Netspar

Network for Studies on Pensions, Aging and Retirement

NETSPAR ACADEMIC SERIES

The effects of transitory income shocks on saving behavior of Dutch households

Friso Wobben

MSc 06/2019-019

UNIVERSITY OF GRONINGEN
FACULTY OF ECONOMICS AND BUSINESS

Department of Economics, Econometrics & Finance

MASTER'S THESIS ECONOMICS
EBM877A20

The effects of transitory income shocks on saving behavior of Dutch households

Author:
Friso WOBBEN

Supervisor:
Prof. dr. R.J.M. ALESSIE

Abstract: Using the data collected in the DNB Household Survey, we estimate transitory income shocks of households using the identification strategy of Kovacs, Rondinelli, and Trucchi (2018). Their research is extended upon by using an income process based on the level of education of the household members. Then, the saving response to transitory income shocks is estimated using interval regression, where differences in household characteristics and individual fixed effects are taken into account. It is found that lower education households do not have a significant saving response to transitory income shocks, whereas higher education household have a saving response to transitory income shocks which is significant, positive, and similar to their general saving response. These findings suggest that there exists a heterogeneous response to income shocks based on the level of education of individuals.

June 10, 2019

1 Introduction

During their lifetime, consumers face many economic choices and experience shocks that affect their current and future wealth. They constantly have to choose: consume now and reduce their wealth, or save the wealth for future use? How they make this decision and plan for the future is based on their individual preferences and characteristics, their level of wealth, the information they possess at any given time, and their expectations for the future. Given all the ways in which consumers can be different from each other, it is no wonder that they all respond differently to events like income shocks. The income shock responses of all consumers together do not only affect the consumption and saving of the individual consumers, but aggregated they also affect the larger macroeconomy and effectiveness of government policies. For policy makers it is important to know how their policies will affect both the economy and the society, and therefore it is important to understand how consumers with different preferences and characteristics will respond to income shocks.

In this research we will investigate the consumer saving response to *transitory income shocks*, the non-persistent fluctuations in income. Examples of these kinds of shocks are an increase in income due to an unexpected bonus or the loss of income due to a short period of sick leave. We will not directly investigate individual consumers, but rather we shall investigate the households belong to. We start by theoretically investigating the saving response to income shocks using a *life-cycle model*, a type of model which is often used to study intertemporal allocation of resources. We use this model to calculate an estimate of the saving rate for transitory income shocks over the entire lifetime a household. The calculated saving rates will serve as a reference point for our empirical findings.

The calculations based on our life-cycle model for consumption and saving predict that permanent changes in income of households will result in an almost one-for-one change in consumption, and thus have a very small effect on savings. Therefore changes in permanent income are not that relevant when studying the saving behavior of households. For transitory income shocks the exact opposite is true; our calculations show that we should find a strong positive savings response to transitory income shocks, which make them very relevant when studying saving behavior. The strong positive savings response to transitory income shocks which is predicted by our model, is the first hypothesis which we will test in our empirical research. Secondly, the life-cycle model predicts that households will have the same saving rate for all different components of income. This will be the second hypothesis that we will test in our empirical research.

In our empirical study of the saving response, we will use the *DNB Household Survey* (DHS), an annual Dutch survey which includes questionnaires on household characteristics, income, and savings. Identification of transitory income shocks from these data has previously been done by Kovacs et al. (2018), and we will follow their methodologies for identification of income shocks. Kovacs et al. (2018) start by estimating the income process to find the expected income growth for individuals using a second order polynomial in age of the household. Then Kovacs et al. (2018) identify the transitory income shocks by taking the difference between the expected income and current income, and applying a correction for the income growth which was expected.

We will extend this methodology by estimating different income processes for different levels of education. As we will not be looking at individuals by themselves but instead look at the households they belong to, we will also control for household composition in the income process. We then proceed in the same way as Kovacs et al. (2018) in order to estimate the transitory income shocks. Kovacs et al. (2018) found an increasing time trend in the mean transitory income shocks for different cohorts. We, however, do not observe a clear time trend for the means of transitory income shocks when comparing different education levels. This could be due to the different income process specification or because such a trend does only exist for cohorts and not the education groups we use.

Additionally we will investigate the effect of transitory income shocks on saving behavior. We will do this using additional DHS survey questions on money-put-aside as a measure for household savings. The subjective data on savings provide a means to test the hypotheses based on the theoretical model. The general saving rates we find are significant and positive, albeit being lower than predicted by our life-cycle model. We also find that households with higher education save almost equally out of transitory income and other components of their income. In contrast, we find evidence that households with lower levels of education have a different saving response to transitory income shocks than to their other components of income. Therefore we find heterogeneous responses to transitory income shocks, where households with lower levels of education deviate from the response expected from a rational forward-looking economic agent.

The structure of this thesis is as follows: In section 2 we will briefly review the life-cycle model. Then we use this model to find theoretical predictions for the saving rate, and thereafter discuss the effects of some concepts which we did not include in our models. Continuing in section 3, we discuss the income process that we will estimate. We will also discuss the methods for identifying transitory income shocks, and how we will use the data available in the DHS Household Survey. In section 4 we will report our empirical findings, and finally we will conclude by discussing our results and their implications in section 5.

2 Saving Behavior of Households

In this research we will assume households to be rational, forward-looking, and finitely lived economic agents, and by doing so we implicitly assume that in any period t of their lifetime they will have an expectation of their real income Y_s for all future periods $s > t$. Income shocks of the household are the difference between realizations of income in period t and the income expectation of the household in the previous period. We will distinguish two different types of income shocks, namely *permanent income shocks* which persist in all future periods and *transitory income shocks* which are only present in period t.

In this section we start by discussing the life-cycle model, a type of model which is often used to study intertemporal allocation of resources. In our research, we will use a life-cycle model to study saving and consumption of households. More specially we will use a life-cycle model to calculate the marginal propensity to save out of transitory income shocks, given that we make some assumptions about the income process and the utility function of the household. In the models we use, households save a constant fraction of their income, and therefore the marginal propensity to save is equal to the saving rate. Based on our calculations, we will formulate two hypotheses that we will empirically test in section 4.3. Then we will conclude this section by discussing two additional saving motives (the precautionary saving motive and the bequest motive) and hyperbolic discounting as an alternative consumer discounting model. These concepts are common extension to the life-cycle model, but we did not include in our calculations. Therefore it is good to qualitatively discuss how they could have changed our theoretical estimates.

2.1 Life-Cycle Model of Consumption and Saving

The *life-cycle model* proposed by Modigliani and Brumberg (1954) and the similar *permanent-income hypothesis* by Friedman (1957) form the basis of a vast amount of research into the intertemporal allocation of resources by consumers. These models have been developed to provide a framework for thinking about many life-cycle choices such as consumption, saving, education and human capital accumulation, marriage, fertility, and labor supply (Browning & Crossley, 2001). Life-cycle models have been used to study consumption and saving behavior for a long time now, and many different aspects of saving behavior have been studied using life-cycle models. For example the consumer response to *income uncertainty* (e.g. Caballero

(1990), Carroll (1994), Hall (1978), Jappelli and Pistaferri (2010), Kimball (1990), Pistaferri (2001), Skinner (1988)), the effects of *lifetime uncertainty* on savings (e.g. Brown (2001), Davies (1981), Hurd (1989), Yaari (1965)), the ability to borrow and *liquidity constraints* (e.g. Deaton (1991), Zeldes (1989)), *behavioral concepts* such as self-control, mental accounting, and framing (e.g. Shefrin and Thaler (1988)), the formation of *habits* in consumption (e.g. Alessie and Lusardi (1997), Guariglia and Rossi (2002)), *bequests* from parents to their children (e.g. Drazen (1978), Dynan, Skinner, and Zeldes (2002), Lockwood (2018), Mariger (1987), Wilhelm (1996)), and *health uncertainty* (e.g. Kotlikoff (1986)).

One of the main findings of life-cycle models for consumption and saving is the following: Households with rational expectations of their future income which are subject to a lifetime budget constraint will choose to smooth the marginal utility of consumption after discounting. They do so in order to maximize utility over their lifetime (Browning & Crossley, 2001). We can easily see why this is true by considering a household which chooses a consumption path such that the marginal utility of consumption is higher in a certain period t_a than the discounted marginal utility in a period t_b thereafter. If one unit of wealth would be reallocated from consumption in period t_b to consumption in period t_a, the drop in utility experienced in period t_b is lower than the gain of utility in period t_a. Therefore the household will reallocated units of wealth from consumption in period t_b to consumption in period t_a until the marginal utilities are equal. At this point, no further utility can be gained from reallocating resources. If the utility function of the household does not change over time, the household will choose a smooth (but not necessarily constant) consumption path based on their expectations and preferences, and adjust the consumption path only if they receive information which changes their expectations.

This idea is at the heart of the life-cycle models, and is captured by the Euler equation for consumption. In this research we will assume rational households, which are constrained in their lifetime budget, maximize utility, have a constant discount factor, can lend and borrow at the same constant rate, and have a utility function $u(\cdot)$ which is state and time separable. Following the derivation in appendix A (see eqs. (A.1)–(A.9)), we can find the relation between the marginal utility of consumption in period t and the expected marginal utility in period $t+1$. This is expressed in the aforementioned Euler equation of consumption

$$u'(c_t) = \beta(1+r)E_t\left[u'(c_{t+1})\right], \tag{2.1}$$

where c_t is consumption of the household in period t, β is the intertemporal discount rate, r is the real interest rate, and E_t is the expectation operator, formed by the information available to the household at time t. This is the structure of a consumption Euler equation based on the assumptions we made and concepts we included in the derivation seen in appendix A. Depending on what is included in the life-cycle model the Euler equation can be more complicated.

2.2 The Saving Response to Income Shocks

Having found the Euler equation in eq. (2.1), we can continue our theoretical exercise and try to find an expression for the marginal propensity to consume out of permanent and transitory income shocks. In section 2.2.2 we will see that the marginal propensity to save out of transitory income shocks for an infinitely lived household is actually a good approximation of the marginal propensity to save of a finitely lived household during their working life. Therefore it is useful to first find an expression for the marginal propensity to save of an infinitely lived household.

Before we can continue our derivation, we have to make a couple of assumptions about the household's income process and utility function. In this section we will assume an income process consisting out of a permanent and a transitory component, such that the income in period t can be described by

$$y_t = p_t + \epsilon_t, \tag{2.2}$$

where p_t is the permanent income following a Markov process with zero-mean and i.i.d. income innovation ζ_t in period t such that

$$p_t = p_{t-1} + \zeta_t, \tag{2.3}$$

and ϵ_t is the mean zero i.i.d. transitory income shock in period t. In our empirical research we will also include deterministic components, but for now this type of income process will suffice to find an estimate for the marginal propensity to save out of transitory income shocks. Next, we will make the assumption that the utility function of the household is a quadratic utility function

$$u(c_t) = \bar{c}c_t - \frac{1}{2}c_t^2, \tag{2.4}$$

where $\bar{c}$ is the bliss level of consumption. We shall make the assumption that the rate of time preference ρ of the household is equal to interest rate r such that $\beta(1+r) = 1$ (because $\beta = 1/(1+\rho)$). The expected lifetime budget constraint of the household in period t is

$$\sum_{s=t}^{T} \frac{E_t(c_s)}{(1+r)^{s-t}} = A_t + \sum_{s=t}^{T} \frac{E_t(y_s)}{(1+r)^{s-t}}, \tag{2.5}$$

where A_t are the household's assets in period t and T is the maximum age of the household. We can use the income process eq. (2.2), the utility function eq. (2.4), and the expected lifetime budget constraint eq. (2.5) to find a closed-form solution for consumption (see eqs. (A.9)–(A.20)):

$$c_t = \left[\sum_{s=t}^{T} \frac{1}{(1+r)^{s-t}}\right]^{-1} \left[A_t + \epsilon_t + \sum_{s=t}^{T} \frac{p_t}{(1+r)^{s-t}}\right]. \tag{2.6}$$

As the summations over the permanent income term in eq. (2.6) cancel each other out, we can easily see that in our current case the consumption increases one-for-one with permanent income as

$$c_t = \left[\sum_{s=t}^{T} \frac{1}{(1+r)^{s-t}} \right]^{-1} [A_t + \epsilon_t] + p_t. \tag{2.7}$$

Therefore we will only have to consider the effects of transitory income shocks on household savings, as permanent income will be consumed entirely. We can also find the marginal propensity to consume out of transitory income shocks as

$$m_t^{(quad)} = \frac{\partial c_t}{\partial \epsilon_t} = \left[\sum_{s=t}^{T} \frac{1}{(1+r)^{s-t}} \right]^{-1}. \tag{2.8}$$

From this expression we can see that all but the first term of the summation will decrease with increasing r, and therefore the marginal propensity to consume out of transitory income shocks will increase with increasing r and $\rho = r$. This makes sense, because even though the remaining assets at the end of period t will be lower, they will generate more interest. The household will choose to increase the level of consumption such that the extra consumption will exactly be offset by the interest on the remaining assets. When we consider the case of an infinitely lived household ($T \to \infty$), we can evaluate the summation as a geometric series. In this case, the marginal propensity to consume out of transitory income shocks will be

$$m_t^{(quad)} = \left[\sum_{s=t}^{\infty} \left(\frac{1}{1+r} \right)^{s-t} \right]^{-1} = \left[\frac{1}{1 - \frac{1}{1+r}} \right]^{-1} = \frac{r}{1+r}. \tag{2.9}$$

Because the interest rate is generally not high (we will assume an interest rate of $r = 0.02$ in section 2.2.2), the marginal propensity to consume out of transitory income shocks of an infinitely lived household will be close to zero. This in turn implies that the marginal propensity to save will be close to one, as wealth is either consumed or saved in our model.

2.2.1 Saving Behavior of Finitely Lived Households

In the previous derivation we made a restrictive assumption: the household had a rate of time preference equal to the interest rate. In this section we are going to relax this assumption by using a different utility function, at the cost of having to make the assumption that the household has point expectations y_t for the income process. We have to make this assumption, as we will use the constant relative risk aversion (CRRA) utility function

$$u(c_t) = \frac{c_t^{1-\theta}}{1-\theta}, \tag{2.10}$$

where θ is the relative risk aversion coefficient. This utility function will in general lead a household to engage in precautionary savings in response to uncertainty in income, as the household is *prudent* ($u''' > 0$). This makes finding an expression for the marginal propensity to consume impossible if we make no further restricting assumptions on the distributions of income innovations and transitory income shocks. We shall further discuss prudence and precautionary savings in section 2.3.1. Here we will assume the household to have point expectations for its income in all future periods. Under this assumption of point expectations the household will not engage in precautionary savings. Then we continue to investigate the propensity to consume out of lifetime wealth.

We can find the marginal propensity to consume by writing the optimization problem as a recursive value function in period t, which we will denote by $V_t(\cdot)$, and using a budget constraint in terms of wealth (see appendix A.2, eqs. (A.21)–(A.24)):

$$V_t(w_t) = \max_{c_t, w_{t+1}} \{u(c_t) + \beta V_{t+1}(w_{t+1})\} \tag{2.11}$$

$$s.t. \qquad w_{t+1} = (1+r)(w_t - c_t), \tag{2.12}$$

where w_t is the lifetime wealth in period t defined as the sum of cash-on-hand and the present value of all future income. Following the derivation in appendix A.2, we find that the marginal propensity to consume out of wealth can recursively be written as (see eqs. (A.21)–(A.34))

$$m_t^{(crra)} = \begin{cases} 1 & t = T \\ \frac{b_t m_{t+1}}{1+b_t m_{t+1}} & t < T \end{cases}, \tag{2.13}$$

where

$$b_t = \left(\beta(1+r)^{1-\theta}\right)^{-\frac{1}{\theta}}. \tag{2.14}$$

Due to the recursive nature of eq. (2.13), it is not easily seen how the marginal propensity to consume out of wealth will develop over the lifetime of a household. However, in the next section we will evaluate marginal propensity to save for several distinct cases of household preferences. This will give an insight into the household response to different combinations of variables.

Furthermore, in our empirical research we look to investigate the response to transitory income shocks, and not the response to lifetime wealth. However, we assume that households form point expectations about their future income. Using the definition of wealth in eq. (A.22)

$$w_t = (1+r)(x_{t-1} - c_{t-1}) + y_t + h_t, \tag{2.15}$$

and the income process in eq. (2.2)

$$y_t = p_t + \epsilon_t, \tag{2.16}$$

we can easily see that $w_t \propto \epsilon_t$. Therefore the marginal propensity to consume out of wealth in period t will also be the marginal propensity to consume out of transitory income shocks.

2.2.2 Evaluating the Marginal Propensity to Save

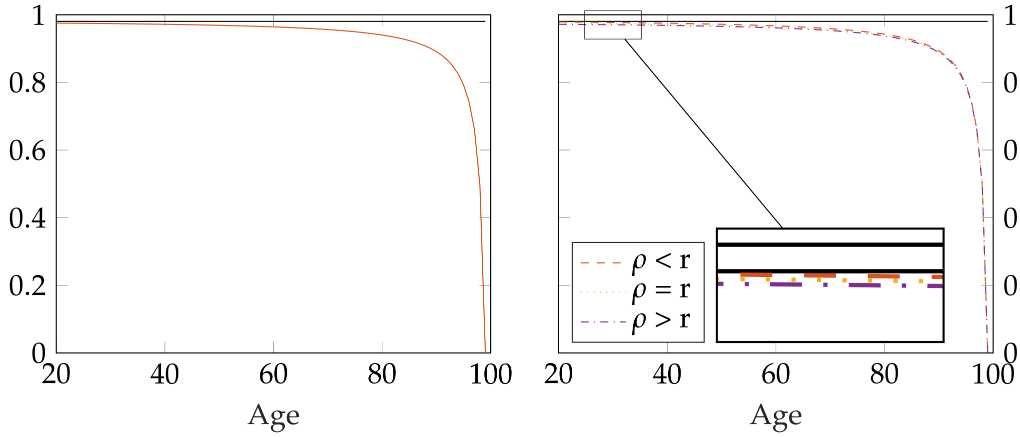
Having found an expression for the marginal propensity to consume out of transitory income shocks for a household with quadratic utility in eq. (2.8) and for a household with CRRA utility in eq. (2.13), we can now evaluate these expressions if we assume some values for the constants in these equations. In our empirical research we will investigate the saving behavior of households, and not their consumption behavior. Therefore we will now continue to use the marginal propensity to save instead of the marginal propensity to consume. These propensities together add up to one, as wealth is either saved of consumed, and therefore the marginal propensity to save is equal to $1 - m_t$. We will follow Kovacs et al. (2018) and assume the interest rate r to be equal to 0.02, and we will use relative risk aversion θ equal to 3 based on Attanasio and Weber (1995). Using these assumptions, we can calculate the marginal propensities from eqs. (2.8) and (2.13) for finitely lived household with a maximum age of 99 years ($T = 99$), the results of which are shown in fig. 2.1.

We can see that the quadratic utility household without lifetime uncertainty in fig. 2.1a has almost the same savings profile as the CRRA utility household in fig. 2.1b. During the working life (ages 20-65), the marginal propensity to save in both figs. 2.1a and 2.1b is relatively constant, similar to the marginal propensity to save of infinitely lived households (indicated by the black line), and fairly close to one. Therefore, our first hypothesis is that we will empirically find marginal propensities to save out of transitory income shocks close to one. Secondly, using eqs. (2.6) and (2.15) we can see that the marginal propensity to save out of current income should be the same for all different components of this income. We should also empirically find no different marginal propensities to consume for different components of income, which is our second hypothesis.

2.3 Additional Saving Motives

Based on the work by Keynes (1936), nine different reasons for household saving behavior were identified by Browning and Lusardi (1996). We will not go into the details of all nine different motives, but we will discuss the *precautionary savings motive* and the *bequest motive*, as these are important motives which we did not include in our models. Then we discuss the *hyperbolic discounting model*, an alternative to the exponential discounting model we used in our calculations. We will provide a short description of the motives and model, and how they would influence the marginal propensity to save, and thus their relevance to our research.

FIGURE 2.1: The marginal propensities to save of a finitely lived household with different utility functions and preferences. The marginal propensity to save for of an infinitely lived household has been added as a black reference line. In these graphs we have set the interest rate $r = 0.02$



(A) The marginal propensity to save of a household with quadratic utility when $\rho = r$.

(B) The marginal propensities to save of patient ($\rho < r$), neutral ($\rho = r$), and impatient ($\rho > r$) households with CRRA utility.

2.3.1 Precautionary Savings

When insurance markets are incomplete, households can engage in self-insurance against uncertainty through precautionary savings (Caballero, 1990; Kimball, 1990; Skinner, 1988). Most household will do so because they are *risk-averse*, or in other words, dislike uncertainty compared to certainty. The level of risk-aversion can be measured by looking at the derivatives of utility as a function of consumption, where the absolute risk aversion can be measured by $-u''(c)/u'(c)$ and the relative risk aversion by $-cu''(c)/u'(c)$ (Arrow, 1965; Pratt, 1964). However, theses measures will not tell much about how a household will choose to save in response to a uncertain future. To investigate the response of a household to risk, we could look at its *prudence*, the sensitivity of the optimal choice of consumption to risk (Kimball, 1990). Measures for prudence were introduced by Kimball (1990), and just as with risk aversion we have measures for absolute prudence ($-u'''(c)/u''(c)$) and relative prudence ($-cu'''(c)/u''(c)$). The higher these measures, the more prudent the household, and therefore the more they will save in expectation of uncertain events. However, if prudent households are sufficiently impatient they will save only when their wealth is lower than a certain wealth-to-permanent-income ratio, defining the so called *buffer-stock*. They will still dissave when their wealth is higher than the buffer-stock as their impatience then dominates their prudent behavior (Carroll, 1997).

Compared to the propensities to save we calculated for figs. 2.1a and 2.1b, precautionary savings will in general cause households to save more, and therefore on average to have a higher marginal propensity to save. Therefore the calculated propensities would serve as a lower bound on the marginal propensity to save for models which additionally include precautionary savings. Also, Hochguertel (2003) investigated precautionary savings using a Dutch panel data, and found that that precautionary saving have only a limited effect in the Netherlands. Therefore we do not expect this motive to significantly influence our results.

2.3.2 Bequests

Households might also choose to save assets because they derive utility from passing on an inheritance to their heirs. Elderly do not seem to dissave as much as predicted by theory, even when taking into account that they might hold on to savings due to an uncertain lifetime (Hurd, 1989). This could indicate that the bequest motive is important in the saving behavior of households. Moreover, most household wealth in the U.S.A. is inherited Kotlikoff and Summers (1981), which also indicates the importance of bequests. There are various reason why a household could leave an inheritance, for example *accidental bequests*, the case in which households leave bequests due to uncertainty (Dynan et al., 2002; Hurd, 1989). This type of bequests is dependent on the state of the world, for example household members that decease at a young age or that have low medical expenses in old age might leave a bequest because they were not expecting these events. Alternatively, households might actively choose to save assets for their heirs, either because of *altruism* (Barro, 1974; Lockwood, 2018; Wilhelm, 1996) or as a *strategic choice* to influence the behavior of their children (Bernheim, Shleifer, & Summers, 1986). Mariger (1987), however, found little evidence that households with regular net worth plan to leave bequests, and notes that this might not be inconsistent with Kotlikoff and Summers (1981), as already 30% of all wealth in the U.S.A. was held by the 46 richest families.

Whether bequests are accidental, motivated by altruism, or are a strategic choice to influence the behavior of heirs, a bequest motive will never cause lower savings of a household and it sometimes even provides an incentive for higher savings. This is the most important thing to keep in mind regarding bequests. As the saving rates we found are already quite high we do not require a specific implementation of bequests in our model.

2.3.3 Alternative Discounting Models

In our calculations we have assumed a constant discount rate $\beta \leq 1$, much like the original discounted utility model by Samuelson (1937). In any period t we discount the expected utility of a future period s exponentially by a factor β^{s-t}. However, it is not to say that this model is always reasonable (Frederick, Loewenstein, & O'Donoghue, 2002). For example Thaler (1981) found empirical evidence that consumers have different discount rates for gains and losses, which Christelis, Georgarakos, Jappelli, Pistaferri, and van Rooij (2017) also found to be true for Dutch consumers. Furthermore, Thaler (1981) also found that consumers have different discount rates for different time frames. Most research into consumer discounting finds that consumers discount rewards further in the future way more than the exponential discounting model predicts, make consumers behave short-sighted. The quasi-hyperbolic discounting model of Laibson (1997) is able to capture this behavior in discrete time, but estimation of the rate of time preferences is difficult and empirical results vary greatly (Frederick et al., 2002).

The implication of the hyperbolic discounting of consumers when compared to our discounting model is that they would rather consumer more now than in the future. This would in turn imply that the marginal propensity to save is lower than those we calculated for figs. 2.1a and 2.1b. Therefore it would be possible that our empirically found marginal propensities to save are lower than those predicted by our calculations, and they should be similarly lower for all components of income.

3 Estimation of the Income Process using Dutch Panel Data

In this section we will start by discussing the income process which we will use in our research. We will use the income process in section 3.1.2 to identify income shocks. Based on the work by Kovacs et al. (2018), we will identify two different types of income shocks, namely *permanent income shocks* which persist in all future periods and *transitory income shocks* which are only present in period t. In section 4.2 we will this identification strategy to estimate the transitory income shocks of the households in our sample population.

We will also discuss the *DNB Household Survey* (DHS), the annual Dutch survey we will use as a data set in our empirical research. More specially, we will discuss the different questions of the survey we will use, our sample selection criteria, and the way in which we aggregate individuals into households. We will conclude this section by discussing our final sample population and the amount of panel attrition in the DHS.

3.1 Income Shocks

3.1.1 Household Income

To understand the effects income shocks have on the saving behavior of household we require a model for the income process of households. Considering that labor income accounts for the largest part of the net household income in the Netherlands[1], we will use a decomposition of real income similar to Blundell, Graber, and Mogstad (2015), Kovacs et al. (2018), Pistaferri (2001)

$$Y_{it} = \alpha' V_i + \beta' Z_{it} + p_{it} + \epsilon_{it}, \tag{3.1}$$

[1] An analysis of the composition of household income in the Netherlands was done by Kovacs et al. (2018) using the DNB Household Survey. They found that 55% of households had zero income from financial assets, on average financial revenue represents less than 4% of net income, and only 2% of households reported income from housing wealth.

where Y_{it} is the real income of household i in period t, $\alpha' V_i$ is a deterministic time-invariant component, $\beta' Z_{it}$ is a deterministic time-varying component including interaction terms with the level of education of the household, p_{it} is a permanent component following a Markov process

$$p_{it} = p_{it-1} + \zeta_{it}, \tag{3.2}$$

where ζ_{it} is a serially uncorrelated zero-mean permanent income shock, and ϵ_{it} is the serial uncorrelated zero-mean transitory income shock. Both the permanent and transitory income shock in period t are observed by the household in period t. It is important to note that we will not use log income, contrary to Blundell et al. (2015), Kovacs et al. (2018), Pistaferri (2001), but instead just use real income. We do this because we expect a constant saving rate based on the theory in section 2, and we can not convert the dependent variable (savings) to log because we only observe the savings in different saving classes (see section 3.2).

Since we will mostly look at income dynamics in this research, and use a fixed-effects model to estimate the deterministic time-varying component, we will only consider the level of education for the time-invariant component $\alpha' V_i$ in our estimations with OLS.

Education is an important investment in human capital made by (mostly) young individuals, and human capital in turn is important in lifetime earnings (Ben-Porath, 1967; Heckman, 1976), even if it just serves a signaling function for ability (Spence, 1973). Our time-varying deterministic component $\beta' Z_{it}$ will therefore not follow Kovacs et al. (2018), Pistaferri (2001) (who include only a second order polynomial in age). Instead we will follow Blundell et al. (2015) and use the interaction terms between education and a second order polynomial in age. Also, since we do not consider individuals but households, we will include the number of adults and the household composition in the time-varying component, as was done by Alessie and Teppa (2010).

In general, transitory income shocks could be modelled as MA(q) process, where q can be determined experimentally (e.g. Meghir and Pistaferri (2004)) or assumed to be of a specific form (e.g. Blundell et al. (2015)). We will abstain from more general processes such as a MA(q) process with $q > 1$, and assume that a transitory income shocks only affects the income in the period in which the shocks occurs. We also assume that both the transitory income shocks and the permanent income shocks are independent from each other and independent from (but not necessarily uncorrelated with) the deterministic components of the income. Furthermore, because the households have rational expectations and both types of income shock are serially uncorrelated, zero-mean, and observed by the household, we know that

$$E_t[\epsilon_{it}] = \epsilon_{it}, \qquad E_t[\zeta_{it}] = \zeta_{it}, \qquad E_t[\epsilon_{it+1}] = 0, \qquad E_t[\zeta_{it+1}] = 0, \tag{3.3}$$

where $E_t[\cdot]$ is the expectation operator based on the information set available to the household in period t.

3.1.2 Identification of Permanent and Transitory Income Shocks

To identify the permanent and transitory income shocks, we will use a method developed by Pistaferri (2001), which was previously used in combination with the DNB Household Survey by Kovacs et al. (2018). In order to be able to use this method, we need to know the realization of a household's income and the household's expectations for the household income in the subsequent period. We start by taking the difference between income in period $t+1$ and in period t using eqs. (3.1) and (3.2)

$$Y_{it+1} - Y_{it} = (\beta' Z_{it+1} - \beta_i' Z_{it}) + \zeta_{it+1} + (\epsilon_{it+1} - \epsilon_{it}). \tag{3.4}$$

This can be rewritten as

$$Y^*_{it+1} - Y^*_{it} = \zeta_{it+1} + (\epsilon_{it+1} - \epsilon_{it}), \tag{3.5}$$

where

$$Y^*_{it} = Y_{it} - \beta' Z_{it} \tag{3.6}$$

is the income net of the time-varying deterministic component, such that only the time-invariant deterministic and the idiosyncratic components remain. By using eqs. (3.3) and (3.5) we find

$$E_t[Y^*_{it+1}] - \underbrace{E_t[Y^*_{it}]}_{=Y^*_{it}} = \underbrace{E_t[\zeta_{it+1}]}_{=0} + (\underbrace{E_t[\epsilon_{it+1}]}_{=0} - \underbrace{E_t[\epsilon_{it}]}_{=\epsilon_{it}}). \tag{3.7}$$

We can therefore identify the transitory income shock of household i in period t as

$$\epsilon_{it} = Y^*_{it} - E_t[Y^*_{it+1}], \tag{3.8}$$

which we can read as the difference between the current income and the expected income for the next period minus the expected income growth. By definition, the total income shock in period t is the difference between the expectation in period $t-1$ and the realization in period t. This must also be equal to the sum of the permanent and transitory parts of the income shock, as this is everything the income shock is composed of

$$\zeta_{it} + \epsilon_{it} = Y^*_{it} - E_{t-1}[Y^*_{it}]. \tag{3.9}$$

Using eqs. (3.8) and (3.9), we can identify the permanent income shock as

$$\zeta_{it} = E_t[Y^*_{it+1}] - E_{t-1}[Y^*_{it}], \tag{3.10}$$

which tell us that the permanent income shocks in period t is identified by the difference in income expectations between period t and period $t-1$, minus the expected income growth.

Two important properties have to be appreciated in the identification of the permanent and transitory income shocks. First, in both eqs. (3.8) and (3.10), all right-hand side terms (Y^*_{it}, $E_{t-1}[Y^*_{it}]$, and $E_t[Y^*_{it+1}]$) contain the same observable time-invariant component $\alpha' V_i$, which will drop in subtraction. Therefore we do not have to assume a specific form of the time-invariant component, as we are not interested in the contribution of this term to the household income. Secondly, all terms in the righthand side of eq. (3.8) concern only the household i in period t, and therefore we have to observe a household's response in period t. Unfortunately, this does not hold for eq. (3.10), as $E_t[Y^*_{it+1}]$ is observable to us only in period t and $E_{t-1}[Y^*_{it}]$ is observable to us only in period $t - 1$.

3.2 The DNB Household Survey

Now that we have a method to identify income shocks, we can proceed to look at the data we have available for our empirical research. In this section we will discuss the data set which we will use and how we will use it. We start by discussing the survey questions which we will use, then continue to discuss our sample selection and aggregation of individuals into households, and finally we will look at our sample population and discuss panel attrition.

The data which we will use comes from the *DNB Household Survey* (DHS), a longitudinal study of Dutch households administered by *CentERdata* for the Dutch central bank (*De Nederlandsche Bank*). As of 1993, they annually collect data about household finances and individual financial decisions through five different questionnaires, namely *Work and Pensions*, *Housing and Mortgages*, *Income and Health*, *Assets and Debts*, and *Economic and Psychological Concepts*. The data are collected through a self-administered online survey. All household members over the age of 16 are asked to participate in the survey, but only household heads and their spouses participate in the questionnaires on household finances. Therefore our final sample will only include adult household members. For a detailed discussion of the DNB Household Survey see Teppa and Vis (2012).

In our research we will use information on the net yearly income of the previous year, the expected net yearly income over the next 12 months, and the amount of money put aside by the household in the previous year. The exact phrasing and the names of all questions in the survey we have used can be found in appendices B.1 and B.2. The household income is self-reported by the individual household member and should be reported as net yearly income of the household, but often the monthly income is given instead of the yearly income. We use the questions about the taxable income, which respondents never answered in monthly amounts (based on our observations), to infer whether a respondent meant monthly or yearly income when answering the question about current household income.

The expected yearly income over the next 12 months is not provided directly by the respondent, but they give an interval within which they expect the income to fall and assign probabilities to the occurrence of next years net income falling within several subintervals. From this we are able to impute the expected net yearly income in a process similar to Kovacs et al. (2018), which is described in appendix B.1.

The questionnaire on Economic and Psychological concepts asks respondents whether their household has put money aside during the last twelve months. The exact phrasing of the question and the intervals used in the questions can be seen in appendix B.2. If the individual responded that the household had saved during the last year, they were asked to answer a multiple-choice question on the amount of savings, where several intervals of different sizes were given as possible answers. In the waves of 2004-2014, respondents who reported dissaving were not asked a follow-up question on the amount that was dissaved, and therefore we only know that they did not save. In the period 2015-2018, the questionnaire included a follow-up question on the amount of dissaving by the household, where the same intervals as with saving were given as multiple-choice answers.

All questions on income and savings are reported in nominal amounts, but we will calculate the real value in 2004 Euro's based on the consumer price index data published by Statistics Netherlands (*Centraal Bureau voor de Statistiek*)[2]. We could have taken inflation expectations of the households into account when interpreting their reported expected income. However, since there is much disagreement about consumer inflation expectations among economists (Mankiw, Reis, & Wolfers, 2003), we will assume that respondents did not take inflation into account when forming their income expectations, giving us an effective inflation expectation of zero.

Finally, we will group individuals into three different levels of education: those who completed a degree at a vocational college, those who completed a degree at an university, and all others to which we will refer to as *lower educated* (i.e. those who attended vocational training, those who only finished high school, etc.).

3.2.1 Sample Selection

In our research we will restrict our sample to the working population (those aged 21-65), and consider only the responses in the period 2004-2018. Although the DHS collected data in the period 1993-2003, the combined effect of heterogeneity in questions and the introduction of the Euro in 2001 make this period less suitable for this research.

We did not include respondents in our sample who did not report their year of birth or their level of education, those who reported unreasonably low (< 500 €) or high (> 250.000 €) income, those who reported an unrealistic interval of net yearly income (either expecting the lowest possible income to be below 10.000 € or the

[2]The data on the consumer price index is published on CBS Statline (see www.statline.cbs.nl), which was accessed by us on May 14 2019.

highest achievable above 250.000 €), and those who reported to expect no significant events which could change their income but nevertheless reported an expected income more than 25% lower or higher than their current income.

The questions about expected income are not homogeneous over all the years, as during the period 2004-2007 an ambiguity existed in these question with respect to the time frame the question was referring to (monthly or yearly income). Therefore we chose to exclude all observations who reported a lower bound on expected income which was lower than € 10.000 during the period 2004-2007, as a lower bound below this number leaves ambiguity whether respondent reported monthly or yearly income, and we consider those to have reported a lower bound above this level to have answered in terms of their net yearly income.

Overall our selection criteria are somewhat different from the ones used by Kovacs et al. (2018). We did not correct for the heterogeneity in questions like they did, and therefore had to set more strict selection criteria on the income expectation questions. Kovacs et al. (2018) chose to exclude households which gave inconsistent answers to the questions on the probability intervals of expected income, a group which we chose to include and for which we imputed a value based on the other observations, as was discussed in the previous section. Kovacs et al. (2018) also did not implement selection criteria for income, but trimmed the top and bottom 5% of the households. Overall the sample populations per year are still fairly similar in numbers and household characteristics.

3.2.2 Aggregation of Households

Respondents in the DNB Household Survey are the individuals who make up a household, but they answer on the income and savings of their entire household. This is why we will consider households rather than individuals to be our economic agent of interest. Doing this, we have to take care of two problems which arise when using the responses of individuals to infer the characteristics, income, and saving of household.

The first problem are the heterogeneous characteristics of individuals, more specially their age and level of education, when a household has more than one respondent in the DHS. Since birth year is immutable, we only have to decide on which birth year best represents the household. We chose to pick the birth year with the highest observation count, and in the case that two birth years were tied for the highest observation count we chose the oldest individual to represent the household age. For representative level of education is a bit more difficult, as individuals might choose to get more schooling during their working life, thus possibly one individual can report multiple levels of education. However, most individuals get most of their education during the schooling period in their early life (Heckman, 1976), and therefore we will use a similar method as was used to determine the representative birth year. We determine the level of education with the highest number of observations, and break ties by picking the highest level of education. By doing this we make education a time-invariant household characteristic.

Secondly, when multiple individuals belonging to a household responded in the same year they often did not report the same (expected) net household income and household savings. Therefore we had to choose the responses which we considered to have the highest probability of being close to the true values. To do this, we made use of an additional question in the DHS on financial accounting of the household. Respondents were asked whether they were the household member who handled most of the household's finances. By picking only those individuals who reported being the one responsible for the household's finance in the case multiple individuals participated in a specific year, we were able to get unique responses for all households in every year.

3.2.3 Sample Population of Households and Panel Attrition

Our final sample consists of 2036 unique households with 5515 observations over all years. In table B.2 we give the descriptive statistics of our sample per year. The first observation we have to make is the number of observations in the period 2004 - 2007. During these years the number of households in our sample is roughly half the number of households per year compared to the years 2008 - 2018. This is due to the selection based on the lower bound of expected income, as was discussed in section 3.2.1. Apart from the lower number of observations during these four years, there are no significant changes in sample composition over time.

The distribution of household levels of education seems to reflect the different proportions one would expect from a developed country, as do the number of adults living in the household and the household size[3]. In contrast, the age distribution sees a strong underrepresentation of those aged 21-29 and similarly an overrepresentation of those aged 60-65. Nevertheless, we do not expect this to influence the findings of our research in a significant manner, as we already saw in section section 2.2.2 that the marginal propensity to save would not change much during this period.

The DNB Household Survey suffers a lot from panel attrition, as can be seen in table B.3. About half the households in any given year do not participate in the survey the year after, suggesting that these households participate in the survey only once. This presents a problem for identifying the permanent income innovations using eq. (3.10), as this requires responses in two consecutive years. Luckily the transitory income shocks are identified from one year's response only, as was seen in section 3.1.2 (eq. (3.8)).

[3]See for example the Statistics Netherlands data on education levels at Statline (Education Levels) (accessed on 08-06-2019) and on household composition at Statline (Households) (accessed on 08-06-2019).

4 Empirical Results

We are now at the point where we can start our empirical research, which is what we will discuss in this section. We start by estimating the income process (eq. (3.1)) in section 4.1 to find estimates for the coefficients of the deterministic time-varying component. The estimates of these coefficients are needed to correct the (expected) income for expected income growth (see eq. (3.6)). Then we use eq. (3.8) to estimate the transitory income shocks, and we will further investigate the properties of the transitory income shocks in section 4.2. Then we conclude our research in section 4.3 by using the transitory income shocks and the household savings to estimate and discuss the empirical saving response to transitory income shocks, and to test the hypotheses we formulated section 2.2.2.

4.1 Deterministic Changes in Household Income

Before we can calculate the transitory income shocks, we first have to find the deterministic income growth, as this growth will be included in the income expectations of the households. We will first find the coefficients of the deterministic income process components in eq. (3.1) by using OLS to estimate

$$Y_{it} = \alpha' V_i + \beta' Z_{it} + u_{it}, \tag{4.1}$$

where V_i contains the level of education of the household and a constant, and Z_{it} contains the second order polynomial in age, interaction terms between the level of education and the second order polynomial in age, the household size, and the number of children in the household, and u_{it} is a zero-mean error term. The results of our estimation can be seen in columns (1) and (2) of table 4.1. We have also estimated the same income function with the fixed-effects estimator by replacing the time invariant deterministic component $\alpha' V_i$ by a individual fixed effect α_i. The results of this estimation can be seen in column (3) of table 4.1.

From the results in table 4.1 we can see that the second order polynomial in age has significant and reasonable coefficients for terms including age and age^2. The large positive coefficients for age combined with the negative coefficients for age^2 predict an income growth early in life, a peak in the second half of the working life and a slight decrease thereafter. This can be seen in fig. C.1, where the observed average income by age can be seen as well as the estimated polynomial of the OLS regression without accounting for household composition (table 4.1, column (1)).

This is one would reasonably expect and is consistent with results found in other research (for example Blundell et al. (2015) and Kovacs et al. (2018)). The estimated polynomials we see in fig. C.1 also motivate the use of the coefficients of the polynomial terms found for those who finished vocational college, because we can easily see that their income process on average is different from those with lower levels of education.

By comparing columns (1) and (2) of table 4.1, we can also see that the addition of variables regarding the household results in very significant coefficients as well as a substantial increase of explained variation in the data. We therefore chose to include these terms in the fixed effect estimation. Overall, the use of the fixed effect estimator is motivated by income process in eq. (2.2), specifically the permanent income component. Assuming that this component would be a valid addition to the income process model, every household would have a non-zero income component with a zero-mean expected change over time. This component could be reasonably well captured by inclusion of a fixed effect, as this would allow for estimation of the average permanent income during the period in which we observe the household. Therefore we chose to use the coefficients of the second order polynomial in age found by using the fixed effects estimator to calculate the income and expected income net of time varying deterministic component.

TABLE 4.1: Regressions of real income (at the 2004 price level) on several household characteristics.

Income	OLS (1)	OLS (2)	FE (3)
Education			
Vocational college	15780.7	7537.7	
	(10952.0)	(10112.9)	
University	-20616.5	-22768.1	
	(16475.1)	(14648.3)	
Age	1182.6***	1134.1***	1589.9***
	(309.1)	(284.3)	(391.0)
Age^2	-12.27***	-12.01***	-15.01***
	(3.240)	(3.012)	(3.924)
Education × *Age*			
Vocational college	-419.9	-65.12	896.5
	(490.1)	(450.9)	(642.5)
University	1507.5*	1582.0**	2669.4***
	(778.0)	(692.1)	(1025.5)
Education × Age^2			
Vocational college	4.48	.73	-10.54
	(5.23)	(4.81)	(6.58)
University	-16.17*	-16.54**	-26.26**
	(8.50)	(7.57)	(10.35)
Household size		11269.7***	4792.6***
		(850.9)	(1351.5)
Number of children		-11518.8***	-5020.0***
		(1034.8)	(1431.8)
Constant	2759.6	-15353.4*	-32080.4***
	(7057.3)	(6598.3)	(7682.3)
Observations	6020[a]	6020[a]	6020[a]
R^2	0.107	0.219	0.056[b]

All standard errors are robust by clustering on the household level; [a] In this population sample we included respondents who did not answer the savings questions; [b] The R^2 of the within variation; * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

4.2 Estimation of Transitory Income Shocks

Having estimated the growth in the deterministic component of income, we can now identify the transitory income shocks. First we calculate the (expected) income net of time-varying deterministic components

$$Y^*_{it} = Y_{it} - \widehat{\beta^{(e)}}' Z_{it}, \qquad E_t[Y^*_{it+1}] = E_t[Y_{it+1}] - \widehat{\beta^{(e)}}' Z_{it}, \tag{4.2}$$

where $\widehat{\beta^{(e)}}$ are the estimated coefficients for the level of education of the household and Z_{it} contains only the *age* and age^2 of the household i in period t. Now we can calculate the transitory income shocks for all households in all periods by using eq. (3.8)

$$\epsilon_{it} = Y^*_{it} - E_t[Y^*_{it+1}]. \tag{4.3}$$

Before we will continue to estimate the effect of transitory income shocks on saving behavior, it is good to investigate the properties of transitory income shocks a bit.

First we note that the expectation of transitory income shock is zero-mean by construction. If they would not be zero-mean, this would be a persistent component in the transitory income shocks. However, such a persistent component would have been identified by the household as part of the permanent income and therefore the transitory income can not have a non-zero mean[1]. This does not imply that the realizations of transitory income shocks are zero-mean, as transitory shocks of different households are most likely correlated. Macroeconomic factors can influence the income of all households at once, and we hypothesize that the income of households with similar characteristics will respond similar to macroeconomic changes. The distribution of transitory income shocks during the period 2004-2018 can be seen in fig. C.2. Given that there were two crisis during this period in the Netherlands, a mean below zero is what one could reasonably expect. Apart from that, the distribution looks fairly normally distributed. Support for the correlation between the mean transitory shocks of households can be seen in table C.1, which shows the correlation between the mean transitory income shocks per year for different levels of education (see fig. C.3 for these means themselves). We see that there exists a fairly strong correlation between the mean transitory income shocks of those who attended university and those who attended vocational colleges, a low correlation between those who attended university and those with lower levels of education, and we see a stronger correlation between those who attended vocational colleges and those with lower levels of education. This suggests that the level of education would influence the income response to external factors, and is consistent with the hypothesis that households with similar characteristics respond more similarly to these external factors. Further research should be conducted to see if the means of transitory income shocks actually correlate with other (macroeconomic) variables or

[1] We implicitly assume that the household is able to observe the composition of its income and form a rational expectation of all components of future income.

are the result of irrational expectations. For now it suffices to note that the distribution of means of transitory income shocks are zero-mean distributed, as this is implied by the assumption that the rational expectation of future transitory income shocks is zero[2].

Furthermore, we would expect the magnitude of transitory income shocks to change with varying household characteristics. For example, a household with a higher wage experiences a larger negative shock in case of unpaid sick leave with a duration of one month than a household with a lower wage, and the same example works the other way around when considering overtime. We tested this hypothesis by investigating the log of the magnitude of transitory income shocks, after centering the transitory shocks by substracting the average transitory shock per education level, and the results of our estimations can be seen in table 4.2. In column (1) of table 4.2 we see that the log of the magnitudes of transitory shock is very strongly non-zero, and that it increases the same for all education levels with increasing income. Adding the household composition to the regression, we see the same relation between income and transitory shocks in column (2) of table 4.2, and an increases in the magnitude of shock when there are more adults in the household. This is consistent with the relationship between income and household composition seen in table 4.1.

In section 3.1.1 we chose to model the transitory income shocks as a MA(1) process, which we could do because we assumed the transitory income shocks to be serially uncorrelated. Now that we have estimated the transitory income shocks, we are able to test the assumption of serially uncorrelated income shocks by regressing the transitory income shocks on the transitory income shocks lagged one period. The results for these estimations, based on the education level of the household, can be seen in table 4.3. The numbers of observations are very small because we grouped by education and required a household's response in two subsequent year in order to be able to include the lagged transitory income shocks. We can see in column (1) that none of the found coefficients for those with lower education is significant, which would be consistent with the assumption of a serial uncorrelated transitory income shocks. However, when we look at the columns (2) and (3) we see that the coefficients for the lagged transitory income shocks are significant. This could imply serial correlation in the model as we specified it, which would hint at a misspecification of the income process for those with higher education, although the R^2 of both estimations is fairly low. However serial correlation could also be caused by irrational expectations of the households. Further research should look into more general income processes, such as those used by Blundell et al. (2015), Meghir and Pistaferri (2004). That research should investigate the existence of serial correlation in a panel data set which suffers less from attrition, and should perhaps also improve on our income process. For now, we will use the estimated transitory income

[2] Assume $\epsilon_{it} \sim IID(\bar{\epsilon}_t, \sigma_{\epsilon_i})$ then if $E_{t-1}[\bar{\epsilon}_t] \neq 0$ we can not have $E_{t-1}[\epsilon_{it}] = 0$, and therefore we must have $E_{t-1}[\bar{\epsilon}_t] = 0$.

TABLE 4.2: Regressions of the log of the magnitude of centered transitory income shocks (at the 2004 price level) on several household characteristics.

log (|Transitory Income Shock|)	OLS (1)	OLS (2)
Education × Income/1000		
Lower education	.02474 ***	.02133***
	(.001880)	(.002032)
Vocational college	.02541 ***	.02241***
	(.001708)	(.001806)
University	.02535 ***	.023091***
	(.001697)	(.001725)
Household size		.2803***
		(.05832)
Number of children		-.3029***
		(.06606)
Constant	6.373***	5.996***
	(.06067)	(.09915)
Observations	6020[a]	6020[a]
R^2	0.0626	0.0757

All standard errors are robust by clustering on the household level; [a] In this population sample we included respondents who did not answer the savings questions;
$^{*}\ p < 0.1$; $^{**}\ p < 0.05$; $^{***}\ p < 0.01$

shocks under the assumption of no serial correlation.

TABLE 4.3: Tests for serial correlation in the transitory income shocks.

Transitory Income Shock	OLS (1)	OLS (2)	OLS (3)
Education × Lagged Transitory Income Shocks			
Lower education	.03256		
	(.04669)		
Vocational college		.1559**	
		(.06240)	
University			.1493***
			(.04893)
Constant	10.50	-1077.6 ***	-44.95
	(190.1)	(272.8)	(323.8)
Observations	1264	818	591
R^2	0.0013	0.018	0.018

All standard errors are robust by clustering on the household level;
* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

4.3 Transitory Income Shocks and Saving Behavior

Now that we have estimated the transitory income shocks, we can continue to investigate the relationship between transitory income shocks and household saving behavior. Note that the actual level of saving is measured in classes, as was discussed in section 3.2, and the actual saving is not observed. Therefore we use an interval regression model. Moreover we take into account that the righthand-side variables might be correlated with an individual effect by including household specific averages of all time-varying variables in the regression (see Mundlak (1978) for a more detailed discussion on including such terms). Moreover, we are interested in the marginal propensity to consume out of transitory income shocks as compared to the marginal propensity to consume out of other component of income. Based on eq. (3.1), we will define *other income* $\tilde{Y}_{it}$ as the income net of transitory income, such that $\tilde{Y}_{it} = Y_{it} - \epsilon_{it}$. To summarize, we will estimate the following regression

$$s^*_{it} = x'_{it}\beta + \bar{x}'_i\gamma + \mu_{it}, \tag{4.4}$$

where s^*_{it} is the saving of household i in period t measured in classes, x_{it} is the vector of characteristic of household i in period t including at least transitory income shocks ϵ_{it} and the other income $\tilde{Y}_{it}$ with corresponding coefficients β, $\bar{x}_i$ are the time averages of all characteristics in x_{it} of household i with corresponding coefficients γ, and μ_{it} is a zero-mean normally distributed error term. To test our hypothesis of household individual effects, we will test for the joint significance of the coefficients in γ. If this test indicates joint significance, we find good evidence for existence of household individual effects.

Overall, the marginal propensities to save we found in the columns (1), (2), and (3) of table 4.4 are quite low compared to both our theoretical predications in section 2.2.2 and as well as to other recent empirical work on the response of Dutch households to transitory income shocks by Christelis et al. (2017). However, the coefficients are positive, which indicates more savings when the household has a positive transitory income shock. This is what we expected based on the theory in section 2.

In the estimation in column (1) we include only transitory income shocks and other income in x_{it}, the results of which can be seen in column (1) of table 4.4. We can see that households on average save slightly less out of transitory income shocks than out of other components of income. The coefficients we find are all lower than 0.1, which would imply that households save less than 10% of their income. These empirically found marginal propensities to save are certainty small compared to the marginal propensities we calculated in section 2.2.2 (figs. 2.1a and 2.1b) which were all close to one. Based on this we would reject our first hypothesis of saving rates which are constant and close to one, which was stated in section 2.2.2. However, the saving rates which we calculated included all savings, whereas the question in the DHS refers to the liquid savings. Specially, the question asked if the household had put money aside during the last year, as was discussed in section 3.2. Therefore households will almost certainly not have included other types of savings, such as pensions and real estate investments. This would explain why the saving rates we found empirically are significantly lower than the ones calculated in section 2.2.2.

When we continue to compare the behavior of households with different education levels by including interactions with education for both variables, we can see in column (2) that the coefficients remain small. There does exists a very pronounced difference between the households without higher education and those who did attend higher education. For the households with higher education we find that the coefficients of saving out of transitory income shocks are fairly similar to those of saving out of the other components of income. In contrast, the saving response to transitory income shocks of households without higher education is not significantly different from zero, whereas their saving response to the other components is fairly certain different from zero.

In section 2.2.2 we formulated the hypothesis that the marginal propensities to save should be the same for all components of income, which was based on the life-cycle model and eqs. (2.6) and (2.15). This now seems to be wrong for households with lower levels of education. The fact that the coefficients we found are all small should not matter; the coefficients should at least be similar. The difference can also not be explained by the alternative savings motives discussed in section 2.3, since precautionary savings, bequests, and hyperbolic discounting should all effect the marginal propensities in the same way. Therefore the difference between the marginal propensity to save out of transitory income shocks and the marginal propensity to save out of other income can not be created by these alternative motives.

In column (3) we can see the results of the estimation when we also control for the household composition and the age of the household. Although the differences with the results in column (2) are small, we do observe that the difference between the saving rate out of transitory income shocks and the saving rate out of other income grew further apart for households with lower education, while the estimated saving rates grew closer to each other for household with higher levels of education. Together, these findings provide evidence of a difference in transitory income saving behavior between households with different levels of education.

Finally, the controls in column (3) by themselves do not seem significant, but *age* and age^2 are jointly significant, as are the variables *Household size* and *Number of children*. The observation of a large increase in the log-pseudolikelihood also supports the inclusion of these controls. The inclusion of Mundlak terms is supported by the found Chi-square values for joint significance of all Mundlak terms. As these values are large for their respective number of degrees of freedom, we conclude that the Mundlak terms should indeed be included into the regression as household individual effects are likely present.

TABLE 4.4: Regressions of the household savings (at the 2004 price level) on several household characteristics using interval regression.

Savings	Interval (1)	Interval (2)	Interval (3)
Transitory Income Shock	.07291***		
	(.02100)		
Education × Transitory Income			
Vocational training or lower		.03246	.02944
		(.02705)	(.02741)
Vocational college		.08474***	.08773***
		(.02850)	(.02867)
University		.1177***	.1117**
		(.04557)	(.04501)
Other income	.09988***		
	(.02284)		
Education × Other Income			
Vocational training or lower		.08079***	.08025***
		(.02397)	(.02411)
Vocational college		.1020***	.1012***
		(.02990)	(.03097)
University		.1074*	.1055*
		(.05752)	(.05548)
Household size			-26.07
			(428.3)
Number of children			-30.25
			(515.1)
Age			106.3
			(214.2)
Age^2			.2058
			(2.21)
Constant	-2800.2***	-2347.1***	-925.9
	(486.8)	(448.7)	(2573.0)
$\chi^2_{mundlak}$	16.74***	18.36***	35.96***
Observations	5515	5515	5515
Log Pseudolikelihood	-9980	-9963	-9925

All standard errors are robust by clustering on the household level;
* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

5 Conclusion

In our research, we build on the research of Kovacs et al. (2018) by following their strategy for identifying transitory income shock in the DNB Household Survey. In their research, Kovacs et al. (2018) started by estimating the income process based on observable characteristics of individuals to determine the deterministic changes in income. Then Kovacs et al. (2018) used the current income, the expected income, and the expected income growth to estimate transitory income shocks. We extend their identification strategy by aggregating individual respondents into their respective households, which allows us to include household characteristics as explanatory variables in the income process. We also extend their income process by allowing for different income processes based on the household level of education, in which we follow Blundell et al. (2015). In section 4.1 we use these methodologies to we estimate coefficients for the time-varying deterministic components of the income process, and our estimates are consistent with Blundell et al. (2015) and Kovacs et al. (2018).

Using the estimated coefficients to account for the expected income grow, we calculate the transitory income shocks in section 4.2. We do this in the same way Kovacs et al. (2018) did. While the expected value of transitory income shocks is zero, we find that the actual distribution of transitory income shocks are not zero-mean, and find evidence that the actual mean is correlated with the level of education. After centering the distributions by education level, we show that the magnitude of transitory income shocks increases with income. In our underlying model, we assume that the transitory income shocks are serially uncorrelated, and using the data we test this hypothesis. We find evidence that there is some serial correlation in our current model, which could imply a misspecification of the income process. Further research should therefore look into more general income processes, for example the MA(q) process with $q > 1$ for transitory income shocks, as was used by Blundell et al. (2015), Meghir and Pistaferri (2004). However serial correlation could also be caused by irrational expectations of the households. Due to panel attrition we are left with a limited sample when we have to consider lagged transitory income shocks. This makes more in-depth research based on our data and sample difficult. Therefore we use the transitory income shocks as we estimated, and further research could perhaps improve on these estimates, either by using a larger panel data set or by using a data set that suffers less from panel attrition.

In section 4.3, we find evidence that households with lower levels of education do not save out of transitory income shocks. Their saving rate for income without transitory income shocks, which we will refer to as *other income*, was significantly different from zero and only slightly lower than those of households with higher levels of education. However, the saving rate found for transitory income of lower education households was not significantly different from zero and a lot lower than their saving rate for other income. In contrast, for households with higher levels of education we found a transitory income saving rate which is significantly different from zero and very close to their saving rate for other income. The difference in saving rate for lower education households can not be explained by the life-cycle model we used in section 2, even when including precautionary savings, bequests, and hyperbolic discounting. This is because the life-cycle model as we implemented it predicts that the marginal propensities to save should be the same for all components of income.

Further research has to be conducted to determine why lower education households seem to respond less to transitory income shocks than other income components, especially when compared to higher education households. Liquidity constraints have been shown to prohibit consumption smoothing and effect purchases of durable goods (Alessie, Devereux, & Weber, 1997; Zeldes, 1989). We suspect households with lower levels of education to me more borrowing constraint, which could cause a correlation between large (durable) expenditures and transitory income shocks, which in turn would explain why these households do not seem to have a saving response to transitory income shocks. Another factor could be differences in financial literacy, and therefore rational behavior and life-cycle planning. Differences in financial literacy based on the level of education have recently been shown to exists in the Netherlands by Alessie, Van Rooij, and Lusardi (2011).

The findings of our research contribute to the literature on the responses of economic agents to shocks in income and wealth. We have shown that the responses are not homogeneous within our sample, and find evidence that the level of education of economic agents is an important factor in studying the savings response of households. This is relevant to policy makers, for example in the design and implementation of pension system changes, because the same policy change could have vastly different effects for different households.

A Analytical Solutions for the Consumption of Households

A.1 Finitely Lived Households with Quadratic Utility under Income Uncertainty

In a life-cycle model, a household chooses an optimal consumption path in period t based on the current and expected future wealth. For a rational household under both income and lifetime uncertainty, the optimization problem can be stated by the following Bellman equation (see for example Zeldes (1989)):

$$V_t(x_t) = \max_{c_t, x_{t+1}} \left\{ u(c_t) + \beta E_t \left[V_{t+1}(x_{t+1}) \right] \right\}, \tag{A.1}$$

$$s.t. \qquad x_{t+1} = (1+r)(x_t - c_t) + y_{t+1}, \tag{A.2}$$

where $V_t(\cdot)$ is a recursive value function, x_t is the cash-on-hand available to the household in period t, c_t is the consumption in period t, $u(\cdot)$ is a state and time separable utility function, β is the intertemporal discount factor, E_t is the expectation operator formed by the information available to the household at time t, r is the interest rate against which the household can borrow and lend, and y_t is the income in period t. We can rewrite this as a Lagrangian with the objective functions as eq. (A.1) and set of contraints as eq. (A.2),

$$\mathcal{L} = u(c_t) + \beta E_t \left[V_{t+1}(x_{t+1}) \right] + \lambda_t \left[(1+r)(x_t - c_t) + y_{t+1} - x_{t+1} \right], \tag{A.3}$$

where λ_t is the Lagrange multiplier for period t. We can set the first derivative of $\mathcal{L}$ with respect to c_t equal to zero to find

$$u'(c_t) = \beta(1+r) E_t \left[V'_{t+1}(x_{t+1}) \right]. \tag{A.4}$$

As this has to hold for all periods, we can also immediately find

$$u'(c_{t+1}) = \beta(1+r)\psi_{t+1,t+2} E_t \left[V'_{t+2}(x_{t+2}) \right]. \tag{A.5}$$

Then, if we differentiate both sides of eq. (A.1) with respect to x_t we get

$$\begin{aligned} V_t'(x_t) &= u'(c_t)\frac{\partial c_t}{\partial x_t} + \beta(1+r)E_t\left[V_{t+1}'(x_{t+1})\right] \\ &\qquad - \beta(1+r)E_t\left[V_{t+1}'(x_{t+1})\right]\frac{\partial c_t}{\partial x_t} \\ &= \beta(1+r)E_t\left[V_{t+1}'(x_{t+1})\right], \end{aligned} \tag{A.6}$$

where the last equality follow from the fact that c_t is the optimal response given x_t (such that $c_t = c_t^*(x_t)$), and therefore if consumption is chosen optimally we have to have $\frac{\partial c_t}{\partial x_t} = 0$ because of the Envelope Theorem. Again, for period $t+1$ we can use the same technique to find

$$V_{t+1}'(x_{t+1}) = \beta\psi_{t+1,t+2}(1+r)E_{t+1}\left[V_{t+2}'(x_{t+2})\right]. \tag{A.7}$$

If we substitute eq. (A.5) into eq. (A.7), we find

$$V_{t+1}'(x_{t+1}) = u'(c_{t+1}), \tag{A.8}$$

which combined with eq. (A.4) gives us the stochastic Euler equation with lifetime uncertainty

$$u'(c_t) = \beta(1+r)E_t\left[u'(c_{t+1})\right]. \tag{A.9}$$

If we assume quadratic utility with bliss level of consumption $\bar{c}$ of the household

$$u(c_t) = \bar{c}c_t - \frac{1}{2}c_t^2, \tag{A.10}$$

we can use $u'(c_t) = \bar{c} - c_t$ to rewrite eq. (A.9) as

$$E_t\left[c_{t+1}\right] = \frac{1}{\beta(1+r)}c_t + \bar{c} - \frac{\bar{c}}{\beta(1+r)}. \tag{A.11}$$

Because of the law of iterated expectations (i.e. $E_t[E_{t+1}[c_{t+2}]] = E_t[c_{t+2}]$), and the fact that we can roll eq. (A.11) $s-t$ periods ahead with respect to period t to get a definition for c_s, which we find to be

$$E_{s-1}\left[c_s\right] = \frac{1}{\beta(1+r)}c_{s-1} + \bar{c} - \frac{\bar{c}}{\beta(1+r)}, \tag{A.12}$$

from which we can get a general definition for the expected consumption in period s from the perspective of period t as

$$\begin{aligned} E_t\left[c_s\right] &= E_t\left[E_{s-1}\left[c_s\right]\right] \\ &= E_t\left[\frac{1}{\beta(1+r)}c_{s-1} + \bar{c} - \frac{\bar{c}}{\beta(1+r)}\right] \\ &= \frac{1}{\beta(1+r)}E_t\left[c_{s-1}\right] + \bar{c} - \frac{\bar{c}}{\beta(1+r)} \\ &= \frac{1}{\beta(1+r)}E_t\left[\frac{1}{\beta(1+r)}c_{s-2} + \bar{c} - \frac{\bar{c}}{\beta(1+r)}\right] \\ &\quad + \bar{c} - \frac{\bar{c}}{\beta(1+r)} \\ &= \frac{1}{\beta^2(1+r)^2}E_t\left[c_{s-2}\right] + \bar{c} - \frac{\bar{c}}{\beta^2(1+r)^2} \\ &= \dots \\ &= \frac{1}{\beta^{s-t}(1+r)^{s-t}}E_t\left[c_t\right] + \bar{c} - \frac{\bar{c}}{\beta^{s-t}(1+r)^{s-t}} \\ &= \frac{1}{\beta^{s-t}(1+r)^{s-t}}(c_t - \bar{c}) + \bar{c}. \end{aligned} \tag{A.13}$$

If we now look at the lifetime budget constraint, which states that the sum of discounted expected consumption must be equal to the current savings A_t in period t plus the discounted sum of expected income:

$$\sum_{s=t}^{T} \frac{E_t(c_s)}{(1+r)^{s-t}} = A_t + \sum_{s=t}^{T} \frac{E_t(y_s)}{(1+r)^{s-t}}. \tag{A.14}$$

Using eq. (A.13) we can rewrite the left-hand side of eq. (A.14) to

$$\sum_{s=t}^{T} \frac{\frac{1}{\beta^{s-t}(1+r)^{s-t}}(c_t - \bar{c}) + \bar{c}}{(1+r)^{s-t}} = A_t + \sum_{s=t}^{T} \frac{E_t(y_s)}{(1+r)^{s-t}}, \tag{A.15}$$

from which we get

$$c_t \sum_{s=t}^{T} \frac{1}{\beta^{s-t}(1+r)^{2(s-t)}} = A_t + \sum_{s=t}^{T}\left[\frac{E_t(y_s)}{(1+r)^{s-t}} + \frac{\bar{c}}{\beta^{s-t}(1+r)^{2(s-t)}} - \frac{\bar{c}}{(1+r)^{s-t}}\right] \tag{A.16}$$

To be able to see the effects of income shocks, we will assume an income process which includes both a permanent and transitory component

$$y_t = p_t + \epsilon_t, \tag{A.17}$$

where p_t is the permanent income following a Markov process with mean zero i.i.d. income innovation ζ_t in period t

$$p_t = p_{t-1} + \zeta_t, \tag{A.18}$$

and ϵ_t is the mean zero i.i.d. transitory income shock in period t. We can use this income process in eq. (A.16) to get

$$c_t \sum_{s=t}^{T} \frac{1}{\beta^{s-t}(1+r)^{2(s-t)}} = A_t + \epsilon_t + \sum_{s=t}^{T} \left[\frac{p_t}{(1+r)^{s-t}} + \frac{\bar{c}}{\beta^{s-t}(1+r)^{2(s-t)}} - \frac{\bar{c}}{(1+r)^{s-t}} \right]. \tag{A.19}$$

If we divide by the summation of the left-hand side we are left to find a closed-form solution for consumption:

$$\begin{aligned} c_t = & \left[\sum_{s=t}^{T} \frac{1}{\beta^{s-t}(1+r)^{2(s-t)}} \right]^{-1} \\ & \times \left[A_t + \epsilon_t + \sum_{s=t}^{T} \left[\frac{p_t}{(1+r)^{s-t}} + \frac{\bar{c}}{\beta^{s-t}(1+r)^{2(s-t)}} - \frac{\bar{c}}{(1+r)^{s-t}} \right] \right]. \end{aligned} \tag{A.20}$$

A.2 Finitely Lived Households with CRRA Utility

If we instead would assume a income process with point expectations y_t we could rewrite the budget constraint eq. (A.2) in terms of wealth w_t in terms of cash-on-hand x_t and human capital h_t (the present value future income)

$$h_t = \sum_{s=t+1}^{T} \frac{y_s}{(1+r)^{s-t}} \rightarrow h_{t+1} = (1+r)h_t - y_{t+1}, \tag{A.21}$$

as

$$\begin{aligned} w_{t+1} &= x_{t+1} + h_{t+1} \\ &= (1+r)(x_t - c_t) + y_{t+1} + h_{t+1} \\ &= (1+r)(w_t - h_t - c_t) + y_{t+1} + h_{t+1} \\ &= (1+r)(w_t - h_t - c_t) + y_{t+1} + (1+r)h_t - y_t \\ &= (1+r)(w_t - c_t). \end{aligned} \tag{A.22}$$

Then our problem can be stated by the Bellman equation eq. (A.1) with point expectations and the budget constraint eq. (A.22) in terms of wealth as

$$V_t(w_t) = \max_{c_t, w_{t+1}} \{u(c_t) + \beta V_{t+1}(w_{t+1})\} \tag{A.23}$$

$$s.t. \qquad w_{t+1} = (1+r)(w_t - c_t). \tag{A.24}$$

Without uncertainty in the income process, we can find an recursive analytical solution for the marginal propensity to consume out of wealth when we assume utility with constant relative risk aversion (CRRA):

$$u(c_t) = \frac{c_t^{1-\theta}}{1-\theta}, \tag{A.25}$$

where theta is the relative risk aversion, such that $u'(c_t) = c_t^{-\theta}$. We first observe that, in absence of a bequest motive, in the final period of the lifetime of a consumer the optimal strategy is to consumer all wealth such that $c_T = w_T$. Then we can evaluate eq. (A.23) in period $T-1$ using eq. (A.22) as

$$\begin{aligned} V_{T-1}(w_{T-1}) &= \max_{c_{T-1},w_T} \left[u(c_{T-1}) + \beta V_T(w_T)\right] \\ &= \max_{c_{T-1},w_T} \left[\frac{c_{T-1}^{1-\theta}}{1-\theta} + \beta \frac{w_T^{1-\theta}}{1-\theta}\right] \\ &= \max_{c_{T-1}} \frac{1}{1-\theta}\left[c_{T-1}^{1-\theta} + \beta((1+r)(w_{T-1}-c_{T-1}))^{1-\theta}\right]. \end{aligned} \tag{A.26}$$

We can take the first derivative of this value function with respect to C_{T-1} as set it equal to zero to find an expression for the consumption in period $T-1$ as

$$\begin{aligned} &c_{T-1}^{-\theta} - \beta((1+r)(w_{T-1}-c_{T-1}))^{-\theta}(1+r) = 0 \\ &c_{T-1} = (1+r)(\beta(1+r))^{-\frac{1}{\theta}}(w_{T-1}-c_{T-1}) \\ &c_{T-1} = (\beta(1+r)^{1-\theta})^{-\frac{1}{\theta}}(w_{T-1}-c_{T-1}) \\ &c_{T-1}(1+(\beta(1+r)^{1-\theta})^{-\frac{1}{\theta}}) = (\beta(1+r)^{1-\theta})^{-\frac{1}{\theta}} w_{T-1} \\ &c_{T-1} = \frac{(\beta(1+r)^{1-\theta})^{-\frac{1}{\theta}}}{1+(\beta(1+r)^{1-\theta})^{-\frac{1}{\theta}}} w_{T-1} \\ &c_{T-1} = \frac{b_{T-1}}{1+b_{T-1}} w_{T-1} = m_{T-1} w_{T-1}, \end{aligned} \tag{A.27}$$

where

$$b_{T-1} = \left(\beta(1+r)^{1-\theta}\right)^{-\frac{1}{\theta}}, \tag{A.28}$$

and the marginal propensity to consume out of wealth in period $T-1$ is

$$m_{T-1} = \frac{b_{T-1}}{1+b_{T-1}}. \tag{A.29}$$

Similarly for period $T-2$ we can write

$$\max_{c_{T-2},c_{T-1},c_T} \left[\frac{c_{T-2}^{1-\theta}}{1-\theta} + \beta\psi_{T-2,T-1}\left[\frac{c_{T-1}^{1-\theta}}{1-\theta} + \beta\left[\frac{c_T^{1-\theta}}{1-\theta}\right]\right]\right]. \tag{A.30}$$

However, we have just found an expression for c_{T-1} in eq. (A.27) and we know that $c_T = w_T$, and therefore we can rewrite eq. (A.30) as

$$\begin{aligned}
&\max_{c_{T-2},c_{T-1},c_T} \frac{1}{1-\theta}\left[c_{T-2}^{1-\theta} + \beta\psi_{T-2,T-1}\left[c_{T-1}^{1-\theta} + \beta\left[c_T^{1-\theta}\right]\right]\right] \\
&= \max_{c_{T-2},c_{T-1},w_{T-1}} \frac{1}{1-\theta}\left[c_{T-2}^{1-\theta} + \beta\psi_{T-2,T-1}\left[m_{T-1}^{1-\theta}w_{T-1}^{1-\theta} + \beta\left[((1+r)(w_{T-1}-c_{T-1}))^{1-\theta}\right]\right]\right] \\
&= \max_{c_{T-2},c_{T-1},w_{T-1}} \frac{1}{1-\theta}\left[c_{T-2}^{1-\theta} + \beta\psi_{T-2,T-1}\left[m_{T-1}^{1-\theta}w_{T-1}^{1-\theta} + b_{T-1}^{-\theta}(w_{T-1}-c_{T-1})^{1-\theta}\right]\right] \\
&= \max_{c_{T-2},c_{T-1},w_{T-1}} \frac{1}{1-\theta}\left[c_{T-2}^{1-\theta} + \beta\psi_{T-2,T-1}\left[m_{T-1}^{1-\theta}w_{T-1}^{1-\theta} + b_{T-1}^{-\theta}(1-m_{T-1})^{1-\theta}w_{T-1}^{1-\theta}\right]\right] \\
&= \max_{c_{T-2},w_{T-1}} \frac{1}{1-\theta}\left[c_{T-2}^{1-\theta} + \beta\psi_{T-2,T-1}w_{T-1}^{1-\theta}\left[m_{T-1}^{1-\theta} + b_{T-1}^{-\theta}(1-m_{T-1})^{1-\theta}\right]\right].
\end{aligned} \tag{A.31}$$

One can easily show that $m_{T-1}^{1-\theta} + b_{T-1}^{-\theta}(1-m_{T-1})^{1-\theta} = m_{T-1}^{\theta}$, and if we define b_{T-2} similar to eq. (A.28), we can use this in eq. (A.31) to get

$$\begin{aligned}
&\max_{c_{T-2},w_{T-1}} \frac{1}{1-\theta}\left[c_{T-2}^{1-\theta} + \beta\psi_{T-2,T-1}m_{T-1}^{\theta}w_{T-1}^{1-\theta}\right] \\
&= \max_{c_{T-2}} \frac{1}{1-\theta}\left[c_{T-2}^{1-\theta} + \beta\psi_{T-2,T-1}m_{T-1}^{\theta}((w_{T-2}-c_{T-2})(1+r))^{1-\theta}\right] \\
&= \max_{c_{T-2}} \frac{1}{1-\theta}\left[c_{T-2}^{1-\theta} + b_{T-2}^{-\theta}m_{T-1}^{\theta}(w_{T-2}-c_{T-2})^{1-\theta}\right].
\end{aligned} \tag{A.32}$$

By taking the derivative with respect to c_{T-2} and following steps similar to eq. (A.27), we can find an expression for c_{T-2} as

$$c_{T-2} = \frac{b_{T-2}m_{T-1}}{1+b_{T-2}m_{T-1}}w_{T-2} = m_{T-2}w_{T-2}. \tag{A.33}$$

From this we can see that marginal propensity to consume can recursively be written as

$$m_t = \begin{cases} 1 & t = T \\ \frac{b_t m_{t+1}}{1+b_t m_{t+1}} & t < T \end{cases}, \tag{A.34}$$

where

$$b_t = \left(\beta(1+r)^{1-\theta}\right)^{-\frac{1}{\theta}}. \tag{A.35}$$

B The DNB Household Survey

B.1 Imputing Income Expectations

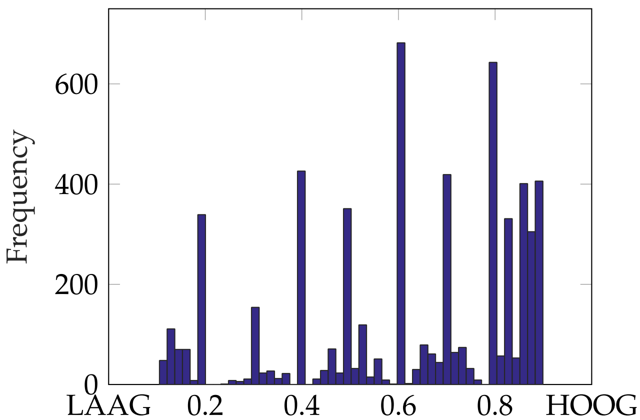


FIGURE B.1: The distribution of normalized income expectations on the interval provided by respondents.

year	mean	median	obs
2008	.625	.65	538
2009	.598	.6	552
2010	.602	.6	541
2011	.609	.6	507
2012	.610	.65	514
2013	.599	.6	447
2014	.571	.6	500
2015	.606	.6	551
2016	.596	.6	524
2017	.595	.6	565
2018	.801	.857	500

TABLE B.1: Descriptive statistics of normalized income expectations on the interval provided by respondents by year.

The DNB Household Survey does not directly ask respondents about their income expectation for the next year, but instead asks for an interval of possible incomes [LAAG,HOOG] for the next year (see questions LAAG/HOOG below), and then continues to ask respondents to give a probability that the actual income might be in one of four sub-intervals (see questions PROB1-4 below). It is important to understand that we will assume the respondent to have given a 0% chance to the income being lower than the answer to LAAG, and a 100% chance to the income being lower than HOOG. To impute the expected income, we assume that the probability increases linearly on the interval between two of the probabilities provided by the respondent (e.g. if the respondent gives a 20% probability to the income being lower than 12.000 € and a probability of 50% to the income being lower than 14.000 €, we will assume that the probability that the income is lower than 13.000 € is 35%). This allows us to find the expected income such that we have a 50% probability that the income will be lower. In the case that two subsequent probabilities were answered with 50% we will choose the middle of the interval defined by these two probabilities.

Unfortunately, not all respondents were able to assign consistent probabilities to the different subintervals. To still be able to impute an expected income for these respondents, we normalized the expected income of the household who did give consistent answers on the interval [LAAG,HOOG]. The distribution of these normalized expected incomes and some descriptive statistics can be seen in fig. B.1 and table B.1. Based on these findings we chose to impute the value at 60% of the interval [LAAG,HOOG] for all households who did not give consistent answers. The final distribution of the expected incomes can be seen in fig. B.2, where we also compare the distribution to the current income. We can see that the distribution are fairly similar, which is what we would expect from the distribution of expected income.

2004 - 2007

LAAG

We would like to know a little bit more about what you expect will happen to the net income of your household in the next 12 months.

What do you expect to be the LOWEST total net monthly income your household may realize in the next 12 months? Please use digits only, no dots or comma's.

HOOG

What do you expect to be the HIGHEST total net income your household may realize in the next 12 months?

2008-2018

LAAG

We would like to know a little bit more about what you expect will happen to the net income of your household in the next 12 months.

What do you expect to be the **lowest** total net yearly income your household may realize in the next 12 months? Please use digits only, no dots or comma's.

HOOG

What do you expect to be the **highest** total net yearly income your household may realize in the next 12 months?

2004-2018

PRO1-4

Below, we will show you a number of amounts that could theoretically be the total net income of your household. Please indicate with each amount what you think is the probability (in percentages (or how many cases out of 100)) that the total net yearly income of your household will be **less** than this amount in the next 12 months.

What do you think is the probability (in percent) that the net yearly income of your household will be less than € [LAAG+((HOOG-LAAG)*2*[1-4])/10] in the next 12 months?

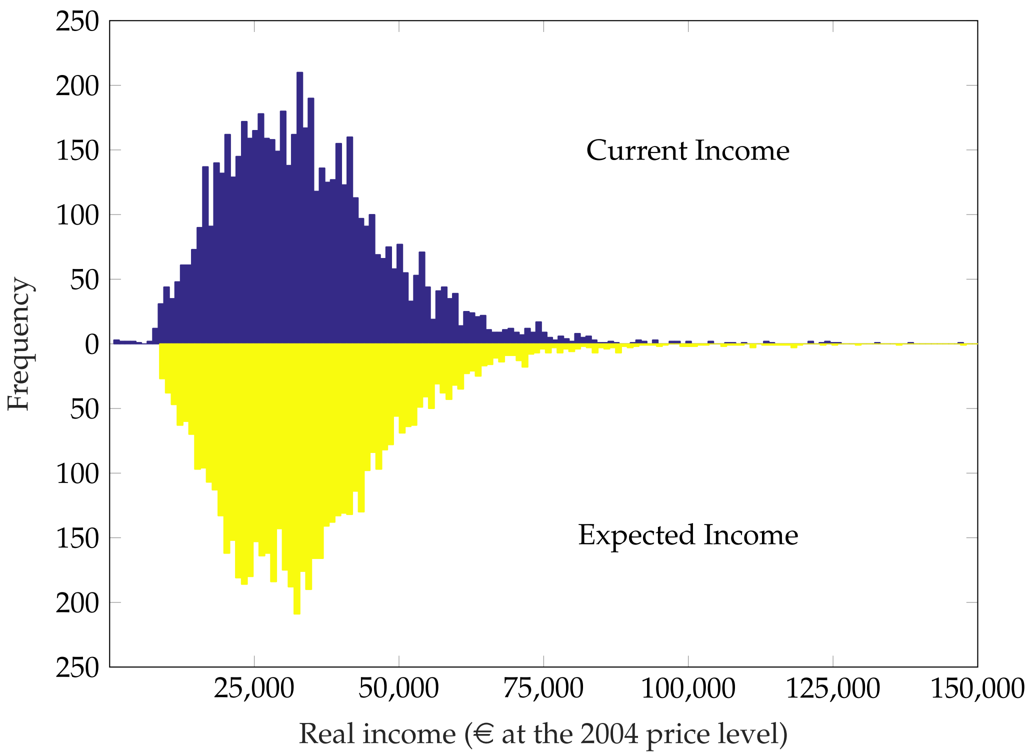


FIGURE B.2: The histogram of the current (upper half) and expected (lower half) income of the households in our sample. For graphical convenience we cut of the histogram at € 150,000.

B.2 Questions on Household Income, Saving, and Education and Summary Statistics

2004 - 2018

IN49A

How much was your taxable income for [YEAR - 1]? We mean your joint income for your tax form.

amount

-9 don't know

2004 - 2010

IN49A

What is the total net income for your household in [YEAR - 1]?

don't know

amount

2011 - 2018

IN49A

What is the total net income **for your household** in [YEAR - 1]?

The total net income for your household is the net income of all household members combined. Net income means the income after deduction of taxes and social security benefits.

amount

-9 don't know

2004 - 2018

OPZIJ

Did your household put any money aside in the past 12 months?

1 yes

2 no

2004-2014

HOEVOPZY

About how much money has your household put aside in the past 12 months?

1 less than € 1,500
2 between € 1,500 and € 5,000
3 between € 5,000 and € 12,500
4 between € 12,500 and € 20,000
5 between € 20,000 and € 37,500
6 between € 37,500 and € 75,000
7 € 75,000 or more
-9 don't know

2015-2018

HOEVSPA

About how much money has your household [if OPZIJ=1: put aside/if OPZIJ=2: cashed from savings accounts] in the past 12 months?

1 less than € 1,500
2 between € 1,500 and € 5,000
3 between € 5,000 and € 12,500
4 between € 12,500 and € 20,000
5 between € 20,000 and € 37,500
6 between € 37,500 and € 75,000
7 € 75,000 or more
-9 don't know

2004-2018

OPLMET

Highest level of education completed

1 (Voortgezet) speciaal onderwijs / (continued) special education
2 Kleuter-, lager- of basisonderwijs / kindergarten/primary education
3 Voorbereidend middelbaar beroepsonderwijs (VMBO) / pre-vocational education
4 HAVO/VWO / pre-university education
5 MBO of het leerlingwezen / senior vocational training or training through apprentice system
6 HBO (eerste of tweede fase) / vocational colleges
7 Wetenschappelijk onderwijs WO / university education
8 Did not have education (yet)
9 other sort of education/training

TABLE B.2: Descriptive statistics on the sample population of households.

	total	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Observations	5515	225	211	196	187	447	440	421	391	387	349	437	458	456	473	437
Education																
Vocational training or lower	2762	124	107	98	97	246	239	211	195	188	148	178	231	202	256	242
Vocational college	1643	61	68	61	52	125	118	136	114	118	128	156	133	139	122	112
University	1110	40	36	37	38	76	83	74	82	81	73	103	94	115	95	83
Age																
21-29	235	14	15	15	5	11	11	4	7	10	21	24	19	24	26	29
30-39	1203	65	54	46	56	105	90	68	63	54	85	115	83	116	110	93
40-49	1295	54	54	42	38	91	98	91	78	94	73	120	120	104	129	109
50-59	1580	57	62	60	62	142	145	139	127	121	91	97	130	106	114	127
60-65	1202	35	26	33	26	98	96	119	116	108	79	81	106	106	94	79
Number of adults																
1	1354	44	40	47	48	108	114	95	101	94	79	89	103	109	144	139
2	4092	181	169	149	137	336	324	323	284	286	266	341	351	342	316	287
3+	69	0	2	0	2	3	2	3	6	7	4	7	4	5	13	11
Household size																
1	1200	44	34	41	40	96	108	85	87	81	67	76	92	100	128	121
2	2132	94	86	76	69	177	164	185	166	158	142	150	161	169	166	169
3	694	22	21	24	21	44	50	54	55	50	45	63	74	64	52	55
4+	1489	65	70	55	57	130	118	97	83	98	95	148	131	123	127	92

TABLE B.3: In this table we show the in which years (vertical) the households in subsamples of each year (horizontal) responded. Therefore, the number on the diagonal represent the total number of households in the subsample of a specific year.

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
2004	225	68	56	47	89	77	58	51	51	38	43	44	33	26	25
2005		211	72	59	86	88	63	62	50	34	38	43	33	34	28
2006			196	58	105	83	60	61	50	48	47	45	39	35	31
2007				187	106	91	82	70	66	55	47	51	45	42	38
2008					447	245	195	174	158	129	126	125	98	83	80
2009						440	211	195	172	130	137	134	107	97	90
2010							421	197	171	135	136	129	111	105	83
2011								391	205	166	162	149	124	118	98
2012									387	187	171	154	133	118	111
2013										349	172	146	124	108	91
2014											437	213	184	163	135
2015												458	236	214	179
2016													456	234	199
2017														473	247
2018															437

C Income and Transitory Income Shocks

C.1 Income Process

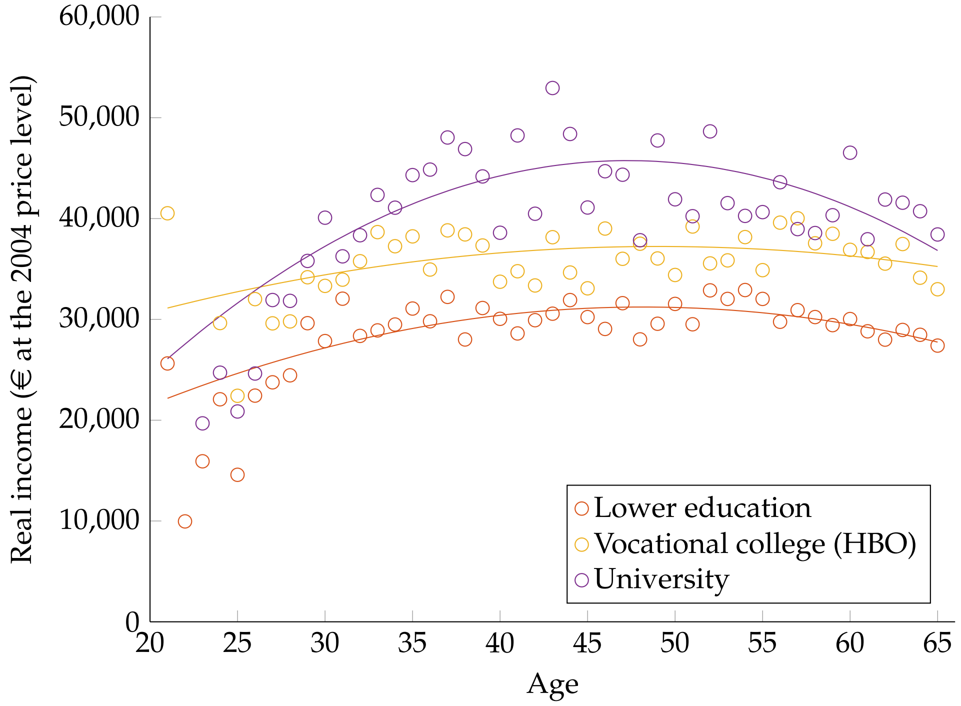


FIGURE C.1: The observed average real income at different ages by education level, and the fitted polynomials by education level.

C.2 Transitory Income Shocks

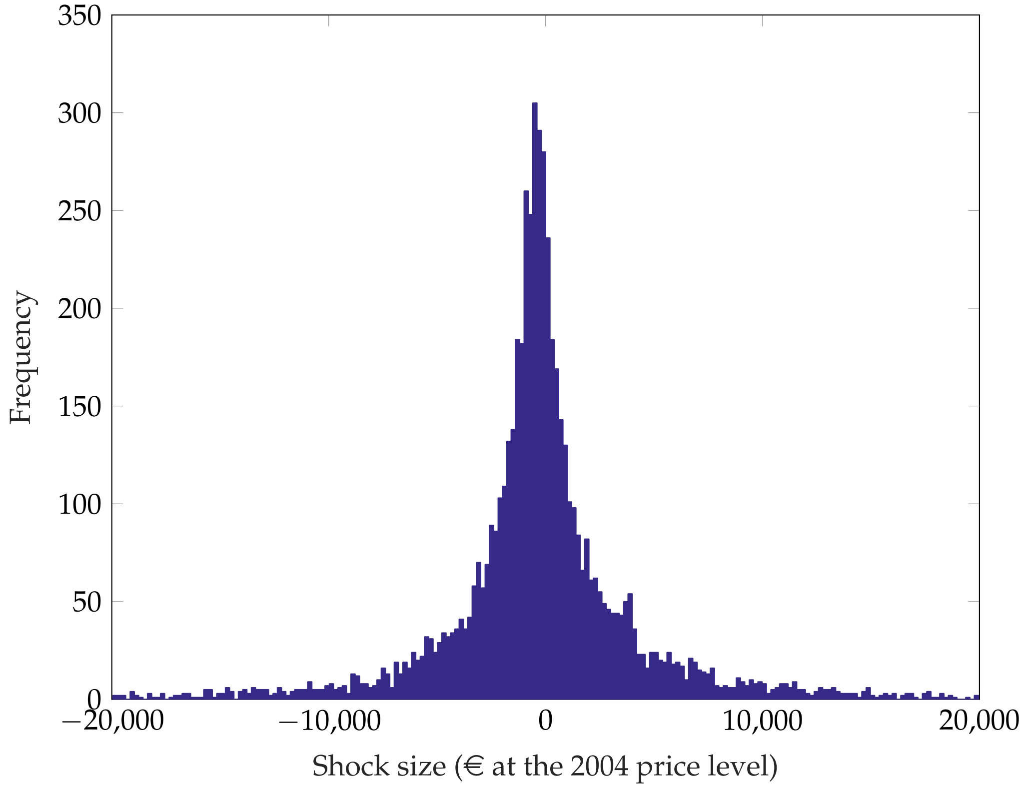


FIGURE C.2: The distribution of transitory income shock by size of the shock. Shocks with magnitudes larger than € 20.000 have been observed but are not displayed for graphical convenience.

TABLE C.1: Correlations between the average transitory income shocks per year by education level.

	$\bar{\epsilon}_t^{(low)}$	$\bar{\epsilon}_t^{(col)}$	$\bar{\epsilon}_t^{(uni)}$
$\bar{\epsilon}_t^{(low)}$	1.0000	0.3001	0.1032
$\bar{\epsilon}_t^{(col)}$		1.0000	0.4758
$\bar{\epsilon}_t^{(uni)}$			1.0000

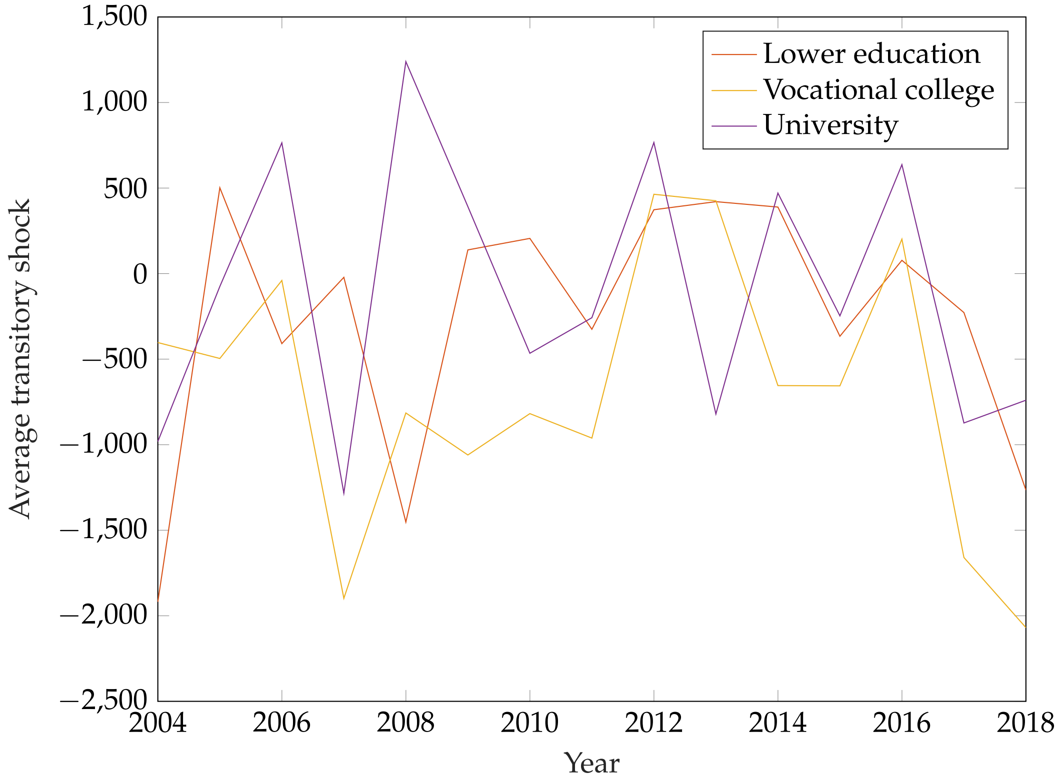


FIGURE C.3: The average transitory income shock per year by education level.

Bibliography

Alessie, R. J. M., Devereux, M. P., & Weber, G. (1997). Intertemporal consumption, durables and liquidity constraints: A cohort analysis. *European Economic Review*, *41*(1), 37–59. doi:10.1016/0014-2921(95)00128-X

Alessie, R. J. M., & Lusardi, A. (1997). Consumption, saving and habit formation. *Economics Letters*, *55*(1), 103–108. doi:10.1016/S0165-1765(97)00061-X

Alessie, R. J. M., & Teppa, F. (2010). Saving and habit formation: Evidence from Dutch panel data. *Empirical Economics*, *38*(2), 385–407. doi:10.1007/s00181-009-0272-z

Alessie, R. J. M., Van Rooij, M., & Lusardi, A. (2011). Financial literacy and retirement preparation in the Netherlands. *Journal of Pension Economics and Finance*, *10*(4), 527–545. doi:10.1017/S1474747211000461

Arrow, K. J. (1965). *Aspects of the theory of risk-bearing*.

Attanasio, O. P., & Weber, G. (1995). Is Consumption Growth Consistent with Intertemporal Optimization? Evidence from the Consumer Expenditure Survey. *Journal of Political Economy*, *103*(6), 1121–1157. doi:10.1086/601443

Barro, R. J. (1974). Are Government Bonds Net Wealth? *Journal of Political Economy*, *82*(6), 1095–1117. doi:10.1086/260266

Ben-Porath, Y. (1967). The Production of Human Capital and the Life Cycle of Earnings. *The Journal of Political Economy*, *75*(4), 352–365. doi:10.1086/259291

Bernheim, B. D., Shleifer, A., & Summers, L. H. (1986). The Strategic Bequest Motive. *Journal of Labor Economics*, *4*(3, Part 2), S151–S182. doi:10.1086/298126

Blundell, R., Graber, M., & Mogstad, M. (2015). Labor income dynamics and the insurance from taxes, transfers, and the family. *Journal of Public Economics*, *127*, 58–73. doi:10.1016/j.jpubeco.2014.04.011

Brown, J. R. (2001). Private pensions, mortality risk, and the decision to annuitize. *Journal of Public Economics*, *82*(1), 29–62. doi:10.1016/S0047-2727(00)00152-3

Browning, M., & Crossley, T. F. (2001). The Life-Cycle Model of Consumption and Saving. *Journal of Economic Perspectives*, *15*(3), 3–22. doi:10.2307/1883282

Browning, M., & Lusardi, A. (1996). Household Saving: Micro Theories and Micro Facts. *Journal of Economic Literature*, *34*(4), 1797–1855. Retrieved from http://www.jstor.org/stable/2729595

Caballero, R. J. (1990). Consumption puzzles and precautionary savings. *Journal of Monetary Economics*, *25*(October 1989), 113–136. doi:10.1016/0304-3932(90)90048-9

Carroll, C. D. (1994). How does Future Income Affect Current Consumption? *The Quarterly Journal of Economics*, *109*(1), 111–147. doi:10.2307/2118430

Carroll, C. D. (1997). Buffer-Stock Saving and the Life Cycle/Permanent Income Hypothesis. *The Quarterly Journal of Economics*, *112*(1), 1–55. doi:10.1108/ilds.2002.12230dab.004

Christelis, D., Georgarakos, D., Jappelli, T., Pistaferri, L., & van Rooij, M. (2017). Asymmetric Consumption Effects of Transitory Income Shocks. *Ssrn*, (551). doi:10.2139/ssrn.2914247

Davies, J. B. (1981). Uncertain Lifetime, Consumption, and Dissaving in Retirement. *Journal of Political Economy*, *89*(3), 561–577. doi:10.1086/260986

Deaton, A. (1991). Saving and Liquidity Constraints. *Econometrica*, *59*(5), 1221–1248. doi:10.3386/w3196

Drazen, A. (1978). Government Debt, Human Capital, and Bequests in a Life-Cycle Model. *Journal of Political Economy*, *86*(3), 505–516. doi:10.1086/260684

Dynan, K. E., Skinner, J., & Zeldes, S. P. (2002). The Importance of Bequests and Life-Cycle Saving in Capital Accumulation: A New Answer. *American Economic Review*, *92*(2), 274–278. doi:10.1257/000282802320189393

Frederick, S., Loewenstein, G., & O'Donoghue, T. (2002). Time Discounting and Time Preference: A Critical Review. *Journal of Economic Literature*, *40*(2), 351–401. doi:10.2307/j.ctvcm4j8j.11

Friedman, M. (1957). The Permanent Income Hypothesis. In *A theory of the consumption function* (pp. 20–37). doi:10.2307/3438865

Guariglia, A., & Rossi, M. (2002). Consumption, habit formation, and precautionary saving: evidence from the British Household Panel Survey. *Oxford Economic Papers*, *54*(1), 1–19. doi:10.1093/oep/54.1.1

Hall, R. E. (1978). Stochastic Implications of the Life Cycle-Permanent Income Hypothesis: Theory and Evidence. *Journal of Political Economy*, *86*(6), 971–987. doi:10.1086/260724

Heckman, J. J. (1976). A Life-Cycle Model of Earnings, Learning, and Consumption. *Journal of Political Economy*, *84*(4), S9–S44. doi:10.1086/260531

Hochguertel, S. (2003). Precautionary motives and portfolio decisions. *Journal of Applied Econometrics*, *18*(1), 61–77. doi:10.1002/jae.658

Hurd, M. D. (1989). Mortality Risk and Bequests. *Econometrica*, *57*(4), 799–813.

Jappelli, T., & Pistaferri, L. (2010). The Consumption Response to Income Changes. *Annual Review of Economics*, *2*, 479–506. doi:10.2139/ssrn.1716786. arXiv: arXiv:1011.1669v3

Keynes, J. M. (1936). *The General Theory of Employment, Interest and Money*. doi:10.4337/roke.2016.01.07

Kimball, M. S. (1990). Precautionary Saving in the Small and in the Large. *Econometrica*, *58*(1), 53–73. doi:10.3386/w2848

Kotlikoff, L. J. (1986). *Health Expenditures and Precautionary Savings*. doi:10.3386/w2008

Kotlikoff, L. J., & Summers, L. H. (1981). The Role of Intergenerational Transfers in Aggregate Capital Accumulation. *Journal of Political Economy*, *89*(4), 706–732. doi:10.1086/260999

Kovacs, A., Rondinelli, C., & Trucchi, S. (2018). *Permanent versus Transitory Income Shocks over the Business Cycle*.

Laibson, D. (1997). Golden Eggs and Hyperbolic Discounting. *The Quarterly Journal of Economics*, *112*(2), 443–477. doi:10.2307/j.ctvcm4j8j.20

Lockwood, L. M. (2018). Incidental Bequests : Bequest Motives and the Choice to Self-Insure Late-Life Risks. *American Economic Review*, *108*(9), 2513–2550.

Mankiw, N. G., Reis, R., & Wolfers, J. (2003). Disagreement About Inflation Expectations. *NBER macroeconomics annual*, *18*, 209–248. doi:10.2139/ssrn.417602

Mariger, R. P. (1987). A Life-Cycle Consumption Model with Liquidity Constraints: Theory and Empirical Results. *Econometrica*, *55*(3), 533–557. doi:10.2307/1913599

Meghir, C., & Pistaferri, L. (2004). Income Variance Dynamics and Heterogeneity. *Econometrica*, *72*(1), 1–32. doi:10.1111/j.1468-0262.2004.00476.x

Modigliani, F., & Brumberg, R. (1954). Utility analysis and the consumption function: an interpretation of cross-section data. *Franco Modigliani*, *1*, 388–436. doi:10.1057/9780230582439

Mundlak, Y. (1978). On the Pooling of Time Series and Cross Section Data. *Econometrica*, *46*(1), 69. doi:10.2307/1913646

Pistaferri, L. (2001). Superior Information, Income Shocks, And The Permanent Income Hypothesis. *The Review of Economics and Statistics*, *83*(3), 465–476. doi:10.2307/j.ctv39x7zh.6

Pratt, J. W. (1964). Risk aversion in the small and in the large. *Econometrica*, *32*(1/2), 122–136. doi:10.1142/9789814417358_0019

Samuelson, P. A. (1937). A Note on Measurement of Utility. *The Review of Economic Studies*, *4*(2), 155–161. doi:10.2307/2967612

Shefrin, H. M., & Thaler, R. H. (1988). The Behavioral Life-Cycle Hypothesis. *Economic Inquiry*, *26*(4), 609–643. doi:10.1111/j.1465-7295.1988.tb01520.x

Skinner, J. (1988). Risky Income, Life Cycle Consumption, and Precautionary Savings. *Journal of Monetary Economics*, *22*(2), 237–255. doi:10.1016/0304-3932(88)90021-9

Spence, M. (1973). Job Market Signaling. *The Quarterly Journal of Economics*, *87*(3), 355–374. doi:10.2307/1882010

Teppa, F., & Vis, C. (2012). The CentERpanel and the DNB Household Survey: Methodological Aspects. *DNB Occasional Studies*, *10*(4), 1–53. Retrieved from https://www.dnb.nl/binaries/DNB%7B%5C_%7DOS%7B%5C_%7D1004%7B%5C_%7DBIN%7B%5C_%7DWEB%7B%5C_%7Dtcm46-277691.pdf

Thaler, R. H. (1981). Some Empirical Evidence on Dynamic Inconsistency. *Economics Letters*, *8*(3), 201–207. doi:10.1016/0165-1765(81)90067-7

Wilhelm, M. O. (1996). Bequest Behavior and the Effect of Heirs' Earnings: Testing the Altruistic Model of Bequests. *American Economic Review*, *86*(4), 874–892. Retrieved from https://www.jstor.org/stable/2118309

Yaari, M. E. (1965). Uncertain Lifetime, Life Insurance, and the Theory of the Consumer. *The Review of Economic Studies*, *32*(2), 137–150. doi:10.2307/2296058

Zeldes, S. P. (1989). Consumption and Liquidity Constraints: An Empirical Investigation. *Journal of Political Economy*, *97*(2), 305–346. doi:10.1086/261605