Durable Expenditure Dynamics under Time-Varying Income Risk*

Karl Harmenberg† Erik Öberg‡

February 12, 2016

Preliminary and incomplete - please do not quote!

Abstract

We explore the relationship between fluctuations in income risk and expenditures on durable goods. First, we study the effect of fluctuations in income risk in a tractable partial equilibrium model of durable expenditure decisions featuring non-convex adjustment costs. Non-convex adjustment costs imply that households follow an Ss-type decision rule. In this setting, temporary increases in income risk raise the option value of postponing purchases. With a mean-preserving income process calibrated to match the US business cycle swings in income risk, the fall in durable expenditures upon entering a recession is three times as large as in the same model without adjustment costs. Second, we investigate the relationship empirically. Using micro level data from the Italian Household Survey of Income and Wealth, we estimate the effect of fluctuations in unemployment risk on durable and non-durable expenditures. We find that durables respond strongly to an increase in unemployment risk, while the effect is negligible and statistically insignificant for non-durable expenditures. We also provide evidence using US time series data.

*We are grateful for helpful comments by Nicholas Bloom, Christoph Boehm, Tobias Broer, David Domeij, John Hassler, Nathaniel Hendren, Paul Klein, Per Krusell, Kurt Mitman, Kathrin Schlafmann, and seminar participants at the IIES macro group. All errors are our own.

†IIES. karl.harmenberg@iies.su.se

‡IIES. erik.oberg@iies.su.se

1 Introduction

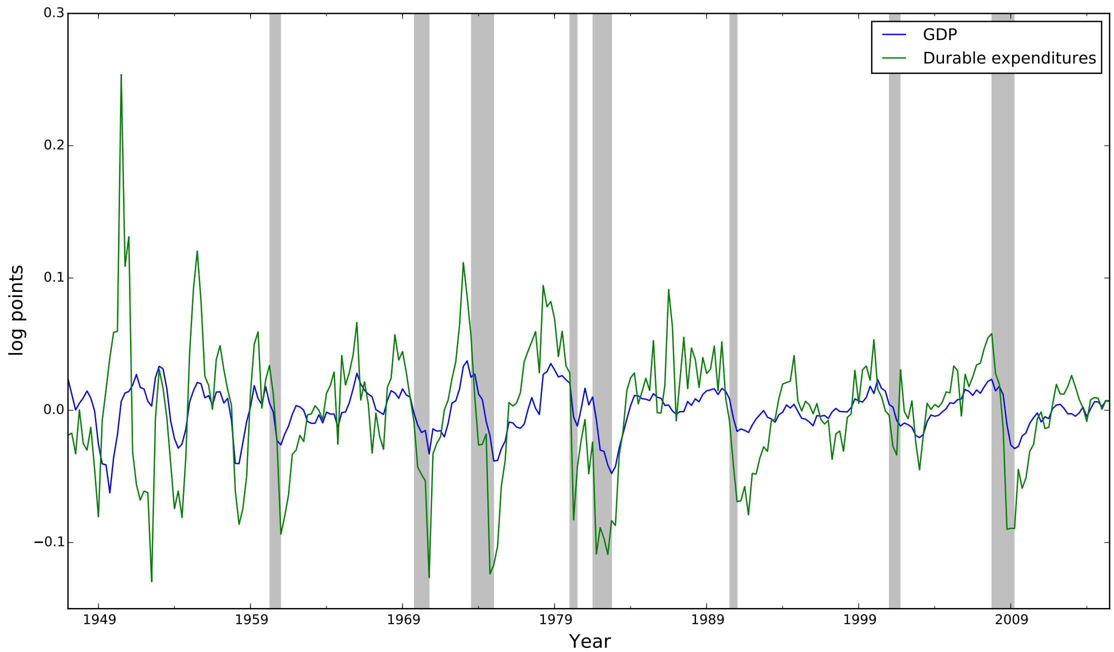

Figure 1: GDP and Expenditures on durable goods. HP-filtered quarterly data deflated with the GDP deflator. Data has been downloaded from Federal Reserve Economic Data. Shaded areas denote NBER recession dates.

Private expenditure on durable goods is one of the most volatile components of US GDP (Figure 1).[1] For the sample period 1959-2015, expenditures on durable goods account for approximately 46 percent of the business cycle variation in total consumption expenditures.[2] In the relationship between business cycle dynamics and aggregate demand, durable expenditure is a first order component.

Why do durable expenditures exhibit these swings? The Michigan Surveys of Consumers have asked households since 1960 whether it is a bad time to buy durables and what the reason for their answer is. In Figure 2, we plot the share of households that have stated that it is a bad time to buy durables because of "uncertain future", together with the responses "can't afford" and "interest rates are high".[3] Although interest rate fluctuations seem important for the cyclical swings before 1983, "uncertain future" is the most

[1]Throughout the paper, our definition of durable goods correspond to that in the NIPA, which excludes housing.

[2]The variance of the HP-filtered aggregate consumption expenditures excluding durable goods is 46 percent lower than the variance of the HP-filtered aggregate consumption expenditures including durable goods.

[3]The fourth answer category, "prices are high", exhibits a pro-cyclical pattern.

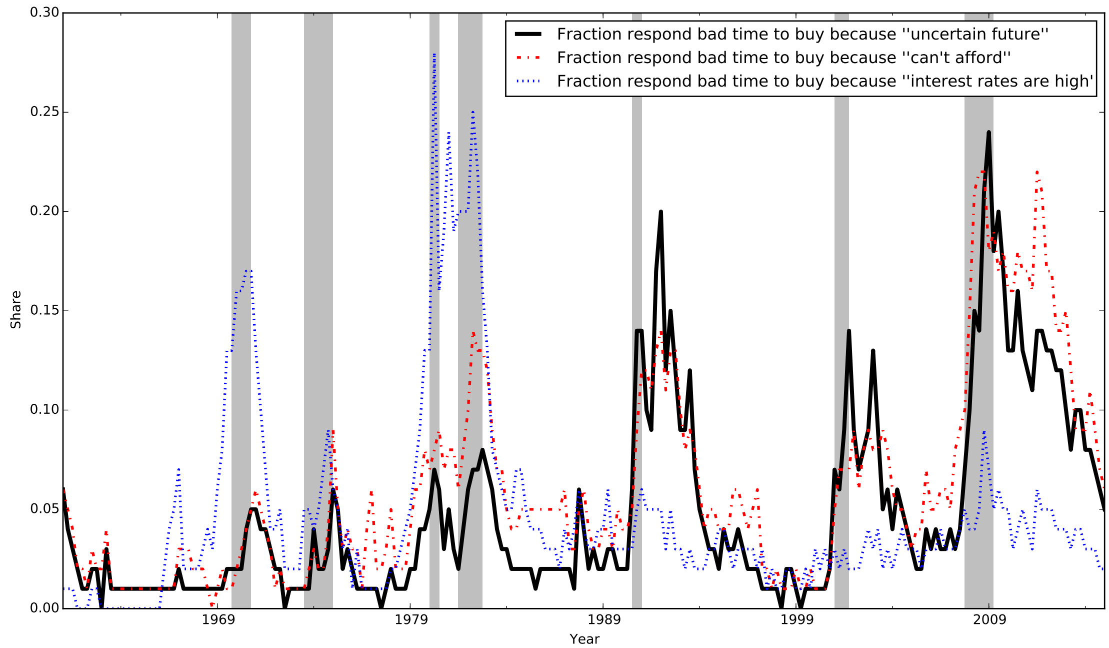

Figure 2: Share of households responding that it is a bad time to buy durables because of uncertainty.

commonly cited reason during the last three NBER recessions. For instance, the share of households that stated uncertainty as a reason to not purchase durables increased by more than 20 percentage points at the onset of the Great Recession.

We take this as motivation to study the impact of fluctuations in one particular form of uncertainty, labor income risk, on durable expenditures. We do so in two steps. First, we simulate the response of durable purchases to income risk shocks calibrated to match an average US recession. Second, we investigate the relationship empirically, both at the micro and the macro level.

For the simulation exercises, we set up a tractable partial equilibrium model of durable expenditure decisions featuring non-convex adjustment costs. Non-convex adjustment costs imply that households follow an Ss-type decision rule and have an option value of postponing adjustments of their durable stock. Temporary increases in income risk raise this option value, causing households to postpone their adjustment.

With this mechanism, we demonstrate that fluctuations in income risk can be a powerful source of fluctuations in durables. We follow McKay (2015) in the calibration of an income process that matches the business cycle swings in left-skewness documented in Guvenen et al. (2014). Even after adding unemployment benefits and a realistically calibrated progressive tax system, entering a recession immediately produces a fall in expenditures on durable goods of about 60 percent. This is about three times the response in the same model without adjustment costs, where fluctuations in income risk only matter through the precautionary-savings motive.

In the empirical investigations, we first use micro level data from the Italian Survey on Household Incomes and Wealth to study the effect that fluctuations in unemployment risk have on durable and non-durable expenditures. We estimate the probability of becoming unemployed using a set of factors extracted from a rich set of covariates. From this measure, we extract the change in unemployment risk by exploiting the panel structure of the data. In a probit regression of the extensive margin of durable purchases on the change in unemployment risk, we find that a uniform increase in unemployment risk by one percentage point translates to a (statistically significant) decrease of the number of durable purchases by 1.6 percentage points. In contrast, a change in unemployment risk has a small (and statistically insignificant) effect on non-durable consumption.

Second, we estimate augmented Euler equations on US data in the style of Campbell and Mankiw (1989), using subjective beliefs about the future unemployment rate from the Michigan Survey as Consumers as a measure of unemployment risk. This method has previously been employed by Carroll and Dunn (1997), but we benefit from being able to use 20 more years of data. In competition with the real interest rate and expected aggregate income, it is only fluctuations in unemployment expectations that significantly predict fluctuations in expenditure on durable goods. In contrast, for non-durable expenditure the effect of unemployment expectations is negligible and statistically insignificant.

Although preliminary, the empirical results suggest that fluctuations in income risk are important for consumption dynamics beyond what a precautionary-savings logic would imply. If precautionary savings were the dominant reason why households respond to fluctuations in income risk, we would expect that non-durable consumption would also be affected by fluctuations in income risk. Instead, we find that non-durable consumption is insensitive to fluctuations in income risk. These results reinforce the findings from the simulation exercise, which show that expenditures on durable goods react much stronger than expenditures on non-durable goods to fluctuations in income risk.

In connection with the model simulations, we also study the state dependency of the aggregate marginal propensity to consume (MPC). A recent and growing literature has highlighted that the aggregate MPC is a key statistic in the transmission of monetary and fiscal policy, as it determines the consumption response to the income effects that these policies may generate (Kaplan and Violante, 2014, Auclert, 2015, McKay, 2015, Berger and Vavra, 2014, 2015, Carroll et al., 2015). We find that in response to a recession shock, the aggregate MPC for durables (total consumption) falls by 50 (30) percent. This result is again due to the increased option value of postponing durable adjustments, which places more households inside an ”inactivity region” where they are unresponsive to small changes in transitory income.

1.1 Related literature

The hypothesis that fluctuations in income risk, through altering the option value of postponing purchases, provide a source of fluctuations in durable expenditures is old. An early discussion is found in Mishkin (1976). Hassler (1996) provides a theoretical analysis of the mechanism in a stylized model, and shows that temporary increases in income risk, in comparison with permanent increases, cause a much larger widening of the Ss-bands. Though not focusing on business cycle dynamics nor *changes* in income risk, Bertola et al. (2005) study the link between subjective income risk and durable adjustment in Italian survey data. The most immediate predecessor to our analysis is Carroll and Dunn (1997), who also aim to quantify the effect of fluctuations in uncertainty on durable purchases, but in a more rudimentary model. They also estimate augmented Campbell-Mankiw regressions, which form the departure point for our analysis in Section 6.3.

Non-convex adjustment costs and Ss-bands are also prominent in the firm investment literature. Early accounts of the link between investment adjustments and uncertainty are found in Bernanke (1983), Romer (1990), Bertola and Caballero (1994), Abel and Eberly (1996) and Caballero and Engel (1999). More recently, the literature has also focused on stochastic variation in uncertainty, e.g. Bloom (2009), Fernández-Villaverde et al. (2011), Bachmann and Bayer (2014) and Bloom et al. (2014), which directly links to our analysis.

Fluctuations in income risk can also cause fluctuations in consumption expenditures through altering the target level of precautionary savings. Although not directly targeted to explain fluctuations in durable expenditures, the precautionary-savings effect should be compared to the real-option effect that we emphasize in this paper. A recent contribution on the precautionary-savings effect can be found in McKay (2015).

In addition, although not focusing on fluctuations in income risk, two recent contributions on consumption dynamics under non-convex adjustment costs are complimentary to our analysis. Kaplan and Violante (2014) show that non-convex adjustment costs can create an amplification of the responsiveness of non-durable consumption expenditures to income shocks, through the creation of 'wealthy hand-to-mouth' households. Berger and Vavra (2015) calibrate a similar model of consumption expenditure to ours, and show that the aggregate marginal propensity to consume durables falls in response to negative income (first moment) shocks.

2 Model

We set up a model for durable consumption decisions under fluctuating income risk. Households receive income exogenously, and allocate resources between non-durable consumption, durables and a liquid asset. The liquid asset pays interest and the durable stock depreciates. The stock of durable consumption goods can only be adjusted if incurring a fixed cost. The income process will depend on the aggregate state; in recessions income risk will be higher than in expansions.

Before turning to the household problem, we describe the evolution of the exogenous aggregate and idiosyncratic states.

2.1 The aggregate state

The aggregate state captures whether the economy is in an expansion or in a recession. Denote the aggregate state by $s_t = \{e, r\}$.[4] We assume the following process:

$$s_{t+1} \sim F(s_t) \tag{1}$$

where F is a Markov process governed by the transition matrix

$$T_F = \begin{pmatrix} p_{ee} & 1 - p_{ee} \\ 1 - p_{rr} & p_{rr} \end{pmatrix}. \tag{2}$$

2.2 Exogenous idiosyncratic states

The household's income process follows McKay (2015). It is generated by the composite of two processes: one for employment status n_t and one for the evolution of labor income Y_t. In every period, the household draws its employment status, *em* or *un*, conditional on its status the previous period and the current aggregate state. Denote the job finding probability by $\lambda(s_t)$ and separation rate by $\zeta(s_t)$.

The evolution of labor income Y_t follows from the realizations of two shocks: η, a shock to permanent income Z_t, and ϵ, a transitory shock to total income:

$$Y_t = Z_t \epsilon_t, \tag{3}$$

$$Z_t = Z_{t-1} \eta_t. \tag{4}$$

ϵ_t is i.i.d. across time and agents while η_t depends on the aggregate state of the economy s_t. When $s_t = e$, η_t will be drawn from the expansionary distribution, while when $s_t = r$, η_t will be drawn from the recessionary distribution:

$$\eta_t = I(s_t = e)\eta_{te} + I(s_t = r)\eta_{tr}. \tag{5}$$

The distributions of η_{te},η_{tr} and ϵ_t will be calibrated to match the state-dependent income risks documented by Guvenen et al. (2014). The distributional assumptions will be discussed in more detail in Section 3.

If employed, the household supplies Y_t units of labor in return for a real wage normalized to unity. On top, it pays income taxes/receives transfers. Following Heathcote et al. (2014), let the net tax payment of an employed individual with earnings Y be $Y - (1-\tau)Y^{1-b^y}$, where τ and b^y control the average level and progressivity of the tax system respectively. Note that for incomes less than $(1-\tau)^{1/b^y}$ the household

[4] Since we only allow for two aggregate states, a recession in our model should be interpreted as an "average" US recession.

receives a transfer. If unemployed, the household receives an unemployment insurance, which is a fraction b^u of its after-tax labor income $(1-\tau)Y^{1-b^y}$.

2.3 The household problem

Households have CRRA preferences over a Cobb-Douglas aggregate of non-durables C_t and durables D_t. They have a subjective discount factor β. We assume a mortality rate of ω to maintain stationarity in the model. The effective discount factor is thus $\hat{\beta} = (1-\omega)\beta$. Households can purchase the goods at a unitary relative price[5] and invest in a risk free liquid asset at a price q.

Adjusting the durable stock is associated with an adjustment cost A proportional to the current stock of durables, $A = hD_{t-1}$. This adjustment cost is meant to capture the costs associated with selling an item and replacing it with a newer one, such as broker's fees and losses from selling at a rebate price in the second-hand market. It is also reasonable to assume that durable adjustment are associated with time costs. However, using PSID data Berger and Vavra (2015) find that these are negligible when calibrating the adjustment cost to match the size and frequency of durable adjustments. Hence, we ignore these costs here.

Without an adjustment, the durable stock depreciates at rate δ. Finally, the household is subject to an ad hoc borrowing constraint proportional to permanent income, $\underline{\mathrm{b}}(1-\tau)Z_t^{1-b^y}$.

Formally, the households solve the problem

$$
\begin{aligned}
\max_{C_t, D_t, B_t} \quad & E_0 \sum_{t=0}^{\infty} \hat{\beta}^t \frac{(C_t^{\alpha} D_t^{1-\alpha})^{1-\sigma}}{1-\sigma} \\
\text{s.t.} \quad & C_t + D_t + q_t B_t \leq (1-\tau) Y_t^{1-b^y} (n_t + b^u (1-n_t)) + (1-\delta) D_{t-1} + B_{t-1} - A(D_{t-1}), && (6) \\
& A(D_{t-1}) = \begin{cases} 0 & \text{if } D_t = (1-\delta) D_{t-1}, \\ hD_{t-1} & \text{if } D_t \neq (1-\delta) D_{t-1}, \end{cases} && (7) \\
& B_t \geq \underline{\mathrm{b}}(1-\tau) Z_t^{1-b^y}, && (8)
\end{aligned}
$$

where the income process is summarized by

$$n_{t+1} = G(s_{t+1}, n_t), \tag{9}$$

$$\log Y_t = \log Z_{t-1} + \log \epsilon_t, \tag{10}$$

$$\log Z_t = \log Z_{t-1} + \log \eta_t, \tag{11}$$

$$\log \eta_t = I(s_t = e) \log \eta_{te} + I(s_t = r) \log \eta_{tr}, \tag{12}$$

[5] Under Cobb-Douglas utility, a constant relative price different than unity would just imply a rescaling of the decision functions.

with

$$G(s_{t+1}, n_t) = \begin{cases} \begin{cases} em & \text{with prob } 1-\zeta(s_{t+1}), \\ un & \text{with prob } \zeta(s_{t+1}) \end{cases} & \text{if } n_t = em, \\ \begin{cases} em & \text{with prob } \lambda(s_{t+1}) \\ un & \text{with prob } 1-\lambda(s_{t+1}) \end{cases} & \text{if } n_t = un. \end{cases} \tag{13}$$

2.4 Recursive formulation

The household problem can be recast into recursive form. Define $V_{NA}(\cdot)$ as the value function conditional on not adjusting D_t and $V_A(\cdot)$ as the value function conditional on adjusting D_t. We can write the problem conditional on not adjusting as

$$\begin{aligned} V_{NA}(B, D; Z, \epsilon, n, s) = \quad & \max_{C, B^*} u(C, D^*) + \hat{\beta} EV(B', D'; Z', \epsilon', n', s') \\ \text{s.t.} \quad & D' = (1-\delta)D^*, \\ & D^* = D, \\ & B' = B^*, \\ & C + qB^* = (1-\tau)Y^{1-b^y}(n + b^u(1-n)) + B, \\ & B^* \geq \underline{\text{b}}(1-\tau)Z^{1-b^y}, \\ & Y = Z\epsilon, \end{aligned} \tag{14}$$

and, while not stated, also subject to the laws of motion for the state variables Z, n and s. We can write the problem conditional on adjusting as

$$\begin{aligned} V_{A}(B, D; Z, \epsilon, n, s) = \quad & \max_{C, D^*, B^*} u(C, D^*) + \hat{\beta} EV(B', D'; Z', \epsilon', n', s') \\ \text{s.t.} \quad & D' = (1-\delta)D^*, \\ & B' = B^*, \\ & C + D^* + qB^* \leq (1-\tau)Y^{1-b^y}(n + b^u(1-n)) + D + B - hD, \\ & B^* \geq \underline{\text{b}}(1-\tau)Z^{1-b^y}, \\ & Y = Z\epsilon, \end{aligned} \tag{15}$$

and, while not stated, also subject to the law of motions for the state variables Z, n and s. The unconditional value is

$$V(B, D; Z, \epsilon, n, s) = \max\{V_{NA}(B, D; Z, \epsilon, n, s), V_A(B, D; Z, \epsilon, n, s)\}. \tag{16}$$

Given this formulation, a solution to the household problem is a collection of policy functions g_C^{NA}, g_B^{NA} and a value function V_{NA} that solves (14), policy functions g_C^A, g_B^A, g_D^A, a value function V_A that solves (15), and a value function V that solves (16).

2.5 Eliminating Z as state variable

We can eliminate Z as a state variable by normalizing all variables by $(1-\tau)Z^{1-b^y}$. Moreover, ϵ and b only enters the problem through a sufficient state variable $a = b + \epsilon^{1-b^y}(n + b^u(1-n))$, which we call 'cash-on-hand'. For a detailed derivation, see Appendix A. The recursive formulation of the problem reduces to:

$$v_{NA}(a,d;n,s) = \max_{b^*,c} u(c,d) + \hat{\beta}E\left[(\eta')^{(1-\sigma)(1-b^y)} v\left(\eta'^{-(1-b^y)}b^* + \epsilon'^{1-b^y}(n' + b^u(1-n')), (1-\delta)\eta'^{-(1-b^y)}d\right)\right] \quad (17)$$

$$\text{s.t.} \quad c + qb^* = a$$

$$b^* \geq \underline{\text{b}}$$

$$v_A(a,d;n,s) = \max_{b^*,c,d^*} u(c,d^*) + \hat{\beta}E\left[(\eta')^{(1-\sigma)(1-b^y)} v\left(\eta'^{-(1-b^y)}b^* + \epsilon'^{1-b^y}(n' + b^u(1-n')), (1-\delta)\eta'^{-(1-b^y)}d^*\right)\right] \quad (18)$$

$$\text{s.t.} \quad c + qb^* + d^* = a + d - hd$$

$$b^* \geq \underline{\text{b}}$$

$$v(a,d;n,s) = \max\{v_{NA}(a,d;n,s), v_A(a,d;n,s)\} \quad (19)$$

We solve the model by value function iteration. In Appendix B, we describe the computational procedure in more detail.

3 Calibration

In this section we describe the calibration for the income process and our choice of parameters for preferences, adjustment costs etc.

3.1 The process for the aggregate state

The calibration of the idiosyncratic labor income process matches the data moments from Guvenen et al. (2014). To be consistent, we will throughout build our calibration on data from their sample period, which is 1978-2011. For the calibration of the transition probabilities of the aggregate state, we also use their indicators of recession and expansion years.[6] The transition probabilities for the aggregate state are set to match two features of these indicators: First, the average time spent in a recession was approximately 18%. Second, the average duration of recessions was approximately 2 years. Table 1 shows the resulting parameters.

[6] Guvenen et al. (2014)'s indicators are based on the NBER classification, but are aggregated to the yearly frequency and treat the period 1980-1983 as a single recession.

Parameter	Value	Motivation
p_{ee}	0.973	18 % of time spent in recession
p_{rr}	0.875	Average recession duration of 2 years

Table 1: Parameters describing the transition probabilities of the aggregate state

3.2 The process for employment status

The separation and job finding rates are calibrated to match the short term and total unemployment rates for recessions and expansions respectively. Specifically, following McKay (2015), we posit the relationships

$$u_t^s = \zeta_t(1-u_{t-1}) \tag{20}$$

$$u_t - u_t^s = (1-\lambda_t)u_{t-1} \tag{21}$$

where u_t, u_t^s are defined as the total and short term (duration less than 15 weeks) unemployment rate. We then recover ζ_t, λ_t for each quarter in the sample period 1978-2011. To find the average separation and job finding rates for recessions and expansions, we regress ζ_t, λ_t on a recession indicator dummy and a linear time trend. To be consistent with the calibration of aggregate state transition probabilities, we use the recession indicators described in the previous subsection, although the quarterly labor market data allows for a refinement. The resulting values are shown in Table 2. We found that there was virtually no difference in the job finding rates between recessions and expansions, so we have set both their values to the sample mean.

We note that this calibration differs from Shimer (2012), who finds that the hiring rate is more procyclical than the job separation rate in monthly US data. The discrepancy is likely due to time aggregation as many unemployment spells are much shorter than a quarter. Since we are interested in the effects that labor market outcomes have on income and not employment status per se, the quarter frequency measure is the relevant measure for our purposes (although we by construction overstate the severity of becoming unemployed since the household is unemployed for at least a full quarter).

Parameter	Description	Value
$\lambda(e)$	Job finding rate, expansion	0.319
$\lambda(r)$	Job finding rate, recession	0.319
$\zeta(e)$	Separation rate, expansion	0.021
$\zeta(r)$	Separation rate, recession	0.030

Table 2: Parameters describing the transition probabilities of the employment status

3.3 The process for idiosyncratic labor income

Our calibration of the idiosyncratic labor income process draws directly from McKay (2015), who successfully matches a number of the key features of the cyclicality of income risks documented by Guvenen et al. (2014). In particular, this calibration captures the differences in the 10th, 50th and 90th percentile of income changes on three and five year horizons well. If anything, it slightly understates the volatility of Kelley's skewness, defined as $\frac{(P90-P50)-(P50-P10)}{P90-P10}$.[7]

[To do: Comparison calibration following Storesletten et al. (2004)]

In each period, ϵ_t is drawn from $N(0,\sigma_\epsilon^2)$. To be able to generate procyclical skewness as documented by Guvenen et al. (2014), η_t is drawn from a mixture of three normals, where the mean of the two outer distributions depend on the aggregate state. Specifically, we assume that in each period

$$\log \eta_t \sim \begin{cases} N(\mu_{1,t},\sigma_1) & \text{with prob } p_1 \\ N(\mu_{2,t},\sigma_2) & \text{with prob } p_2 \\ N(\mu_{3,t},\sigma_3) & \text{with prob } p_3 \end{cases} \tag{22}$$

The time-varying means of the process evolve according to

$$\mu_{1,t} = \bar{\mu}_t \tag{23}$$

$$\mu_{2,t} = \bar{\mu}_t + \mu_2 - x_t \tag{24}$$

$$\mu_{3,t} = \bar{\mu}_t + \mu_3 - x_t \tag{25}$$

where $\bar{\mu}_t$ is normalized so that $E(e^\eta) = 1$ in all periods. Notice that the aggregate state influences the income process through shifting the mean of the left and right tail of the η distribution uniformly.

We take the parameter values $\mu_2, \mu_3, \sigma_1, \sigma_2, \sigma_3, p_1, p_2, p_3$ directly from McKay (2015). The main difference between McKay's and our process lies in the dependence of x_t on the aggregate state, for which we assume a two-state structure whereas McKay (2015) uses a continuous support.[8] McKay (2015) assumes that it is a linear combination of four variables: The ratio of short-term unemployed to the labor force, the same ratio of long-term unemployed, an index of average weekly hours and the labor force participation rate. Its factor loadings are jointly calibrated with the other parameters to generate the fluctuations in left-skewness documented by Guvenen et al. (2014). We only allow the aggregate state to take two values, and therefore take approximate average values for x_t found by McKay (2015) in recessions and expansions respectively. That is, we assume that $x_t = x(s_t)$. Table 3 shows all the parameter values for the idiosyncratic income process.

[7] Kelley's skewness is the measure of downward risk preferred by Guvenen et al. (2014), due to its lesser dependence on extreme observation compared to the sample skewness measure.

[8] Our process also differs in that households learn which distribution η_t is drawn from in the same period as the shocks are realized, whereas McKay (2015) assumes that the distribution is known one period in advance. We do not see that choosing one assumption over the other will significantly affect our results.

Parameter	Description	value
$x(s=e)$	Distribution shifter in expansion	0
$x(s=r)$	Distribution shifter in recesion	0.25
p_1	Weight of center of η distribution	0.8948
p_2	Weight of right tail of η distribution	0.0526
p_3	Weight of left tail of η distribution	0.0526
μ_2	Mean of right tail of η distribution	0.355
μ_3	Mean of left tail of η distribution	-0.298
σ_1	St. dev. of mean of η distribution	0.0143
σ_2	St. dev. of right tail of η distribution	0.1041
σ_3	St. dev. of left tail of η distribution	0.1041
σ_ϵ	St. dev. of ϵ distribution	0.1580

Table 3: Parameters describing the idiosyncratic income process

3.4 Taxes and transfers

We take the parameters for the tax and transfer system directly from McKay (2015), who in turn uses numbers from Heathcote et al. (2014) and Martin (1996). They are summarized in Table 4.

Parameter	Description	value
b^u	Replacement rate of UI	0.3
b^y	Tax-and-transfer progressivity	0.151

Table 4: Parameters describing taxes and transfers

3.5 Preferences, adjustment costs etc.

Preferences are described by non-durable Cobb-Douglas weight α, risk aversion (or equivalently, the inverse of the intertemporal elasiticity of substitution) σ and the discount factor β. The durable consumption decision has two governing parameters, the size of the proportional adjustment cost h and the depreciation rate δ. The liquid asset market is described by the borrowing constraint $\underline{\mathrm{b}}$ and price q. In addition, households die at rate ω. All parameter values are shown in Table 5.

We set $\sigma = 2$. As the model is calibrated to quarterly income data, we set the discount factor to $\beta = 0.97$. The mortality rate is set to $\omega = 0.005$, which implies an average working lifetime of 50 years.

The quarterly depreciation rate of durables is set to $0.175/4 = 0.044$, which is an approximate average of BEA estimates of depreciation rates for durable goods.

The fixed cost h and the Cobb-Douglas parameter α are calibrated to match a yearly adjustment rate of 14 percent (Bertola et al. (2005)) and a durable goods share of total consumption expenditures of 8.3 percent (average of NIPA 1978-2011).

The borrowing constraint is set to the natural borrowing limit, which is $\underline{\mathrm{b}} = 0$ given the full support of the random walk in permanent income. We set q, the price of the risk free liquid asset, to 1.01, corresponding to a yearly risk free interest rate of 4 percent.

Parameter	Value
β	0.97
α	0.88
σ	2
ω	0.005
δ	0.044
h	0.22
q	1.01
$\underline{\mathrm{b}}$	0

Table 5: Parameters describing preferences and durable adjustment

4 Intuition

Before we present the quantitative results from our model, let us first describe the qualitative properties of our model. The intuition is depicted in Figure 3. We stress that the intuition provided here is not exact. In our full model, the state space has three dimensions (durable goods holdings, liquid asset holdings and permanent income) which can be reduced to a two-dimensional representation (durable goods holdings over permanent income and liquid asset holdings over permanent income). Here, we will consider a thought experiment in a one-dimensional state representation.

If we ignore the portfolio choice between liquid assets and durable goods, the households in our model will roughly behave as if according to an Ss-rule for durables normalized by total wealth (the sum of permanent income and liquid assets). That is, they will have a lower threshold and an upper threshold for $D/W := \tilde{d}$. Once they reach a threshold, they will incur the fixed cost and readjust their holding of durables to a target ratio $\tilde{d}^*$. We think of the regions outside these thresholds as "activity regions", and the region inside these

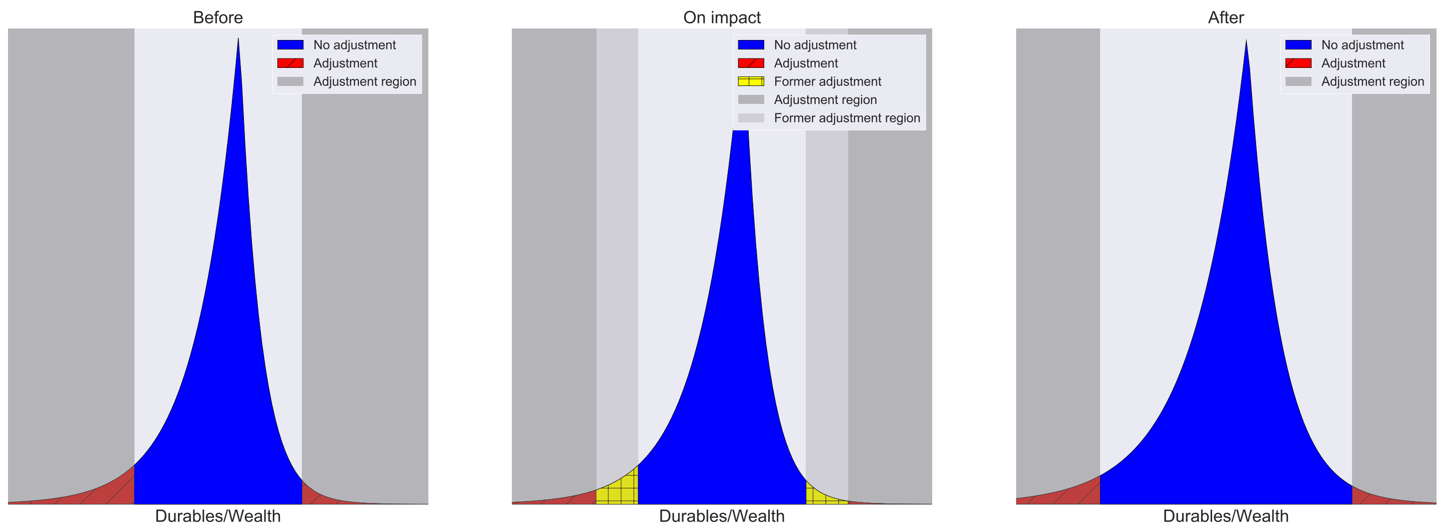

Figure 3: The Ss intuition behind the fall in durable purchases and MPC for durables. To the left is the distribution of households, and the adjustment regions prior to the increased uncertainty. In the middle, the distribution of households is the same as in the left figure, but the adjustment regions have moved due to the heightened uncertainty. To the right, the distribution of households has evolved under higher uncertainty so the frequency of adjustment has more or less returned to its prior level.

thresholds as the ”inactivity region”.

The distribution of households will peak at the reset ratio $\tilde{d}^*$. Some households will see their permanent income decline and therefore their durable-to-wealth ratio increase over time, while some households will see their permanent income increase and durable-to-wealth ratio decrease over time. However, since the stock of durable goods depreciates, the durable-to-wealth ratio drifts to the left in the absence of income shocks. Therefore, the distribution of household durable holdings will have more mass to the left of $\tilde{d}^*$, as depicted in the leftward picture in Figure 3.

When the economy enters a period of temporary higher income risk, the inactivity region widens, as depicted in the middle picture in Figure 3. Since the heightened income risk is temporary, the households have an incentive to 'wait-and-see' whether they will be hit by a large shock or not, before they adjust their durables. Put another way, when income risk rises, the probability of being in the activity region tomorrow increases, in which the household incurs the fixed cost and adjust. As a response, the willingness to adjust today declines, since by doing so the household decreases the probability of incurring multiple fixed costs.

In the short run, the distribution of households is essentially fixed, and as a result the share of households adjusting will fall when the inactivity region widens. Since, due to depreciation, there are more households upgrading than downgrading, net durable expenditures will temporarily fall.

After the initial response, the distribution of households will resettle inside the wider thresholds, as depicted in the right picture in Figure 3 and the fall in durable expenditures will more or less disappear. When the economy exits the recession, the logic works in reverse and durable expenditures will be temporarily higher.

5 Results

In this section, we present the results under the calibration described in Section 3.

5.1 Inactivity regions and policy functions

5.1.1 Inactivity regions

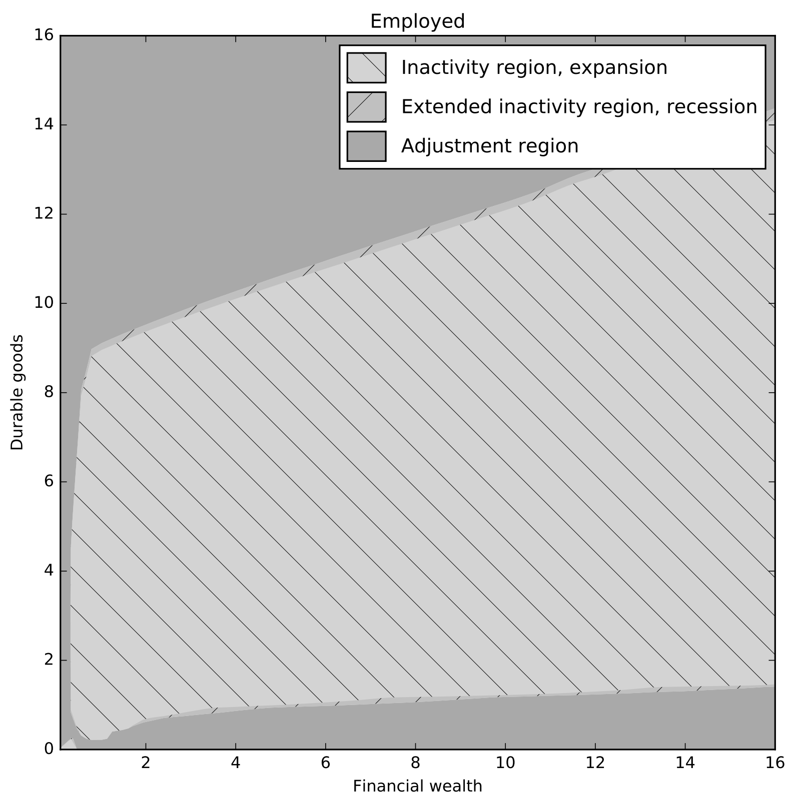

Figure 4: The inactivity regions for the employed in the expansionary and recessionary state.

In Figure 4, we show the inactivity regions for employed in both the expansionary and the recessionary state. The x axis is liquid assets normalized by permanent income, a, while the y axis is durables normalized by permanent income, d (i.e., the figure shows the endogenous state variables to the normalized problem (17)-(19)). Notice that the inactivity region widens in the recession. Due to heightened uncertainty, households at the margin of adjustment now decide to postpone, as described in Section 4. In equilibrium, households rarely downgrade their durable holdings, and instead rely on depreciation when their durable holdings are higher than they would prefer if adjustment were flexible (see the discussion of the distribution of households in subsection 5.2).

5.1.2 Policy functions

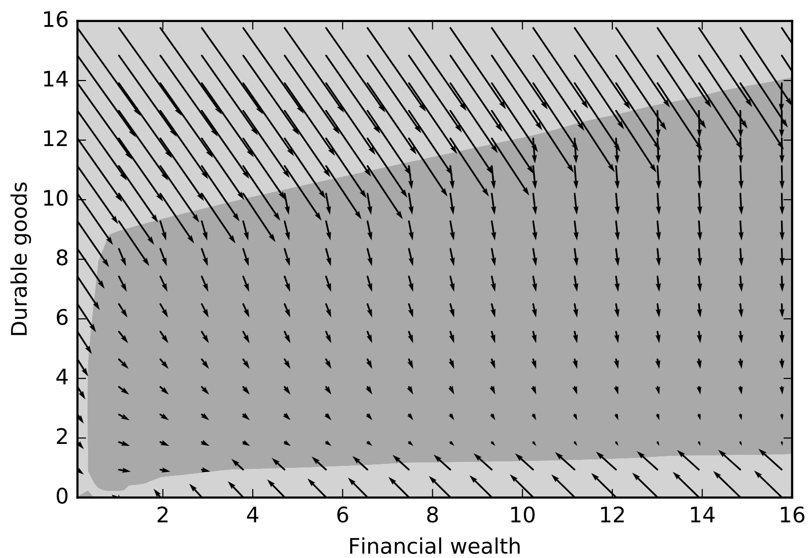

Figure 5: Decision functions for employed in the expansionary state.

In Figure 5, we show the policy functions for an employed households in an expansion. The arrows indicate in which direction the endogenous state (the pair of normalized liquid assets and normalized durables) would evolve if the income shocks in the next periods were both realized at their mean of 1. To make the figure interpretable, the arrows are not drawn to scale. The arrows from the adjustment regions understate the magnitude of the adjustment in comparison with the arrows in the inactivity region.

From Figure 5, we can see the basic buffer stock savings logic of Carroll (1997), but with lumpy adjustments in durables. Inside the inactivity region, with lower normalized liquid assets the households save more (the rightward drift in the left part of the figure). With higher normalized liquid assets, the households save less. As the durables depreciate (the downward drift in the inactivity region), households will enter the adjustment region, incur the fixed cost and substitute liquid assets for durable goods. The ”target wealth” (in liquid assets *and* durables) is found where the arrows of the adjustment region point in the opposite direction of the arrows of the inactivity region.

5.2 Impulse response functions – an income risk shock

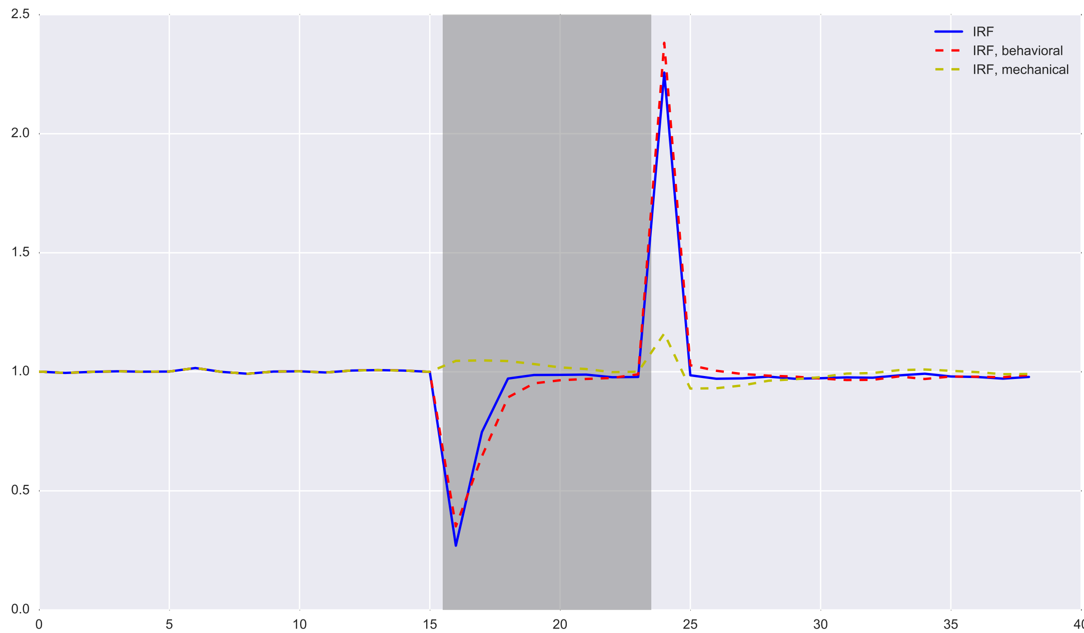

Figure 6: The response of aggregate expenditures on durables in response to a two-year recession. The recession begins in period 16 and lasts for 8 quarters.

Having explored the decision functions above, we now turn to the quantitative effects of a recession on durable purchases and savings. We conduct the following experiment: Let the economy run for a long time and settle, then force a recession that lasts for 2 years (the agents do not know the length of the recession ex ante). Repeat this experiment many times and plot the average response of aggregate variables.[9]

We want to stress that the analysis here is of a recessionary shock that has no effect through TFP, but only on the distribution of income shocks, including unemployment shocks. Aggregate income will

[9]We let the economy run for 500 periods, followed by an 8 period of recession and an additional 24 periods where the economy evolves according to the postulated probabilities. This experiment is simulated 2000 times with 2000 households.

fall gradually, due to the rise in unemployment, but the effect is small. Steady state unemployment in a permanent expansion is 6.1 percent and steady state unemployment in a permanent recession is 8.5 percent, the gradual fall in income levels out at $(8.5 - 6.1)(1 - b_u) = 1.7$ percent.

In Figure 6, we plot the response of durable expenditures to a recession shock. Notice that purchases fall dramatically on impact and remain below trend for two quarters. When the economy exits the recession, there is a large rebound effect when many households purchase durables at the same time. The effect of the heightened income risk on durable expenditures is large, a fall of approximately 60 percent followed by a rebound of about 125 percent.

The results thus suggests that fluctuations in income risk can generate large swings in durable purchases. In our simulation, the swings are even much too large, compared with the US data in Figure 1. This discrepancy is likely due to two modelling simplifications. First, all households switch from an expansionary to a recessionary income process at the same time. In reality, the switch from the expansionary to the recessionary state is more gradual, occurring in some industries and regions earlier than in others. Second, households in the model only adjust their durable holdings in response to suboptimal durables stock-to-permanent income and/or suboptimal cash-on-hand-to-permanent income ratio. Since few households adjust in each period, and all of the adjusting households are driven by changes in these two ratios, aggregate expenditures respond too strongly to changes in the income process. In reality, there are many other reasons why households adjust their stock of durable goods. An change in household size may require the household to purchase a new vehicle, or a change in taste for durables may occur. Arguably, a large share of adjustments in durables are not driven by considerations related to the durables stock-to-permanent-income nor the cash-on-hand-to-permanent-income ratio, and therefore our estimate of the response of durable expenditures is exaggerated.

For completeness, we plot the response of non-durable consumption in Figure 7. Non-durable consumption falls on impact by 1.5 % due to an increased precautionary-savings motive. We discuss how to disentangle the real options effect and precautionary savings effect more below.

5.3 Decomposing the IRF into mechanical and behavioral responses

We have argued that the reason for the fall in durable expenditures is that households change their behavior by postponing their adjustments. To confirm this, we do two alternative experiments, which are shown alongside the main IRF in Figures 6 and 7. In the first alternative experiment, we feed in the shocks of a recession, but let the households behave as if they were in an expansion (they are aware of their own idiosyncratic state, including employment, but not of the fact that the economy is in a recession). We call the impulse responses under this experiment 'mechanical'. In the second alternative experiment, we do the reverse. That is, we feed in the shocks of an expansion, but let the households behave as if they were in a

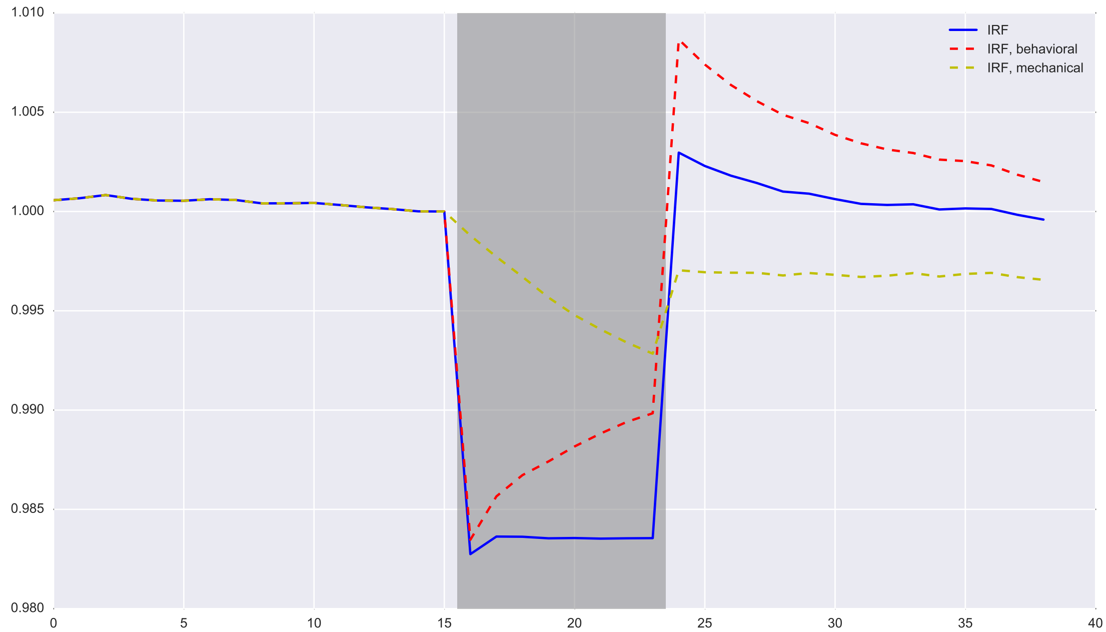

Figure 7: The response of non-durable consumption to a two-year recession. The recession begins in period 16 and lasts for 8 quarters.

recession. We call this 'behavioral'. In Figures 6 and 7, we see that the impulse response functions are largely driven by the behavioral effect, which confirms the argument we have outlined above. The perceived ex ante risk is more important for the aggregate expenditure response in this setting than the ex post realization of the income shocks.

We also note that the impulse response functions are roughly the sums of the behavioral and mechanical effects, suggesting that there are no strong interaction effects between the mechanical and behavioral effects.

5.4 Impulse response functions without adjustment costs

There are two conceptually distinct reasons why durable purchases may fall and savings in liquid wealth increase when income risk increases. The first is the real-option effect due to the fixed adjustment costs. The second is the precautionary-savings effect, where higher income risk motivates households to hold a higher buffer stock of liquid wealth. To isolate the precautionary-savings effect, we do the same recession shock experiment in a model with one minor adjustment compared to our baseline model, namely that holdings of durables can be adjusted costlessly ($h = 0$). All other parameters are held constant.

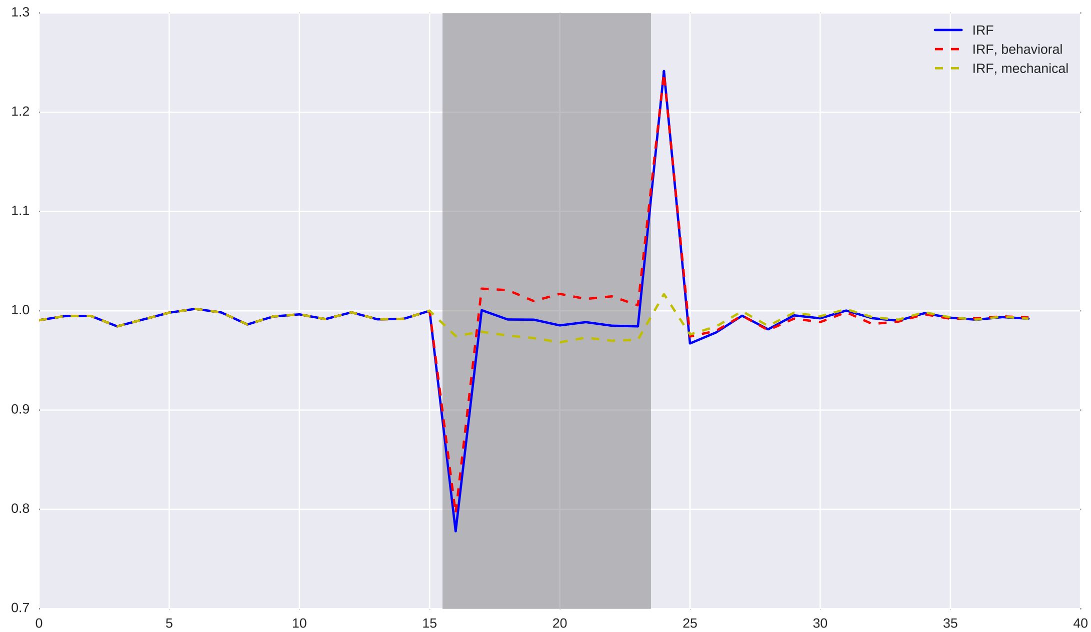

Figure 8: The response of aggregate expenditures on durables in response to a two-year recession, with flexible adjustment. The recession begins in period 16 and lasts for 8 quarters.

In Figure 8, we plot the response of durable expenditures for the flexible adjustment model. The fall on impact of durables is approximately 20 percent compared with approximately 60 percent in the model with adjustment costs. The rebound effect is much weaker (35 percent rather than 125 percent).

In Figure 9), we plot the response of non-durable consumption for the flexible adjustment model. The fall in non-durable consumption on impact (2%) is slightly larger than in the model with adjustment costs (1.5%).

5.5 Time-varying MPC

We now turn to how the aggregate marginal propensity to consume (MPC) both non-durables and durables vary over the business cycle. The aggregate MPC is a key statistic for evaluating the consumption response to various stabilization policies, as recently discussed in e.g. Auclert (2015), Kaplan and Violante (2014), Berger and Vavra (2015), McKay and Reis (2015). In our model, the aggregate MPC will decline in response to a recession shock for two reasons: (1) fewer households are within the adjustment region (and adjusting at the margin) and (2) the density of households at the thresholds is lower so the extensive margin response

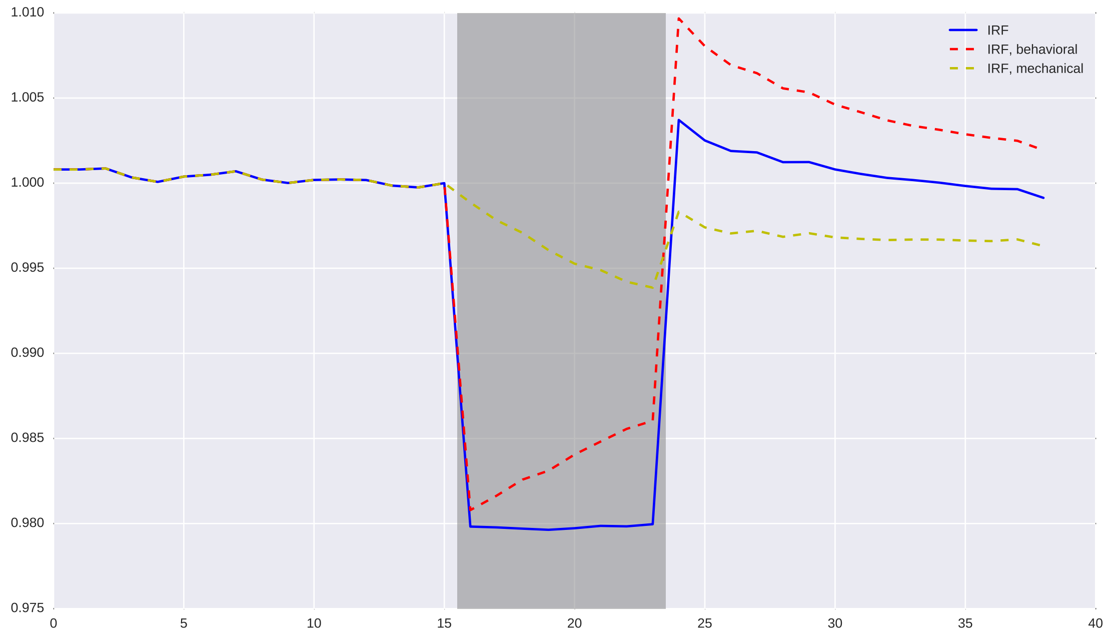

Figure 9: The response of non-durable consumption to a two-year recession, with flexible adjustment. The recession begins in period 16 and lasts for 8 quarters.

to lump sum transfers is smaller. In this section, we quantify the overall effect.

In Figure 10, we show how the one quarter marginal propensities to consume for durables and non-durables evolve before, during and after a recession shock. When the recession shock hits, the marginal propensity to consume for durables fall temporarily, from roughly 12 to 7 percent. After the initial impact, the MPC is slightly lower than in an expansion, and when the economy leaves the high uncertainty recession, marginal propensity to consume durables is temporarily higher.

For non-durables, marginal propensity to consume actually increases when uncertainty increases. This is a standard finding: Increased uncertainty makes the consumption function more concave causing marginal propensity to consume to increase (Kimball (1990)). The quantitative magnitude, however, is much smaller than the magnitude for durable purchases.

In sum, the total marginal propensity to consume falls when entering a recession. This could have important policy implications. Monetary policy and fiscal transfers have a larger effect on aggregate demand and so aggregate income when the MPC is higher. The implication from our model is thus that such stabilizing policies can be less effective when entering a recession. The flip side is that monetary and fiscal

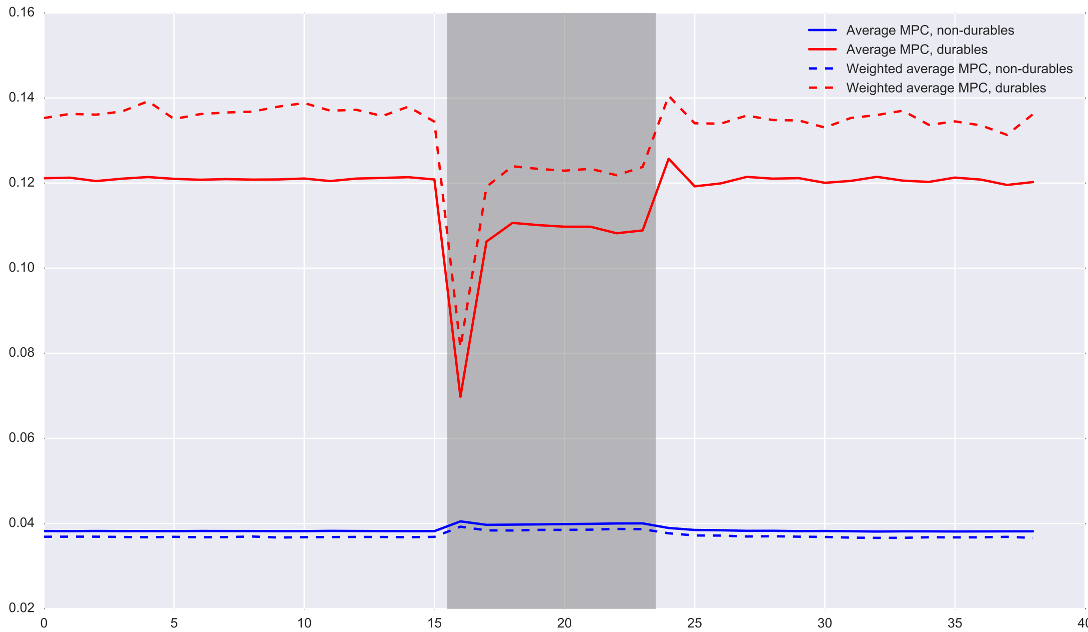

Figure 10: The response of average marginal propensity to consume durables and non-durables. The average MPC is the unweighted average response to a small lump sum transfer, while the weighted average MPC is weighted by permanent income. Conceptually, the two correspond to a uniform lump sum tax rebate and a proportional tax rebate. The recession begins in period 16 and lasts for 8 quarters.

policy are likely more powerful when exiting a recession.

6 Empirical evidence

In this section, we provide evidence for the hypothesis that income risk is a major determinant of fluctuations in durable expenditures. We employ two different methods on two different datasets. First, we use Italian survey data to construct a measure of unemployment risk that can be linked to durable purchases at the household level. Second, we use aggregate US data to estimate Euler equations augmented with a measure of subjective expectations about changes in the aggregate unemployment rate, similarly to Carroll and Dunn (1997).

Common to both methods is that we study the link between *fluctuations* in income risk and durable purchases, corresponding to the simulation exercises in Section 5. This should be viewed in contrast to studies that have studied the link between the *level* of income risk and durable purchases, such as Foote et al. (2000), Benito (2006) and Bertola et al. (2005). The distinction is important, as previous literature (e.g. Hassler (1996)) have shown that the permanent level of income risk has a much smaller effect on durable purchases compared to fluctuations in income risk under Ss-type behavior.

Also common to both methods is that we compare the results for durable purchases with non-durable purchases. In our model, fluctuations in income risk affect consumption expenditures both through raising the option value of postponing durable purchases and through raising the target level of precautionary wealth. It is only the latter, however, that would predict a fall in non-durable purchases. By comparing the results for the two goods classes, we can possibly distinguish the two mechanisms.

6.1 Evidence from Italian survey data

In this section, we study the effects of fluctuations in income risk on durable and non-durable expenditures at the micro level.

6.2 Data

We use data from the Italian Survey of Household Income and Wealth (SHIW). The SHIW is a biannual representative household survey of approximately 8000 Italian households in each wave. Half of the sample is part of a rotating panel. We use data from the survey waves 2002, 2004, 2006, 2008, 2010 and 2012. Individual variables such as employment, education and age refer to the household heads, which is the household member with highest income.

Durable consumption expenditures consists of transportation vehicles, jewelry and household equipment such as furniture and electronic devices.

A descriptive table of all numerical variables used in the analysis is found in Table 6.

6.2.1 Constructing a measure of income risk

As a measure of income risk, we use the estimated probability that an employed household head will be unemployed in a given year. This proxy have been used extensively in previous studies of the effects of income risk in the consumption-savings literature, e.g. Carroll et al. (2003), Benito (2006) and Foote et al. (2000). As emphasized in Carroll et al. (2003), experiencing an unemployment spell is likely a major disruption to the household income stream over which the household generally has little influence, and therefore it has a good chance of capturing exogenous fluctuations in income risk. One concern is that an increased probability of becoming unemployed also affects the expected level of future income, which should have a separate effect on consumption expenditures through changing the level of permanent income. However, to the extent that fluctuations in unemployment risks are not too large, the effect on permanent income should be small.

Table 6: Descriptive statistics: SHIW sample

	Mean	Std. Deviation	Minimum	Maximum
Age	46.35	9.05	17.0	75.0
log(non-durable consumption)	10.07	0.42	8.46	11.98
Durable purchase	0.48	0.5	0.0	1.0
log(income)	10.43	0.49	6.53	12.44
log(wealth)	11.56	1.62	2.89	17.17
log(deposits)	8.83	1.19	0.69	14.43
Household size	3.12	1.19	1.0	9.0
Sex	0.25	0.43	0.0	1.0
Deltaurisk	0.0	0.02	-0.21	0.2

We estimate the change in the probability of becoming unemployed by exploiting the panel structure of the data. With the panel sample, we construct the measure in two steps. First, we estimate the probability of becoming unemployed for each wave. Second, we compute the change in the probability of becoming unemployed between two consecutive waves.

In the first step, we estimate the unemployment probability with a probit model, using a rich set of household characteristics. Because such an exercise very soon run in to the problem of overfitting, we do not estimate the probability by directly regressing on the household characteristic variables. Instead, we extract a limited number of factors from the set of household characteristics, and project the households on the space spanned by these factors. We construct these factors using the entire sample, and not only the panel.

The household characteristics variables that we use are mainly categorical. We therefore extract the factors using multiple correspondence analysis (MCA). This method is similar to principal component analysis, but adapted to suit categorical variables. MCA was popularized in the social sciences by Bourdieu (1984), for a detailed textbook description see Greenacre and Blasius (2006). The variables entering the factor analysis are ”age group”, ”gender”, ”marital status”, ”education”, ”family size”, ”region”, ”city size”, ”district”, ”profession”, ”industry”, ”income quintile” and ”wealth quintile”.

Our approach is similar in spirit to Carroll et al. (2003) and Benito (2006), who also estimate unemployment probabilities using household characteristics to study its effect on precautionary wealth and consumption expenditures respectively. Beside our focus on durable expenditures and our usage of a different dataset, we differ in two aspects.

First, both these studies estimate the level of unemployment risk rather then the change in unemployment risk. In terms of identification, these studies face the problem of not being able to control for all individual characteristics, which might bias their estimates. In contrast, by estimating the change in unemployment risk, we do not need to worry about omitted individual fixed effects. This advantage is best illustrated by an example. If using occupation to predict unemployment risk, one concern is that the choice of occupation is endogenous to risk preferences. Hence, the estimated unemployment risk can not be treated as exogenous. In contrast, when predicting the change in unemployment risk, such an effect is differenced out.

Second, both these studies construct estimates by using the household characteristics variables directly. To our knowledge, ours is the first study to use the factor estimation design for predicting unemployment risk.

6.2.2 Model specifications

We seek to estimate the effect of increase in unemployment risk on durable and non-durable consumption expenditures. For non-durable consumption, our left-hand-side variable is log of expenditures, and we estimate the effect by standard OLS. This specification cannot be used for durable goods since purchases are infrequent. Instead, we estimate the effect on the probability that a purchase will happen, i.e. the extensive margin of purchases, using a probit model.

In our basic specification, we control for the stock of durables (by quintile dummies for total value of durables normalized by household income), family characteristics (household head age group, household size, region, and a coarse measure of region) as well as year fixed effects. In our extended specifications, we also include fixed effects for district, education, profession and industry.

6.2.3 Results

We start analyzing the results for durable purchases, which are shown in Table 7. In all specifications, a change in unemployment risk has a large effect on the probability of making a durable expenditure. The average marginal effect of a one percentage point increase in unemployment risk is a decrease of the probability of a durable purchase by 0.8 percentage points. To make this number interpretable, we note from Table 6 that the average probability of a durable purchase in the sample is 0.48. Hence, the estimated effect of a uniform one percentage point increase in unemployment risk for all households is a $0.8/0.5 = 1.6$ percent fall in the aggregate number of durable purchases.

Apart from the effect of unemployment risk, we note that a larger durable stock compared to current income reduces the probability of purchasing durables in a monotonic fashion, which is consistent with the model that we proposed in Section 2. Current income is positively correlated with the probability of purchasing durables, which is also consistent with our model to the extent that this captures the effect of a transitory income shock. We also see that the level of deposits is positively correlated with the expenditure probability, but the effect is small.

The results for non-durable consumption expenditures are shown in Table 8. In sharp contrast to the result for durable expenditures, unemployment risk has essentially no effect on consumption expenditures. The main determinant of non-durable consumption expenditures is current income. The coefficient is large, but difficult to interpret given that this variable can both capture transitory as well as permanent income. Non-durable consumption is slightly higher, all else equal, if the household owns a large durable stock.

The results suggest that fluctuations in unemployment risk are a major determinant of durable expenditures but not of non-durable expenditures. Fluctuations in income risk thus seem to affect household purchasing decisions mainly through raising the option value of postponing durable purchases, rather than through raising the precautionary motive to save.

6.2.4 Robustness

In Appendix D we show that the results are robust to estimating the effect of unemployment risk on durable expenditures with logit and OLS rather than probit.

6.3 Evidence from US aggregate data

In this section, we provide evidence on the link between fluctuations in durable expenditures and income risk using US time series data. Our method is to estimate Euler equations in the style of Campbell and Mankiw (1989), augmented with a control for income risk constructed with data from the Michigan Survey of Consumers. This method has previously been employed by Carroll and Dunn (1997). The main difference is that we benefit from having access to approximately 20 more years of data.

Denote the log of aggregate expenditure on non-durable goods with C_t and the log of aggregate expenditure on durable goods with X_t. We estimate augmented log-linearized Euler equations of the form,

$$\Delta C_t = \gamma_0 + \sum_{i=1}^{k} \gamma_i P_{it} + \epsilon_t, \tag{26}$$

$$\Delta X_t = \gamma_0 + \sum_{i=1}^{k} \gamma_i P_{it} + \epsilon_t, \tag{27}$$

where $P_i \in \mathcal{P}$ and $\mathcal{P}$ is a set of predictor variables. When $\mathcal{P}$ includes income growth ΔY_t, and possibly the real interest rate R_t, estimating equation (26) can be used to test the hypothesis that the economy has some fixed share of hand-to-mouth households, as done by Campbell and Mankiw (1989). We will depart from Campbell and Mankiw (1989)'s specification and jointly test whether expenditure growth is significantly affected by both income growth and income uncertainty growth, denoted by ΔU_t. Our baseline specification

Table 7: Probit model of probability of making a durable purchase, average marginal effects.

	Basic	Extended 1	Extended 2	Extended 3
Δ(unemployment risk)	-0.73**	-0.79**	-0.85**	-0.82**
	(0.34)	(0.34)	(0.34)	(0.34)
Durable stock, Q2	-0.07***	-0.07***	-0.07***	-0.07***
	(0.02)	(0.02)	(0.02)	(0.02)
Durable stock, Q3	-0.11***	-0.12***	-0.11***	-0.12***
	(0.02)	(0.02)	(0.02)	(0.02)
Durable stock, Q4	-0.12***	-0.13***	-0.12***	-0.13***
	(0.02)	(0.02)	(0.02)	(0.02)
Durable stock, Q5	-0.12***	-0.14***	-0.12***	-0.13***
	(0.02)	(0.02)	(0.02)	(0.02)
log(deposits)	0.03***	0.02***	0.03***	0.02***
	(0.01)	(0.01)	(0.01)	(0.01)
log(income)	0.15***	0.13***	0.13***	0.12***
	(0.02)	(0.02)	(0.02)	(0.02)
log(wealth)	-0.01*	-0.01*	-0.01*	-0.01*
	(0.00)	(0.00)	(0.00)	(0.00)
Year FE	Yes	Yes	Yes	Yes
City size+Region FE	Yes	Yes	Yes	Yes
Age group FE, Family size	Yes	Yes	Yes	Yes
Education FE	No	Yes	Yes	Yes
Gender+Marital FE	No	Yes	Yes	Yes
Profession FE	No	Yes	Yes	Yes
Industry FE	No	No	Yes	Yes
District FE	No	Yes	No	Yes
N	7283	7283	7281	7281

Table 8: OLS model of log(non-durable consumption)

	Basic	Extended 1	Extended 2	Extended 3
Δ(unemployment risk)	-0.07	-0.01	-0.04	-0.04
	(0.17)	(0.17)	(0.17)	(0.17)
Durable stock, Q2	0.01	0.01	0.01	0.01
	(0.01)	(0.01)	(0.01)	(0.01)
Durable stock, Q3	0.03***	0.02**	0.02*	0.02**
	(0.01)	(0.01)	(0.01)	(0.01)
Durable stock, Q4	0.04***	0.03***	0.03***	0.03***
	(0.01)	(0.01)	(0.01)	(0.01)
Durable stock, Q5	0.06***	0.04***	0.04***	0.04***
	(0.01)	(0.01)	(0.01)	(0.01)
log(deposits)	-0.01***	-0.01***	-0.01***	-0.01***
	(0.00)	(0.00)	(0.00)	(0.00)
log(income)	0.59***	0.55***	0.55***	0.55***
	(0.01)	(0.01)	(0.01)	(0.01)
log(wealth)	0.02***	0.02***	0.02***	0.02***
	(0.00)	(0.00)	(0.00)	(0.00)
Year FE	Yes	Yes	Yes	Yes
City size+Region FE	Yes	Yes	Yes	Yes
Age group FE, Family size	Yes	Yes	Yes	Yes
Education FE	No	Yes	Yes	Yes
Gender+Marital FE	No	Yes	Yes	Yes
Profession FE	No	Yes	Yes	Yes
Industry FE	No	No	Yes	Yes
District FE	No	Yes	No	Yes
R2	0.67	0.68	0.68	0.68
N	7283	7283	7281	7281

is

$$\Delta C_t = \gamma_0 + \gamma_1 R_{t-1} + \gamma_2 \Delta Y_t + \gamma_3 \Delta U_t + \epsilon_t \tag{28}$$

$$\Delta X_t = \gamma_0 + \gamma_1 R_{t-1} + \gamma_2 \Delta Y_t + \gamma_3 \Delta U_t + \epsilon_t. \tag{29}$$

6.3.1 Implementation

To implement (28) and (29), we need to correct for two well-known issues in these types of regressions. First, while we typically want to think about household expenditure decisions being made at a high frequency, data on C_t, X_t are only available at a monthly or quarterly frequency. It is well-known that this time-aggregation problem produces an MA(1) error term (for a formal treatment, see Working (1960)):

$$\epsilon_t = \nu_t + \kappa \nu_{t-1}. \tag{30}$$

We will therefore estimate the relationships with maximum likelihood under the assumption of an MA(1) error term. We also note that the relationship (29) should include an MA(1) error term for an independent reason. The Euler equation applies to the consumption growth rate and not to the expenditure growth rate, which differs from each other whenever the depreciation rate is less than 100 percent between the measurement periods. As shown in Mankiw (1982), translating the Euler equation to correspond to the expenditure growth rate of durable consumption produces an MA(1) term.

Second, if there are omitted variables and/or general equilibrium feedback effects, we cannot interpret γ_2 and γ_3 as the effect of income growth and income risk on expenditure growth. To overcome this, we will instrument ΔY_t and ΔU_t with information available at $t-1$. We use a similar set of instruments as Carroll and Dunn (1997): Three lags of total consumption expenditure growth, three lags of income growth, three lags of income risk growth, one lag of the change in the 3-month T-bill interest rate, one lag of the unemployment rate, one lag of the change of the S&P 500 index and one lag of the consumption/income ratio.

6.3.2 Data

We estimate (28) and (29) using quarterly US data from 1960:Q4 to 2014:Q4. All variables but ΔU_t and R_t are standard and retrieved from the Federal Reserve Economic Data.

For the income risk growth variable ΔU_t we use a measure of changes in subjective unemployment expectations constructed from data by the Michigan Survey of Consumers (MSC). The MSC surveys a minimum of 500 households each month (each quarter before 1978) on approximately 50 questions, most of them concerning their beliefs about the US economy. Specifically, households are asked the following question: *"How about people out of work during the coming 12 months - do you think that there will be more unemployment than now, about the same, or less?"*. As a measure of the change in income uncertainty, we

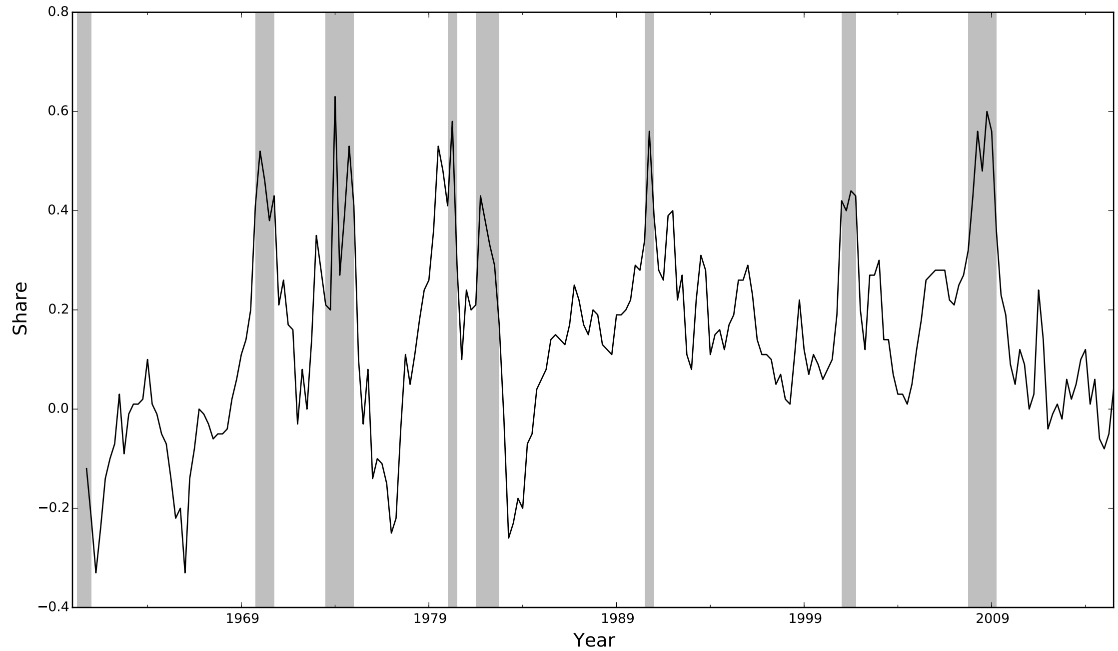

Figure 11: The time evolution of our income risk measure ΔUE_t. Shaded areas denote NBER recession dates.

follow Carroll and Dunn (1997) and use the fraction of households answering ”more” less of the fraction of households answering ”less”. We denote this variable with ΔUE_t. In Figure 11, we show how this variable fluctuates over time.

The variable ΔUE_t should capture fluctuations in idiosyncratic income risk given two premises. The first is that a sufficiently large fraction of US households faces an income process which is significantly correlated with the aggregate unemployment rate, so that expectations about the future unemployment rate is informative about the likelihood of negative income shocks at the micro level. We have not been able to test this, but it would be surprising if this were not the case. The second premise is that the regression includes a control for the expected aggregate income growth, so that ΔUE_t captures fluctuations in income risk rather than fluctuations in expected income.

We construct the measure of the real interest rate R_t by subtracting a measure of expected inflation rate from the 3-month T-bill interest rate. The measure of expected inflation rate we use is the inflation rate predicted by the same set of variables as we use as instruments for income and income risk growth.

6.3.3 Results

We present the results in Table 9, corresponding to the non-durable expenditures regression (28), and Table 10, corresponding to the durable expenditures regression (29). Alongside our preferred estimation method using maximum likelihood under the assumption of an MA(1) error term, we also present the results from estimating the relationships with standard OLS for comparison.

As can be seen from Table 9, without controlling for the change in unemployment expectations, the coefficient of expected income growth on non-durable expenditure growth is positive and statistically significant, with a coefficient around 0.5. This is close to the estimate in Campbell and Mankiw (1989). As we add the change in unemployment expectations, the coefficient on income growth is still large and positive but no longer significant. The coefficient on unemployment expectations is negative but statistically insignificant.

The results for durable expenditure growth are different. It is still true that without controlling for the change in unemployment expectations, the coefficient of expected income growth on durable expenditure growth is positive and statistically significant. The point estimate is about 2, which is four times larger than the corresponding coefficient for non-durable expenditure growth. However, when controlling for the change in unemployment expectations, this point estimate drops to around 0.2 and loses all significance. The coefficient on unemployment expectations is negative and, in contrast, statistically significant. To understand the magnitude of the point estimate -0.06, we can compare it to the fluctuations in ΔUE_t from Figure 11. As an example, we see that from peak to trough during and shortly after the recessions 1980-1983, ΔUE_t dropped from close to 0.6 to -0.2, implying a predicted increase in durable expenditure of close to 5 per cent. The results are not significantly affected by controlling for the real interest rate.

In line with the findings from the Italian micro data, these results suggest that fluctuations in income risk are an important determinant of fluctuations in durable expenditures, while not for non-durable expenditures. We interpret this evidence as supportive of the hypothesis that income risk mainly affects consumption expenditures through raising the option value of postponing durable purchases and not through altering the target level of precautionary savings.

Our results should be compared with those of Carroll and Dunn (1997). Similar to us, they find that the change in unemployment expectations ΔUE_t has a negative effect on durable expenditures, but in contrast, they also find that income growth has a statistically significant negative effect (although small in comparison to the effect of ΔUE_t). In addition, they also find that unemployment expectations have a significant effect on non-durable expenditure growth.

The difference could possibly be explained by the fact that our sample includes data for the period 1994-2014, which was not available to them, or that they use a somewhat different specification which includes measures of annuity income. At this stage, we have investigated the first of these possibilities (we seek to investigate the second going forward). Table 11 and Table 12 show the regression results using the sample

	MA(1) I	MA(1) II	MA(1) III	OLS I	OLS II	OLS III
ΔY_t	0.52***	0.31	0.28	0.58***	0.53*	0.52*
	(0.16)	(0.32)	(0.33)	(0.14)	(0.29)	(0.29)
ΔUE_t		-0.01	-0.01		-0.00	-0.00
		(0.01)	(0.01)		(0.01)	(0.01)
R_{t-1}			0.02			0.01
			(0.04)			(0.03)
Intercept	0.00	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
MA(1)	0.14*	0.15**	0.16**			
	(0.07)	(0.08)	(0.08)			
N	213	213	212	213	213	212

Table 9: Regression of non-durable expenditure growth on income growth and income risk growth. Standard errors are showed in parenthesis. Sample 1960:Q4 to 2014:Q4

	MA(1) I	MA(1) II	MA(1) III	OLS I	OLS II	OLS III
ΔY_t	2.04***	0.27	0.21	1.55***	-0.74	-0.80
	(0.31)	(0.70)	(0.71)	(0.39)	(0.76)	(0.78)
ΔUE_t		-0.06***	-0.06***		-0.08***	-0.08***
		(0.02)	(0.02)		(0.02)	(0.02)
R_{t-1}			0.09			0.11
			(0.07)			(0.09)
Intercept	-0.01***	0.01*	0.01	-0.00	0.03***	0.02**
	(0.00)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)
MA(1)	-0.27***	-0.24***	-0.24***			
	(0.07)	(0.07)	(0.07)			
N	213	213	212	213	213	212

Table 10: Regression of durable expenditure growth on income growth and income risk growth. Standard errors are showed in parenthesis. Sample 1960:Q4 to 2014:Q4

	MA(1) I	MA(1) II	MA(1) III	OLS I	OLS II	OLS III
ΔY_t	0.34**	0.11	0.12	0.39***	0.22	0.24
	(0.14)	(0.25)	(0.25)	(0.13)	(0.24)	(0.24)
ΔUE_t		-0.01	-0.01		-0.01	-0.01
		(0.01)	(0.01)		(0.01)	(0.01)
R_{t-1}			-0.04			-0.05
			(0.04)			(0.03)
Intercept	0.00*	0.01*	0.01*	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
MA(1)	0.15*	0.17**	0.16*			
	(0.08)	(0.08)	(0.08)			
N	121	121	120	121	121	120

Table 11: Regression of non-durable expenditure growth on income growth and income risk growth. Standard errors are showed in parenthesis. Sample 1963:Q3 to 1994:Q3, as used in Carroll and Dunn (1997)

period used by Carroll and Dunn (1997): 1963:3-1994:3. For this sample, no variable is significant neither in the regression for durable nor for non-durable expenditure growth. The point estimates are neither consistent with our baseline results nor with those in Carroll and Dunn (1997). Although difficult to interpret, we can dismiss that it is the choice of sample period that explains the difference between our and Carroll and Dunn (1997)'s results.

In the Appendix, we estimate the sensitivity of our results to the choice of the sample period further. In particular, we investigate if there is difference of using the sample before and after the 1980-1983 recession. The motivation comes from Figure 2, which shows that it was only after 1983 that the response "uncertainty" as reason for why it is bad time to buy durables became prominent. We find that all results from Table 9 and Table 10 go through for different sample period as long as the period 1983:Q4-2014:Q4 is included. In contrast, for the sample period 1960:Q4-1983Q4, no variable is significant. These results are consistent with the graph in Figure 2, suggesting that fluctuations in income risk became a much more important determinant of fluctuations in expenditure growth after 1983.

7 Discussion

In this paper, we investigate whether business cycle fluctuations in income risk are an important determinant of fluctuations in expenditure on durable goods. For that purpose, we have simulated income risk shocks in

	MA(1) I	MA(1) II	MA(1) III	OLS I	OLS II	OLS III
ΔY_t	2.19***	1.10	1.12	1.74***	0.28	0.27
	(0.38)	(0.80)	(0.81)	(0.51)	(0.92)	(0.94)
ΔUE_t		-0.04	-0.04		-0.06*	-0.06*
		(0.02)	(0.02)		(0.03)	(0.03)
R_{t-1}			-0.01			-0.01
			(0.09)			(0.13)
Intercept	-0.01***	0.00	0.00	-0.01	0.01	0.01
	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
MA(1)	-0.31***	-0.29***	-0.29***			
	(0.08)	(0.08)	(0.08)			
R2				0.09	0.12	0.11
N	121	121	120	121	121	120

Table 12: Regression of durable expenditure growth on income growth and income risk growth. Standard errors are showed in parenthesis. Sample 1963:Q3 to 1994:Q3, as used in Carroll and Dunn (1997)

a realistically calibrated model of household expenditure decisions, and investigated the impact of a change in income risk using both micro and macro data.

For the simulation exercise, we have used a calibrated income process that matches the business cycle fluctuations in variance and skewness for US data, and found that the aggregate partial equilibrium response to a recession shock can be sizable. We have also shown that this effect is largely driven by the increased option value of postponing durable purchases, and not by an increased precautionary savings motive. Indeed, when the non-convex adjustment costs were removed from the model, the response of durable expenditures decreased from 60 to 20 percent.

In the empirical section, we proxied fluctuations in income risk with fluctuations in the probability of becoming unemployed, and investigated the link between fluctuations in unemployment risk and expenditures on durable and non-durable growth using Italian micro data and US time series data. To the best of our knowledge, this paper is the first to study empirically the relationship between *changes* in unemployment risk and consumption expenditures, which is the test informed by our model simulations. Previous work, such as Benito (2006), have studied the relationship between the level of unemployment risk and consumption.

Using Italian micro data, we found that durable expenditures respond strongly to changes in unemployment risk. A uniform increase in unemployment risk by one percentage point translates to a fall in durable purchases by two percent. Non-durable expenditures do not seem to react at all to changes in unemployment risk. Using US aggregate data, we found that fluctuations in the expected unemployment rate is a significant predictor of durable expenditure growth, while not for non-durable expenditure growth.

Although preliminary, the empirical results suggest that fluctuations in income risk are important for consumption dynamics beyond what a precautionary-savings logic would imply. If precautionary savings were the dominant reason why households respond to fluctuations in income risk, we would expect that non-durable consumption would also be affected by fluctuations in income risk. Instead, we find that non-durable consumption is insensitive to fluctuations in income risk. These results reinforce the findings from the simulation exercise, which showed that expenditures on durable goods react much stronger than expenditures on non-durable goods to fluctuations in income risk, through increasing the option value of postponing purchases.

Our results may carry important implications for fiscal and monetary policy, through their implications for the aggregate marginal propensity to consume (MPC). A recent and growing literature has highlighted that the aggregate MPC is a key statistic in the transmission of monetary and fiscal policy, as it determines the consumption response to the income effects that these policies may generate (Kaplan and Violante, 2014, Auclert, 2015, McKay, 2015, Berger and Vavra, 2014, 2015, Carroll et al., 2015). If the main effect of an increased income risk is an increased option value of postponing durable purchases, the aggregate marginal propensity to consume falls in response to increased risk. In our calibrated model, we have showed that this fall is sizable, amounting to fall of 30 percent in response to a recession shock. This may indicate that fiscal policy is less effective in periods when income risks are high, e.g. in early stages of a recession.

References

Abel, A. B. and Eberly, J. C. (1996). Optimal Investment with Costly Reversibility. *The Review of Economic Studies*, 63(4):581–593.

Auclert, A. (2015). Monetary Policy and the Redistribution Channel.

Bachmann, R. and Bayer, C. (2014). Investment Dispersion and the Business Cycle. *American Economic Review*, 104(4):1392–1416.

Benito, A. (2006). Does job insecurity affect household consumption? *Oxford Economic Papers*, 58(1):157–181.

Berger, D. and Vavra, J. (2014). Measuring How Fiscal Shocks Affect Durable Spending in Recessions and Expansions. *American Economic Review*, 104(5):112–115.

Berger, D. and Vavra, J. (2015). Consumption Dynamics During Recessions. *Econometrica*, 83(1):101–154.

Bernanke, B. S. (1983). Irreversibility, uncertainty and cyclical investment. *Quarterly Journal of Economics*, 98(1):85–106.

Bertola, G. and Caballero, R. J. (1994). Irreversibility and aggregate investment. *Review of Economic Studies*, 61(2):223–247.

Bertola, G., Guiso, L., and Pistaferri, L. (2005). Uncertainty and consumer durables adjustment. *Review of Economic Studies*, 72(4):973–1007.

Bloom, N. (2009). The Impact of Uncertainty Shocks. *Econometrica*, 77(3):623–685.

Bloom, N., Floetotto, M., Jaimovich, N., Saporta-Eksten, I., and Terry, S. J. (2014). Really Uncertain Business Cycles.

Bourdieu, P. (1984). *Distinction: A Social Critique of the Judgement of Taste*. Harvard University Press.

Caballero, R. J. and Engel, E. M. R. A. (1999). Explaining Investment Dynamics in U.S. Manufacturing: A Generalized (S, s) Approach. *Econometrica*, 67(4):783–826.

Campbell, J. Y. and Mankiw, N. G. (1989). Consumption, income and interest rates: Reinterpreting the time series evidence. *NBER Macroeconomics Annual*, 4:185–246.

Carroll, C. (1997). Buffer-Stock Saving and the Life Cycle/Permanent Income Hypothesis. *Quarterly Journal of Economics*, 112(1):1–55.

Carroll, C. and Dunn, W. E. (1997). Unemployment Expectations, Jumping (S,s) Triggers, and Household Balance Sheets. *NBER Macroeconomics Annual*, 12(January):165–230.

Carroll, C., Slacalek, J., Tokuoka, K., and White, M. N. (2015). The Distribution of Wealth and the Marginal Propensity to Consume.

Carroll, C. D., Dynan, K. E., and Krane, S. D. (2003). Unemployment Risk and Precautionary Wealth: Evidence from Households' Balance Sheets. *Review of Economics and Statistics*, 85(August):586–604.

Fernández-Villaverde, J., Guerrón-Quintana, P., Rubio-Ramírez, J. F., and Uribe, M. (2011). Risk Matters: The Real Effects of Volatility Shocks. *American Economic Review*, 101(6):2530–2561.

Foote, C., Hurst, E., and Leahy, J. (2000). Testing the (S, s) Model. *American Economic Review: Papers and Proceedings*, 90(2):116–119.

Greenacre, M. and Blasius, J., editors (2006). *Multiple correspondence analysis and related methods*. Chapman & Hall/CRC.

Guvenen, F., Ozkan, S., and Song, J. (2014). The Nature of Countercyclical Income Risk. *Journal of Political Economy*, 122(3):621–660.

Hassler, J. (1996). Variations in risk and fluctuations in demand: A theoretical model. *Journal of Economic Dynamics and Control*, 20(6-7):1115–1143.

Heathcote, J., Storesletten, K., and Violante, G. L. (2014). Optimal Tax Progressivity: An Analytical Framework.

Kaplan, G. and Violante, G. L. (2014). A Model of the Consumption Response to Fiscal Stimulus Payments. *Econometrica*, 82(4):1199–1239.

Kimball, M. S. (1990). Precautionary Saving and the Marginal Propensity to Consume.

Mankiw, N. G. (1982). Hall's consumption hypothesis and durable goods. *Journal of Monetary Economics*, 10(3):417–425.

Martin, J. P. (1996). Measures of replacement rates for the purpose of international comparisons: a note. *OECD Economic Studies*, 1(26):99–115.

McKay, A. (2015). Time-Varying Idiosyncratic Risk and Aggregate Consumption Dynamics.

McKay, A. and Reis, R. (2015). The role of automatic stabilizers in the U.S. business cycle.

Mishkin, F. S. (1976). Illiquidity, Consumer Durable Expenditure, and Monetary Policy. *American Economic Review*, 66(4):642–655.

Romer, C. D. (1990). The great crash and the onset of the Great Depression. *Quarterly Journal of Economics*, 105(3):597–625.

Shimer, R. (2012). Reassessing the ins and outs of unemployment. *Review of Economic Dynamics*, 15(2):127–148.

Storesletten, K., Telmer, C. I., and Yaron, A. (2004). Cyclical Dynamics in Idiosyncratic Labor Market Risk. *Journal of Political Economy*, 112(3):695–717.

Working, H. (1960). Note on the Correlation of First Differences of Averages in a Random Chain. *Econometrica*, 28(4):916–918.

A State space reduction in the recursive formulation

We start from the recursive formulation of the household problem (14)-(15). Define $v(b,d;n,s) = \frac{1}{(1-\tau)Z^{(1-\sigma)(1-b^y)}} V(Z,B,D;n$ as well as $b = \frac{B}{(1-\tau)Z^{1-b^y}}$ $c = \frac{C}{(1-\tau)Z^{1-b^y}}$, $d = \frac{D}{Z^{1-b^y}}$, $b^* \frac{B^*}{Z^{1-b^y}}$, $d^* = \frac{D^*}{(1-\tau)Z^{1-b^y}}$. Using that $\frac{(1-\tau)Y^{1-b^y}}{(1-\tau)Z^{1-b^y}} = \epsilon^{1-b^y}$, we can rewrite (14)-(15) as

$$
\begin{aligned}
v_{NA}(b,d;\epsilon,n,s) = \quad & \max_{c,b^*} u(c,d^*) + \hat{\beta} E\left[(\eta')^{(1-\sigma)(1-b^y)} v(b',d';\epsilon',n',s')\right] && (31)\\
\text{s.t.} \quad & d' = (1-\delta)\left(\frac{1}{\eta'}\right)^{1-b^y} d^* \\
& d^* = d \\
& b' = \left(\frac{1}{\eta'}\right)^{1-b^y} b^* \\
& c + qb^* = b + \epsilon^{1-b^y}(n + b^u(1-n)) \\
& b^* \geq \underline{\text{b}} \\
v_A(b,d;\epsilon,n,s) = \quad & \max_{c,d^*,b^*} u(c,d^*) + \hat{\beta} E\left[(\eta')^{(1-\sigma)(1-b^y)} v(b',d';\epsilon',n',s')\right] && (32)\\
\text{s.t.} \quad & d' = (1-\delta)\left(\frac{1}{\eta'}\right)^{1-b^y} d^* \\
& b' = \left(\frac{1}{\eta'}\right)^{1-b^y} b^* \\
& c + d^* + qb^* \leq b + d - hd + \epsilon^{1-b^y}(n + b^u(1-n)) \\
& b^* \geq \underline{\text{b}} \\
v(b,d;\epsilon,n,s) = \quad & \max\{v_{NA}(b,d;\epsilon,n,s), v_A(b,d;\epsilon,n,s)\} && (33)
\end{aligned}
$$

From this formulation, define $a = b + \epsilon^{1-b^y}(n + b^u(1-n))$ and substitute the expressions for d', b' to find (17)-(19).

B Computation

We solve the functional system of equations, and its associated decision functions, defined by (17)-(19) by value function iteration with a convergence criterion of 10^{-5}. We conduct the computations in Python. We use a mixture of linear (for the lower end) and exponential (for the upper end) grids for d and a, each with a total number of 80 grid points. The value function iteration is in itself computationally demanding, and so we employ three different methods to speed it up.

First, we use the Howard improvement algorithm. In practice, we let the value function iterate a couple of rounds before we turn it on, we then run 60 Howard iterations in every value function iteration. We let it run until the average error of the value function has stopped improving, after which we run the value function iteration without Howard iterations in between.

Second, conditional on adjusting, the value function only has one relevant state variable, $a + (1 - h)d$, rather than the two states $\{a, d\}$. Hence, conditional on adjusting, we reduce the state space of the problem to this single dimension.

Third, we make use of the Python Numba package, which can send functions using a selected set of operations, to be compiled and executed in C. We use these for the computation of the expected value function and bilinear interpolations.

C Figures

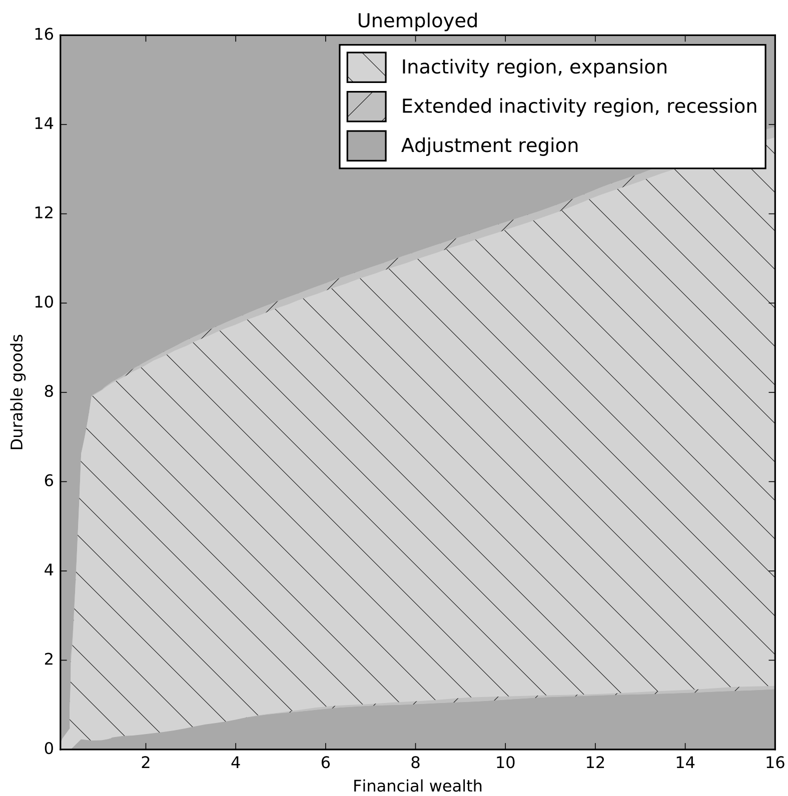

Figure 12: The inactivity regions for the unemployed in the expansionary and recessionary state.

Table 13: Robustness: Estimating the probability of purchase with logit.

	Basic	Extended 1	Extended 2	Extended 3
C(durstockquint)[T.1.0]	-0.07***	-0.07***	-0.07***	-0.07***
	(0.02)	(0.02)	(0.02)	(0.02)
C(durstockquint)[T.2.0]	-0.11***	-0.12***	-0.11***	-0.12***
	(0.02)	(0.02)	(0.02)	(0.02)
C(durstockquint)[T.3.0]	-0.12***	-0.13***	-0.12***	-0.13***
	(0.02)	(0.02)	(0.02)	(0.02)
C(durstockquint)[T.4.0]	-0.12***	-0.14***	-0.12***	-0.13***
	(0.02)	(0.02)	(0.02)	(0.02)
Deltaurisk	-0.68*	-0.78**	-0.87**	-0.90**
	(0.35)	(0.35)	(0.35)	(0.35)
logdeposits	0.03***	0.02***	0.03***	0.02***
	(0.01)	(0.01)	(0.01)	(0.01)
logincome	0.15***	0.13***	0.13***	0.12***
	(0.02)	(0.02)	(0.02)	(0.02)
logwealth	-0.01*	-0.01*	-0.01*	-0.01*
	(0.00)	(0.00)	(0.00)	(0.00)
Pseudo-R2	0.04	0.05	0.05	0.06
N	7283	7283	7281	7281

D Tables

D.1 Robustness of SHIW durable expenditures model

D.2 Robustness to sample period

In tables 15-21, we show the results when estimating the relationships (28) and (29) for the sample periods 1970:Q3 to 2014:Q4,1980:Q3 to 2014:Q4 and 1983:Q3 to 2014:Q4 (Post-Volcker period). As can been see by comparing the coefficients with the Tables 9 and 10, our results are not significantly affected by the choice of sample period.

Table 14: Robustness: Estimating the probability of purchase with OLS.

	Basic	Extended 1	Extended 2	Extended 3
C(durstockquint)[T.1.0]	-0.07***	-0.07***	-0.07***	-0.07***
	(0.02)	(0.02)	(0.02)	(0.02)
C(durstockquint)[T.2.0]	-0.11***	-0.12***	-0.11***	-0.12***
	(0.02)	(0.02)	(0.02)	(0.02)
C(durstockquint)[T.3.0]	-0.12***	-0.13***	-0.12***	-0.13***
	(0.02)	(0.02)	(0.02)	(0.02)
C(durstockquint)[T.4.0]	-0.12***	-0.14***	-0.12***	-0.13***
	(0.02)	(0.02)	(0.02)	(0.02)
Deltaurisk	-0.66**	-0.61*	-0.72**	-0.70**
	(0.33)	(0.33)	(0.34)	(0.34)
logdeposits	0.03***	0.02***	0.03***	0.03***
	(0.01)	(0.01)	(0.01)	(0.01)
logincome	0.14***	0.12***	0.13***	0.12***
	(0.02)	(0.02)	(0.02)	(0.02)
logwealth	-0.01*	-0.01*	-0.01*	-0.01*
	(0.00)	(0.00)	(0.00)	(0.00)
R2	0.06	0.08	0.07	0.08
N	7283	7283	7281	7281

	MA(1) I	MA(1) II	MA(1) III	OLS I	OLS II	OLS III
ΔY_t	0.46**	0.30	0.28	0.55***	0.56*	0.56*
	(0.18)	(0.34)	(0.34)	(0.16)	(0.29)	(0.29)
ΔUE_t		-0.01	-0.01		0.00	0.00
		(0.01)	(0.01)		(0.01)	(0.01)
ΔR_{t-1}			0.01			-0.00
			(0.04)			(0.04)
Intercept	0.00	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
MA(1)	0.14*	0.16*	0.17*			
	(0.09)	(0.09)	(0.09)			
N	173	173	172	173	173	172

Table 15: Regression of non-durable expenditure growth on income growth and income risk growth. Standard errors are showed in parenthesis. Sample 1970:Q4 to 2014:Q4

	MA(1) I	MA(1) II	MA(1) III	OLS I	OLS II	OLS III
ΔY_t	0.62**	0.28	0.17	0.71***	0.49	0.44
	(0.24)	(0.41)	(0.43)	(0.21)	(0.36)	(0.38)
ΔUE_t		-0.01	-0.02		-0.01	-0.01
		(0.01)	(0.01)		(0.01)	(0.01)
ΔR_{t-1}			0.02			0.00
			(0.05)			(0.05)
Intercept	0.00	0.01	0.01	0.00	0.00	0.00
	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)
MA(1)	0.11	0.14	0.16			
	(0.11)	(0.11)	(0.12)			
N	133	133	132	133	133	132

Table 16: Regression of non-durable expenditure growth on income growth and income risk growth. Standard errors are showed in parenthesis. Sample 1980:Q4 to 2014:Q4

	MA(1) I	MA(1) II	MA(1) III	OLS I	OLS II	OLS III
ΔY_t	0.74**	0.44	0.01	0.87***	0.58	0.24
	(0.34)	(0.44)	(0.52)	(0.29)	(0.41)	(0.50)
ΔUE_t		-0.01	-0.02		-0.01	-0.02
		(0.01)	(0.02)		(0.01)	(0.01)
ΔR_{t-1}			0.10			0.07
			(0.07)			(0.06)
Intercept	0.00	0.00	0.01	-0.00	0.00	0.01
	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)	(0.01)
MA(1)	0.13	0.13	0.17			
	(0.12)	(0.12)	(0.11)			
N	121	121	120	121	121	120

Table 17: Regression of non-durable expenditure growth on income growth and income risk growth. Standard errors are showed in parenthesis. Sample 1983:Q4 to 2014:Q4

	MA(1) I	MA(1) II	MA(1) III	OLS I	OLS II	OLS III
ΔY_t	0.31**	0.15	0.17	0.36***	0.25	0.25
	(0.14)	(0.25)	(0.25)	(0.13)	(0.25)	(0.25)
ΔUE_t		-0.01	-0.01		-0.00	-0.01
		(0.01)	(0.01)		(0.01)	(0.01)
ΔR_{t-1}			-0.05			-0.06
			(0.05)			(0.04)
Intercept	0.00*	0.01	0.01*	0.00*	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
MA(1)	0.15	0.15*	0.14			
	(0.09)	(0.09)	(0.09)			
R2				0.08	0.08	0.10

Table 18: Regression of non-durable expenditure growth on income growth and income risk growth. Standard errors are showed in parenthesis. Sample 1960:Q4 to 1983:Q4

	MA(1) I	MA(1) II	MA(1) III	OLS I	OLS II	OLS III
ΔY_t	1.99***	-0.19	-0.30	1.37***	-1.16	-1.29*
	(0.36)	(0.71)	(0.70)	(0.41)	(0.70)	(0.71)
ΔUE_t		-0.09***	-0.09***		-0.11***	-0.11***
		(0.02)	(0.02)		(0.03)	(0.03)
ΔR_{t-1}			0.10			0.12
			(0.07)			(0.09)
Intercept	-0.01***	0.02**	0.02**	-0.00	0.03***	0.03***
	(0.00)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)
MA(1)	-0.26***	-0.21**	-0.23***			
	(0.08)	(0.09)	(0.09)			
N	173	173	172	173	173	172

Table 19: Regression of durable expenditure growth on income growth and income risk growth. Standard errors are showed in parenthesis. Sample 1970:Q4 to 2014:Q4

	MA(1) I	MA(1) II	MA(1) III	OLS I	OLS II	OLS III
ΔY_t	1.73***	0.09	-1.25	1.27***	-0.65	-1.74**
	(0.42)	(0.74)	(0.77)	(0.47)	(0.77)	(0.76)
ΔUE_t		-0.07***	-0.10***		-0.08***	-0.11***
		(0.02)	(0.02)		(0.03)	(0.03)
ΔR_{t-1}			0.24***			0.27***
			(0.08)			(0.09)
Intercept	-0.01	0.02**	0.03***	-0.00	0.03***	0.03***
	(0.00)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)
MA(1)	-0.22**	-0.20**	-0.14			
	(0.09)	(0.10)	(0.09)			
N	133	133	132	133	133	132

Table 20: Regression of durable expenditure growth on income growth and income risk growth. Standard errors are showed in parenthesis. Sample 1980:Q4 to 2014:Q4

	MA(1) I	MA(1) II	MA(1) III	OLS I	OLS II	OLS III
ΔY_t	1.90***	0.70	-0.83	1.35**	-0.08	-1.54
	(0.57)	(0.80)	(1.06)	(0.62)	(0.84)	(1.02)
ΔUE_t		-0.05**	-0.09***		-0.06**	-0.10***
		(0.02)	(0.03)		(0.03)	(0.03)
ΔR_{t-1}			0.26**			0.33**
			(0.13)			(0.13)
Intercept	-0.01*	0.01	0.02**	-0.00	0.02*	0.03***
	(0.00)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)
MA(1)	-0.21**	-0.20**	-0.15			
	(0.10)	(0.10)	(0.10)			
N	121	121	120	121	121	120

Table 21: Regression of durable expenditure growth on income growth and income risk growth. Standard errors are showed in parenthesis. Sample 1983:Q4 to 2014:Q4

	MA(1) I	MA(1) II	MA(1) III	OLS I	OLS II	OLS III
ΔY_t	2.10***	0.98	1.00	1.84***	0.73	0.77
	(0.39)	(0.79)	(0.80)	(0.50)	(0.91)	(0.93)
ΔUE_t		-0.04	-0.04		-0.05	-0.04
		(0.03)	(0.03)		(0.03)	(0.03)
ΔR_{t-1}			0.03			0.01
			(0.11)			(0.16)
Intercept	-0.01**	0.01	0.00	-0.01	0.01	0.01
	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
MA(1)	-0.28***	-0.28***	-0.28***			
	(0.09)	(0.09)	(0.09)			
N	89	89	88	89	89	88

Table 22: Regression of durable expenditure growth on income growth and income risk growth. Standard errors are showed in parenthesis. Sample 1960:Q4 to 1983:Q4