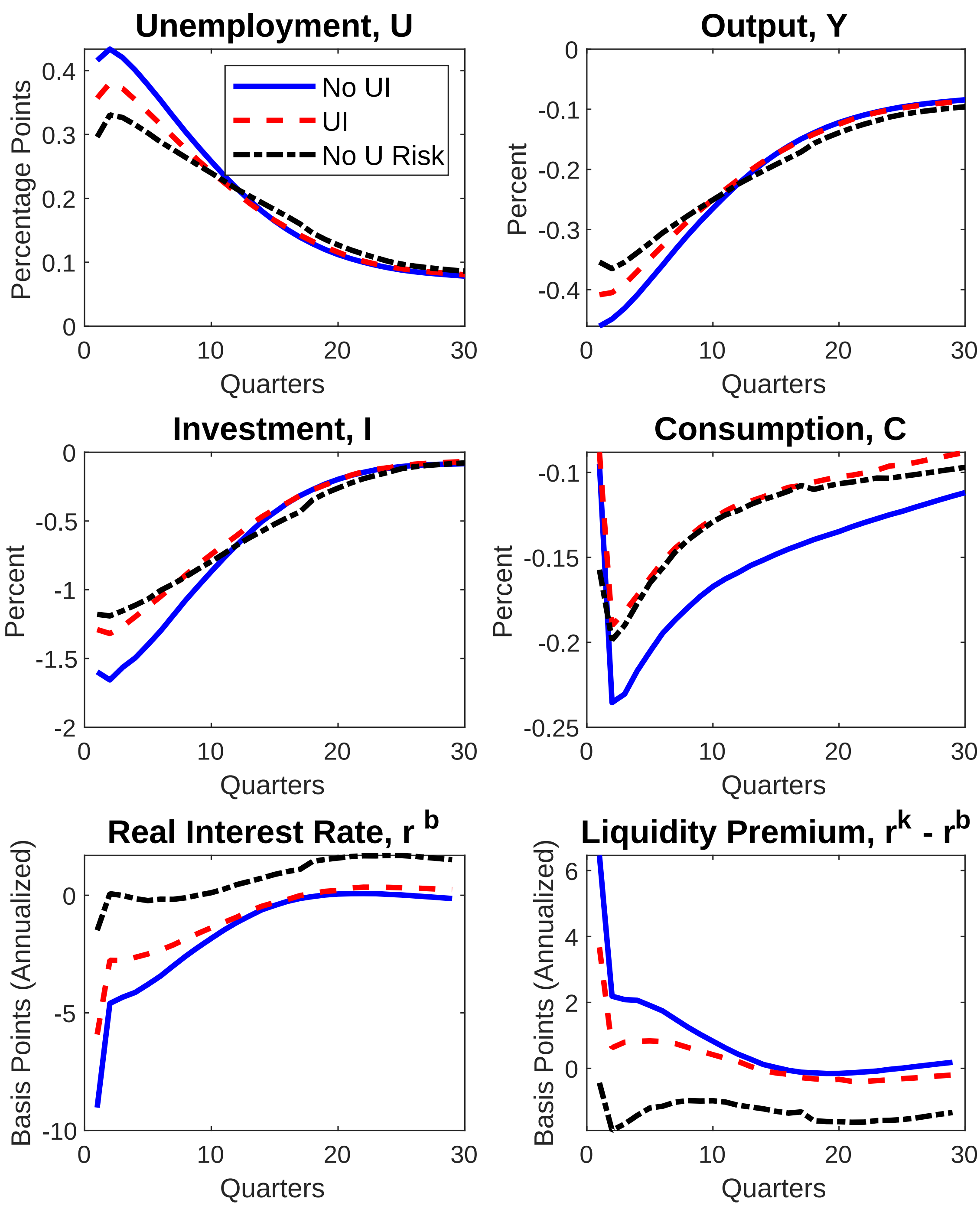
Notes: This figure shows the response of the economy to a negative aggregate productivity shock. "No UI" refers to the model without unemployment insurance. "UI" refers to the baseline model with unemployment insurance. "No U Risk" refers to the model in which households pool unemployment risk. See the text for full details.

Figure 26: Robustness: Profits Distributed to Households



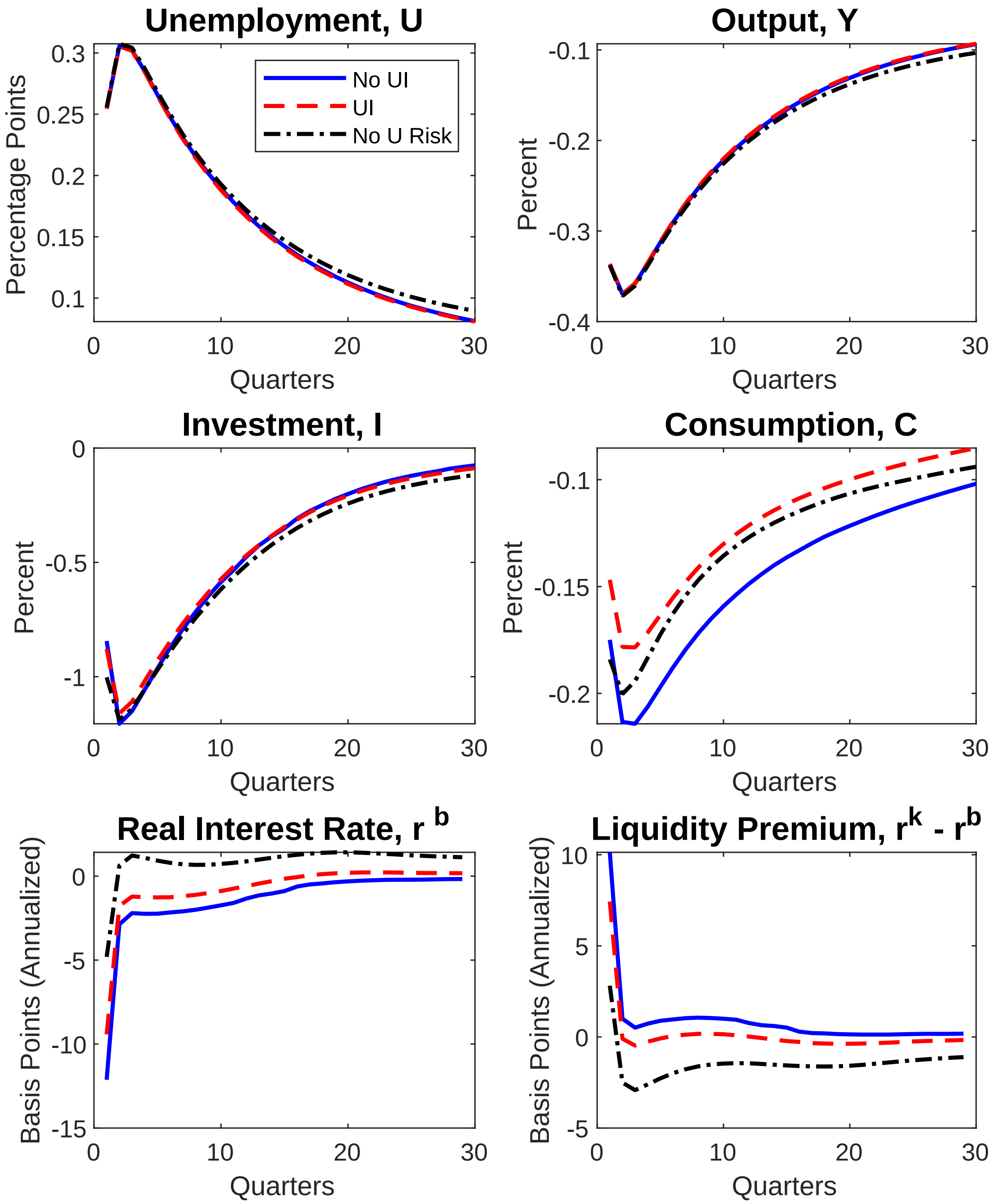
Notes: This figure shows the response of the economy to a negative aggregate productivity shock. "No UI" refers to the model without unemployment insurance. "UI" refers to the baseline model with unemployment insurance. "No U Risk" refers to the model in which households pool unemployment risk. See the text for full details.

Figure 27: Robustness: Heterogeneous Separation Rates



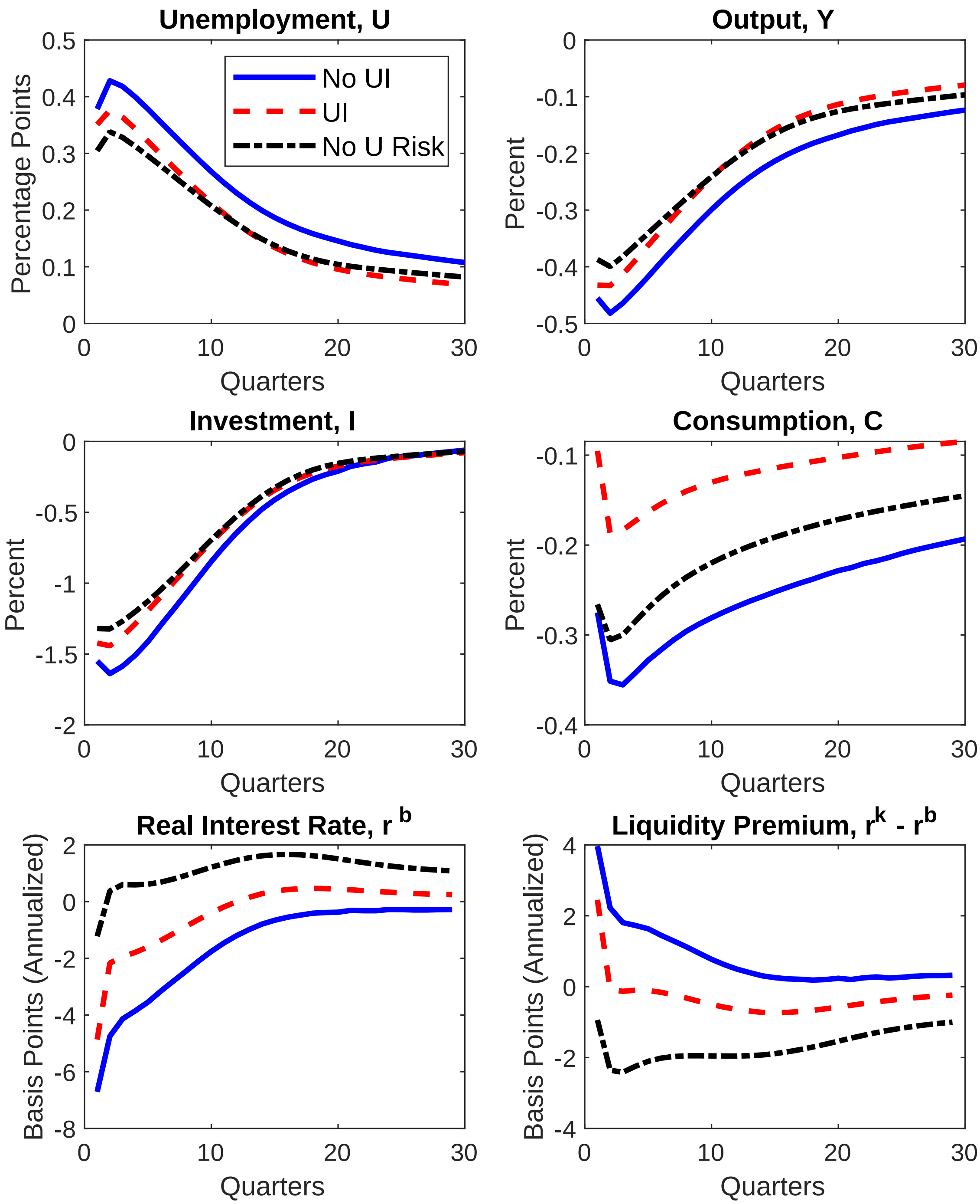
Notes: This figure shows the response of the economy to a negative aggregate productivity shock. "No UI" refers to the model without unemployment insurance. "UI" refers to the baseline model with unemployment insurance. "No U Risk" refers to the model in which households pool unemployment risk. See the text for full details.

Figure 28: Robustness: Flexible Prices



Notes: This figure shows the response of the economy to a negative aggregate productivity shock. “No UI” refers to the model without unemployment insurance. “UI” refers to the baseline model with unemployment insurance. “No U Risk” refers to the model in which households pool unemployment risk. See the text for full details.

Figure 29: Robustness: Alternate Fiscal Policy: T_t Adjusts



Notes: This figure shows the response of the economy to a negative aggregate productivity shock. "No UI" refers to the model without unemployment insurance. "UI" refers to the baseline model with unemployment insurance. "No U Risk" refers to the model in which households pool unemployment risk. See the text for full details.