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Davud Rostam-Afschar

Labor Income Risk and Consumption/Saving Behavior

by

Davud Rostam-Afschar

Berlin, 2015

The search for a reason is the reason to research.

Research, though, is to search with reason.

Is the researched reason the reason we

Searched, the reason in our research,

Or the reason to research?

Nihil est sine

Ratione.

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1 Preface

1.1. Purpose

To explain observed economic inequality has been the motivation of great efforts since the early times of economic thought. The nature of inequality is of such unabated interest because not only economists are obsessed to think about it but also policy makers, lawyers, sociologists, and philosophers. Often with the aim to find robust mechanics which can be used to reform the social architecture to change the level of inequality and eventually increase some sense of efficiency (Mirrlees et al. (2011), Bach et al. (2014), Piketty (2014)). The purpose of this thesis is to contribute to our understanding of these mechanics.

To be conclusive, this endeavor requires of course the use of data, for instance provided by the widely used German socio-economic panel (GSOEP)[1] or collected in laboratory experiments to meet specific requirements, both of which was done for this thesis. On the household level, economic inequality is usually defined in terms of annually measured income, wealth or consumption. The cross-sectional distributions of these variables were continuously studied from the time when statistics became available (e.g. Kuznets and Jenks (1953)) until recently (e.g. Carroll (2000); Bach et al. (2009); Blundell and Etheridge (2010); Carroll et al. (2014)).

At the same time several groundbreaking findings in economic theory sharpened our understanding of the determinants of economic inequality. A particularly vibrant literature[2] that has evolved, usually focuses attention to uninsured risk[3] from labor

[1] In all chapters GSOEP refers to the 100 percent research sample of German Socio-Economic Panel (SOEP).

[2] See Deaton (1992) and Attanasio (1999) for reviews.

[3] Throughout I use uncertainty interchangeably to risk to refer to measurable uncertainty (Knight (1921)).

income since micro data reject the assumption of complete markets, i.e. that consumption is fully insured against labor income risk (e.g. Attanasio and Davis (1996)). With a special focus on policy implications, this thesis studies some important mechanics that generate economic inequality in the tradition of this literature which combines advances in the theory of consumption behavior and the literature on the estimation of stochastic processes of income.

In particular, this thesis addresses methodological issues on how to quantify precautionary savings in micro data (Chapter 2), how much we can trust Ricardian Equivalence, a fundamental principle of economics, (Chapter 3), whether distortionary effects of progressive taxation on saving are offset by its insurance effect (Chapter 4), and finally, how a reform of means-tested benefits for unemployed in Germany affected precautionary saving (Chapter 5). Following studies on consumption and income inequality like Blundell et al. (2008), I go back to the permanent income hypothesis and use modern versions in my analysis.

In his treatise *A Theory of the Consumption Function* (Friedman (1957)), Friedman linked consumption, income and wealth in the permanent income hypothesis (PIH) that may be summarized as follows: consumption is equal to the annuity value of total wealth given by the sum of financial wealth, i.e. cumulative savings, and human wealth, defined as the discounted expected value of future income. This relationship is the common theme of all chapters of this dissertation.

Friedman distinguished two kinds of income, permanent and transitory, but intentionally left the definitions of these components somewhat vague. Parts of this thesis refer to a specification of a component determined by aging, training, occupation, ability, etc. and two uninsurable, random parts: one lasting a single time period (often interpreted as illness, a bad guess about when to buy or sell, bad weather etc.), and the other lasting through all subsequent periods (e.g. promotions, some health shocks). This resembles the hypothesis concerning permanent and transitory components of income advanced by Friedman but is not exactly the same (Muth (1960)). Moreover, this specification or slight variations are widely used in related literature, for instance Abowd and Card (1989); Meghir and Pistaferri (2004); Biewen (2005); Myck et al. (2011)).

The link between consumption, income and wealth in the simplest early models under certainty imply that consumption is smoothed over the life cycle and does not track current income but depends on preferences and lifetime resources. Hall (1978) generalized this insight to the stochastic case using time separable quadratic utility. This implies, however, that households only save to smooth consumption and do not engage in precautionary saving because the expectation of marginal utility is the marginal utility of the expectation in this case.

This restrictive prediction is rejected by the data (e.g. Flavin (1981)) and relaxed with more realistic assumptions on preferences, in particular, marginal utility is specified to be convex to allow for precautionary saving. Leland (1968), Sandmo (1970), and Drèze and Modigliani (1972) were among the earliest works on precautionary savings. Kimball (1990) proposed prudence as measure of the strength of the precautionary motive which is defined by the elasticity of the slope of marginal utility.

Much of this dissertation assumes rational and prudent households to asses the importance of precautionary behavior empirically. For prudent households not only the marginal utility of consumption is higher when consumption is low, but also the *rate* at which the marginal valuation rises when consumption falls is greater when consumption is low than when it is high (Deaton (1992)). This implies that households react to increases in uncertainty by increasing saving.[4]

Unfortunately, an analytical solution that links consumption to income and wealth is not known with stochastic labor income and constant relative risk aversion (CRRA)

[4]Liquidity constraints (see, e.g., Beznoska and Ochmann (2012)) are not the focus of this thesis, although precautionary behavior and liquidity constraints are intimately linked (Deaton (1992)).

utility.[5] Zeldes (1989) therefore used numerical methods to approximate the optimal consumption function with CRRA utility and showed that consumption of rational households deviates from predictions of models that do not allow for precautionary savings because introducing labor income uncertainty makes the consumption function *concave*, a property that is explicitly stated in Keynes (1936).

Therefore, models in which the future is discounted to some extent due to precautionary saving reconcile Friedman's original intuition where the future is heavily discounted (see also Friedman (1963)), Keynes intuition of a concave consumption function, and simple "Keynesian" consumption functions where consumption tracks income (Carroll (1997)).[6]

For constant absolute risk aversion (CARA) preferences in the presence of labor income uncertainty only, a *linear* solution is known due to Caballero (1990, 1991). In this dissertation, I use both the analytical solution with CARA utility in the laboratory where I can control the environment[7] and numerical methods assuming CRRA utility to calculate optimal consumption using survey data because a linear consumption function is rather unrealistic.

This impressive line of research has improved our understanding of how consumption, income and wealth relate in the presence of income uncertainty, however, we are still—maybe not surprisingly—far from predicting these variables with a reasonable accuracy as urged, e.g., in Keane and Wolpin (2007). The main reason is that parsimoniously specified models require strong assumptions and by design simplify important factors that shape decision making to remain tractable. Moreover, to limit the reliance on extra-theoretic assumptions like functional form and distributional specifications strengthens theoretical coherence but weakens accuracy of out-of-sample predictions.

[5] More general utility functions based on Kreps and Porteus (1978) determine decision rules for consumers who are not indifferent to the time at which uncertainty is resolved, see Epstein and Zin (1989, 1991).

[6] See, e.g., Beznoska and Ochmann (2013) for a "Keynesian" approach.

[7] In particular, I can induce CARA preferences with monetary incentives.

For example, it is not clear how much we can trust the premise of behavior according to Ricardian Equivalence. Therefore, in one of the chapters, this assumption is tested and rejected for a large part of the sample. Thus, results of studies that rely on this assumption should not be taken at face value but rather as benchmark for comparison with models that are more loosely tied to theory until operational alternatives based on weaker assumptions are available. Therefore, instead of abandoning one approach, I advocate a two-pronged approach of theoretical and empirical research which is necessary in order to identify an economic *reasoning* for including more parameters or more flexible specifications. This thesis takes some steps in this direction.

1.2. Main Findings and Contribution

I organize the main analysis in four chapters, each of which is devoted to a specific question of consumption/saving behavior under labor income uncertainty and each of which is based on evidence from micro data. In all chapters, precautionary saving behavior is one way for households to self-insure against labor income risk. Chapter by chapter, more complex tax and transfer systems, some of which provide additional insurance, are introduced.

Chapter 2[8] is concerned with the measurement of the precautionary savings from German survey data, taking the tax and transfer system as given. In a large literature, precautionary saving is thought to be evident from the correlation between wealth and some measure of income uncertainty. Often, these studies found the magnitude of precautionary savings to be relatively large (e.g. Carroll and Samwick (1997, 1998)).

We demonstrate that this correlation results when different saving motives are not explicitly accounted for. Three motives that are important for our analysis are listed (among others) in Keynes (1936): “To build up a reserve against unforeseen contingencies”. “To provide for an anticipated future relation between the income and the needs

[8]This chapter is joint work with Frank Fossen and based on Fossen and Rostam-Afschar (2013).

of the individual or his family different from that which exists in the present, as, for example, in relation to old age, family education, or the maintenance of dependents". "To secure a masse de manoeuvre to carry out speculative or business projects".

In line with Hurst et al. (2010), the results of this chapter indicate that the precautionary saving motive, the first stated motive, was overestimated, because the previous literature failed to separate this motive from the old age and the entrepreneurial motive to save, the second and third of the motives cited above. Both are important in countries like Germany, because entrepreneurs, in contrast to employees, are not covered by the social security system and thus must save for their retirement and old age consumption. Therefore, once entrepreneurs are excluded from the estimation sample and the estimation is repeated for employees, the large estimates of precautionary savings reported in prior studies disappear.

This chapter contributes to the literature in two ways. First, the results of Hurst et al. (2010) are replicated for Germany and more strikingly than for the United States no statistically significant evidence for precautionary saving is found. In light of these results, we discuss and compare three ways to avoid biased estimates: to use a dummy variable for entrepreneurs; to exclude entrepreneurial households from the sample; to use a measure of wealth that does not include business equity.

The main methodological contribution of this analysis that moves beyond the findings of Hurst et al. (2010) is the recognition of entrepreneurial status as endogenous with respect to wealth. Wealthy households are more likely to engage in entrepreneurship than low wealth households because of tighter borrowing constraints. At the same time entrepreneurs hold more wealth due to the business saving motive. Therefore, we apply instrumental variable (IV) estimators and an endogenous switching regression model.

Second, another possible misinterpretation is identified, namely that portfolio shifts which are associated with different degrees of uncertainty might be mistaken as evidence for precautionary savings, even if the bias from business saving is accounted for. Many studies use liquid wealth only (Fuchs-Schündeln and Schündeln (2005); Bartzsch (2008)) with the argument that illiquid wealth such as housing might not be available fast enough for consumption smoothing. In principle, illiquid wealth might even be reduced to increase the liquidity of a portfolio in response to increasing uncertainty. While total wealth remains unchanged in the data, higher uncertainty is related to shifts to more liquid wealth. It is not obvious, though, that this is due to the precautionary saving motive, that implies cutting consumption in response to higher uncertainty. This relation might simply reflect portfolio choices. For instance, the degree of diversification of portfolios might be related to the level of income uncertainty. Moreover, income uncertainty from labor might be related to the rate of return.

Although the results do not provide evidence in support of the importance of precautionary savings, these findings *do not reject* the hypothesis that German households actually save for precautionary reasons. The reason is that none of the measures of uncertainty does have a closed-form analytical relationship with the target wealth-to-income ratio from which an appropriate empirical specification of the relationship between uncertainty and wealth could be derived (Carroll and Samwick (1998)).

Chapter 3[9] uses a simpler model in which an analytical solution is known to study the Ricardian Equivalence proposition in the presence of income uncertainty and precautionary saving behavior. This proposition is one of the earliest thought experiments in economics: it states the hypothesis that consumption decisions should not be affected by whether a government's refinancing scheme is based on lump sum taxes or debt because consumers will take the governments budget constraint into account. In survey data, the presence of progressive taxation, political uncertainty, heterogeneity in preferences and uncertainty, etc., lead to a violation of Ricardian Equivalence. There-

[9]This chapter is based on a collaboration with Thomas Meissner, documented in Meissner and Rostam-Afschar (2014).

fore, we analyze the Ricardian Equivalence proposition in a laboratory experiment. In our setup, Ricardian Equivalence may hold regardless of precautionary saving behavior. In turn, if Ricardian Equivalence is violated, the model will mispredict saving choices, even if precautionary saving is correctly calculated.

One of the methodological novelties of this chapter is the experimental design that allows us to test Ricardian Equivalence in the framework of a dynamic stochastic model of consumption/saving behavior with induced CARA preferences and labor income uncertainty, extended by lump sum taxation. In this setting we solve for the linear optimal consumption functions following Caballero (1990, 1991) and use non-parametric and panel data methods to study the effect of tax cuts and increases.

The main contributions of this chapter are threefold. First, we can test whether subjects systematically deviate from optimal consumption resulting from expected utility theory[10] which implies Ricardian Equivalence. Second, we test whether Ricardian Equivalence holds given that subjects do not follow the consumption rule implied by expected utility theory, for instance if they follow a consumption rule based on pre-government income or some other function of lifetime income. Third, our experiment allows us to asses learning behavior.

A further methodological contribution is that we take into account that the perceived difficulty to smooth consumption over the life cycle may confound a test of Ricardian Equivalence. Therefore, we introduce two different taxing schemes, one that increases the difficulty to smooth consumption and one that decreases it relative to a control treatment where taxes are constant. A comparison of the treatment groups allows us to distinguish the effects of difficulty and Ricardian taxation separately.

The main finding of this chapter is that taxation *does* influence consumption decisions. In our experimental setting, these effects are economically and statistically

[10]Expected utility theory states that given the axioms of choice the subjective value associated with a gamble by an individual is the statistical expectation of that individual's valuations of the outcomes of that gamble (Bernoulli (1954); Von Neumann and Morgenstern (2007)).

relevant. For instance, about 17 percent of a tax cut translate into higher consumption suggesting that reforms involving tax cuts would affect consumption outside the laboratory as well. To quantify the magnitude of effects to be expected from such a reform, however, requires representative data.

While this finding is striking, it does not mean that Ricardian Equivalence is rejected for the entire sample. We cannot reject behavior in accordance to Ricardian Equivalence for more than one third of our subjects.

Chapter 4[11] extends the model used in the previous chapter by progressive taxation to study how changes in the progressivity of the tax and transfer system affect precautionary savings in a dynamic stochastic life cycle model assuming CRRA utility and risky labor income. The tax and transfer function resembles the German progressive tax and transfer system and allows to control progressivity in a single parameter. This function, the parameters of the utility function, and the income process are estimated with GSOEP data.

Using simulation techniques, we find that the German progressive taxation system crowds out about 24 percent of wealth for a median household over the life cycle in comparison to a revenue-neutral flat tax system. This hypothetical, proportional tax is an interesting benchmark because it is directly comparable to previous studies that abstract from social insurance. Depending on the growth and the risk profiles of pre-government income the effect of progressive taxation on savings varies across different subgroups. For instance, the share of savings crowded out by progressive taxation is only 19 percent for college graduates whereas it is 60 percent for blue collars.

Our second main result is that progressive taxation provides more insurance than a revenue-neutral flat tax for all the subgroups we consider. For the total sample, our simulated economy shows that approximately 60 percent of permanent shocks and 90 percent of transitory shocks to pre-government labor income are insured against

[11] This chapter is coauthored with Jiaxiong Yao.

under progressive taxation. In comparison, only 30 percent of permanent shocks and 70 percent of transitory shocks are insured against in an economy with a revenue-neutral flat tax where saving is the only way to insure. Therefore we argue that not accounting for social insurance may lead to misleading conclusions when studying consumption/saving behavior for countries with progressive tax and transfer systems like Germany. Though the hypothetical reform is intended to bridge the gap to the previous literature, it bears implications for actual reform proposals advocating less progressive tax and transfer systems like Kirchhof's "flat tax" proposal for Germany. Thus, reform proposals that imply a reduction of social insurance need to discuss the consequences on saving behavior explicitly.

Third, our results show considerable heterogeneity in welfare gains for different subgroups when comparing the certainty equivalent lifetime income under progressive taxation to that under the hypothetical revenue-neutral flat tax. For instance, whereas blue collars need to be compensated with 16.5 percent of equivalent income under progressive taxation to be indifferent under revenue-neutral flat taxation, college graduates would ask for 0.1 percent more equivalent income under progressive taxation to be indifferent. The results highlight the need to discuss policy implications of progressive taxation for subgroups with different preferences and lifetime incomes separately.

Chapter 5[12] evaluates the effect of a recent reform of means-tested unemployment benefits in Germany ("Hartz IV") on precautionary saving. To do this, the methodology of Chapter 4 is adapted and extended by explicitly incorporating changes due to the reform in the budget constraint. The reform had two main components. First, the maximum unemployment benefit entitlement periods were cut (in effect in 2005). Second, unemployment assistance that depended on previous earnings was replaced by a lump sum transfer with a tighter asset-based means-test from 2006 on.

In this chapter, three channels through which the reform may have influenced pre-

[12]This chapter is single-authored.

cautionary saving behavior are identified: first, the reform increased the general level of income uncertainty leading to more precautionary saving. On the other hand precautionary saving was reduced by the reform because unemployment assistance which was *uncertain* due to its determination by uncertain previous income was replaced by *certain* lump sum transfers. Overall, the change in uncertainty faced by households reduced precautionary saving if the latter effect outweighs the former. Second, higher (lower) transfer before the reform leads to more (less) precautionary saving after. Third, a tighter means-test causes less/more precautionary saving (depending on lifetime income).

The first main finding of this chapter is that short-term effects of the reform on median precautionary savings were small and negative. Short-term effects on the share of precautionary saving were negative as well and decreasing with age. After 5 and 10 years, the reduction of the share of precautionary saving was smaller at most ages both 5 and 10 years after the reform.

The second main finding is that the household at 40 percent of median life-time income would pay 2.8 percent of this income to live under "Hartz IV". This is similar for most households. Only the 90th percentile life-time income household needs to be compensated with 0.4 percent of life-time income to be indifferent to "Hartz IV". This is due to the fact that consumption can be smoothed better when unemployment assistance is certain and that the consumption floor was raised for many households by the reform.

The fact that the reform in practice caused emotional debates and much disappreaciation may be due to the emphasis on efforts to reduce the level of unemployment when the details of the reform were communicated to the public. Further, higher transactions costs, increased perceived stigma attached to transfer dependence, and more rigorous threat of benefit cuts which are not part of the model may explain why this reform was not perceived as the welfare analysis suggests.

Beyond this evaluation, this chapter tests how well the model captures important features of the data by comparing two statistics not targeted by the estimation procedure that are interesting in the context of the reform: the share of transfer recipients, and the share of low wealth households. The model simulations predicts these statistics reasonably well.

Chapter 6 summarizes the main findings and conclusions, followed by a short outlook.

2 Precautionary and Entrepreneurial Savings[1]

2.1. Introduction

Various studies have suggested that a large share of household wealth can be explained by a precautionary saving motive. Quantity estimates of precautionary savings have important implications for policies that affect income risk, particularly with regard to labor market, social security, and taxation policy. If the precautionary saving motive is strong, policies that increase income risk will raise savings, which likely influences the growth rate of an economy (e.g. Femminis, 2001).

A widely applied estimation approach uses the relationship between the income risk of households and their wealth holdings to quantify the fraction of wealth held as precaution against idiosyncratic uncertainty. If the stock of wealth relates positively to income variations, the relationship is interpreted as evidence for the existence of precautionary saving. For example, with panel data from the United States, Kazarosian (1997) finds a strong precautionary saving motive, and Carroll and Samwick (1997, 1998) report that precautionary savings amount to almost half of U.S. households' wealth. By analyzing data about the subjective assessments of risks, Lusardi (1997, 1998) casts doubt on these high estimates of precautionary saving though. Guariglia and Kim (2003) estimate that Muscovite households in 1996 saved significantly more if they faced a more variable consumption growth.[2]

[1]This chapter is based on Fossen and Rostam-Afschar (2013) which is a substantial extension of a term paper that I wrote in 2009 entitled "Precautionary Saving and Entrepreneurship: Evidence from German Households".

[2]Early empirical work on income variability and savings behavior, including that of the self-employed, was pioneered by Fisher (1956). He relied on cross-sectional data and on occupational classes and age as indicators for income variability, which triggered some discussion (Klein and Liviatan, 1957; Fisher, 1957).

Hurst et al. (2010) show that the precautionary saving motive has been overestimated, because previous literature failed to account for heterogeneity between entrepreneurial and non-entrepreneurial households. Entrepreneurs hold more wealth, confront greater income risk, and differ in their saving motives compared with other, non-entrepreneurial households. By explicitly acknowledging the special role of entrepreneurial households, Hurst et al. (2010) estimate that precautionary wealth represents less than 10% of overall U.S. wealth. They also show that the large estimates of precautionary savings reported by prior studies resulted from pooling of entrepreneurial and non-entrepreneurial households and vanish if the sample is split or the study controls for entrepreneurial households.

We add to this evolving literature by providing the first analysis of the existence and quantity of precautionary savings explicitly accounting for entrepreneurship in Germany. The findings reported by Hurst et al. (2010) for the United States turn out to be even more important in Germany: When the dependent variable is total net worth (with or without business wealth), rather than just financial wealth, and we use our preferred specifications to account for entrepreneurship, we find no statistically significant evidence of precautionary saving. Our analysis is based on the German Socio-Economic Panel (GSOEP), which offers the crucial advantages of providing information about both private wealth balance sheets and individual measures of risk aversion (for both partners in case of couple households).

By focusing on Germany, this study examines the importance of accounting for entrepreneurship when estimating precautionary savings in a country in which employees are covered by an extensive social security system, whereas entrepreneurs must save for their retirement and old age consumption. Therefore, saving behavior may differ between entrepreneurs and non-entrepreneurs even more in Germany than in the United States.

Further, we investigate how income risk and entrepreneurial status affect the composition of households' asset portfolios. This analysis reveals that households shift their portfolios towards more liquid assets when they are confronted with higher income volatility, but they do not hold more wealth in total. Studies which find a positive effect of income risk on financial assets, which represent the most liquid component of a households wealth portfolio, need to show that this is indeed due to precautionary reasons and not due to portfolio decisions. For instance, the degree of diversification of portfolios might be related to the level of income uncertainty. Moreover, income uncertainty from labor might be related to the rate of return. Finally, owner-occupied housing may serve a precautionary purpose, since single rooms may be rented out. For example, Fuchs-Schündeln and Schündeln (2005) and Bartzsch (2008) base their conclusions, that approximately one-fifth of household wealth in Germany represents precautionary savings, on their evidence for a positive effect of uncertainty on financial assets only. They employ the same data, the German SOEP, and use different strategies to control for risk aversion.

Essig (2005) and Schunk (2009) instead have used the German SAVE data set of the Mannheim Research Institute for the Economics of Aging (MEA) to relate saving behavior to motives that they elicit using subjective importance measures. Essig (2005) notes a higher savings rate among the self-employed and in line with our reasoning, expresses doubt that it can be attributed solely to uncertainty.

In comparison with prior research, particularly that by Hurst et al. (2010), the main methodological contribution of our study is the recognition of entrepreneurial status as endogenous with respect to wealth. Endogeneity may arise from the credit constraints faced by nascent entrepreneurs, which means that wealthy people are more likely to be able to enter entrepreneurship. Therefore, we estimate the wealth equations using instrumental variable (IV) estimators and an endogenous switching regression model. We account for the self-selection of less risk-averse people into riskier occupations by also controlling for individual risk attitudes, according to experimentally validated survey measures.

In the following section, we present the empirical methodology employed to test the precautionary saving hypothesis. We discuss the specification of the wealth equation and outline some different strategies to account for entrepreneurship appropriately. This is followed by a description of the data and the construction of measures of permanent income and income uncertainty. In Section 2.3, we present the results, and then discuss them in comparison with the literature in Section 2.4. Section 2.5 analyzes the effects of income risk and entrepreneurship further by investigating asset portfolios of households. Section 2.6 concludes the analysis.

2.2. Methodology

2.2.1. Empirical Specification

The estimation equation is motivated by the buffer-stock model developed by Deaton (1991) and Carroll (1992, 1997, 2011b), particularly by its target wealth-to-income ratio that describes a positive relation between wealth W and permanent income P that consumers want to maintain. If wealth exceeds the target, consumption exceeds income, and wealth will fall. If wealth is below the target, income exceeds consumption, and wealth will accrue.[3] According to the model, the size of the wealth target depends on the degree of uncertainty ω that a consumer faces.[4] Target wealth also may be shifted by a vector of observed characteristics x and an unobserved error term u:

$$\frac{W}{P} = f(\omega, x, u). \tag{2.1}$$

[3]This model can explain why the saving rate increased in the United States, after wealth balances shrank during the recent financial turmoil. From the beginning of 2005 to April 2008, the seasonally adjusted annual personal saving rate as provided by the Bureau of Economic Analysis of the U.S. Department of Commerce remained quite stable, at an average of 1.8%. After May 2008, the point at which the financial crisis hit the overall economy, savers reacted by accumulating at a 3.9% savings rate on average.

[4]In this general notation, ω is a vector, because in one specification, we decompose income risk into permanent and transitory components (see Section 2.2.2).

Because wealth and income are highly unequally distributed, natural logarithms are chosen for the linearized empirical specification, and $ln(P)$ is added to both sides of the equation:

$$ln(W_{it}) = \alpha_0 + \gamma' \omega_{it} + \alpha_1 ln(P_{it}) + \beta' x_{it} + u_{it}. \tag{2.2}$$

The equation refers to the household level, because household members likely make saving decisions jointly and according to their pooled income. Thus, P denotes permanent net household income,[5] and we measure W as total net worth, that is, total assets of the household minus total debt. Unlike analyses of wealth components only, such as financial assets, this approach attempts to avoid mixing savings with portfolio decisions, though we also consider wealth components to enable comparisons with prior literature.

The vector x reflects the characteristics of the household as control variables. For couple households, i.e. households with cohabiting adult partners, who may be married or unmarried, we include individual characteristics of both partners, for single adult households the sole household head's characteristics only. Specifically, we control for each partner's age, age squared, years of work experience and its square, years of unemployment experience and its square, German nationality, and disability. A dummy variable which equals one for couple households is also included. As further household characteristics, we include the number of children under 17 years in the household, region, and the year of observation. Moreover, we control for gender and marital status of the household head, who is defined as the earner with the highest gross monthly income in a given year. According to this definition, the household head may change between observation years. In Section 2.3, we assess the sensitivity of the results with respect to the definition of the household head.

[5] We assume that households regard uncertainty in terms of the variation in their net rather than gross income, which is an important distinction, because one effect of progressive taxation is that variation in net income is smaller than in gross income. This effect is studied in Chapter 4 in detail.

To control for the risk attitudes of the household members, we use a method similar to Bartzsch (2008). In the 2004 and 2006 survey waves of the GSOEP, respondents were asked to indicate their general willingness to take risks on an 11-point scale, from 0 to 10, where 0 means ’risk averse’, and 10 means ’fully prepared to take risks’. We aggregate the 11 possible responses into three categories: low (responses 0-2), medium (3-7), and high willingness to take risks (8-10).[6] By including dummy variables for medium and high risk tolerance of both cohabiting partners or the single household head (with low risk tolerance as the base category), we control for the potential self-selection of less risk-averse people into occupations with higher income risk, which might otherwise create a downward selection bias in the coefficient of the income variance (Fuchs-Schündeln and Schündeln, 2005). In a field experiment with a representative sample of 450 subjects and with real money at stake, Dohmen et al. (2011) find that these measures of the willingness to take risks in the GSOEP are good predictors of actual risk-taking behavior.[7]

For this specification, the buffer-stock model predicts $\alpha_1 > 0$. With respect to γ, the a positive value[8] is expected, because the optimal reaction to greater uncertainty is to hold more wealth, that is, to demonstrate a precautionary saving motive. We will describe the different uncertainty measures later; in the following section, we elaborate on the specification to account for the specific role of entrepreneurship.

2.2.2. Dealing with Entrepreneurs

As we mentioned in the introduction, Carroll and Samwick’s (1997) estimation results for the United States indicated that almost 50% of household’s total net worth stemmed

[6]The results are very similar if we include dummy variables for all the possible answers to the risk question instead of the aggregated category dummies.

[7]The 2002 and 2007 waves provide the wealth information for estimating the wealth equation. The individual risk attitude of the same respondent in 2004 provides a proxy for the risk attitude in 2002, and the risk attitude in 2006 is a proxy for 2007. See also Fossen (2011).

[8]Or, positive components of γ, for the decomposed measure of uncertainty.

from a precautionary motive. For their study, they used occupational categories, including self-employed managers, as instruments for measures of earnings risk and permanent income. This approach requires the strong assumption that entrepreneurship has no direct influence on wealth. The authors even identified the self-employed as crucial for their high estimate of precautionary savings: When they excluded farmers and the self-employed from the sample, their estimations offered almost no support for the existence of precautionary saving. However, they argued that these two groups provided variation in income and therefore should remain in the same sample (Carroll and Samwick, 1998, p. 415).

Yet as Hurst et al. (2010) argue, the correlation between wealth and income uncertainty in the pooled sample is not due to a precautionary motive rather than to differences between entrepreneurs and non-entrepreneurs, because entrepreneurs have both higher income variance and more wealth for reasons unrelated to precautionary saving. They argued that other incentives to save for entrepreneurs could explain the higher amounts of wealth among entrepreneurs, such as their need to save for their old-age provision to address a lack of pension. Entrepreneurial and non-entrepreneurial households also differ in their preferences, such that an entrepreneurial household could have a different bequest or housing motive or a distinct discount factor. Going back to Keynes (1936), the precautionary saving motive has been distinguished from the motive to "secure a masse de manoeuvre to carry out speculative or business projects".

The evident heterogeneity between entrepreneurs and non-entrepreneurs demands consideration. We consider three potential strategies for doing so:

1. Employ a dummy variable for entrepreneurial households in x.
2. Exclude entrepreneurial households from the sample.
3. Use a measure of wealth W that does not include business equity.

Hurst et al. (2010) showed the effect of accounting for entrepreneurship using the Panel Study of Income Dynamics (PSID) for the United States. They demonstrate that the estimated amount of precautionary saving decreases from 50% without accounting for entrepreneurs to less than 10%. Yet, these authors did not consider the potential endogeneity of entrepreneurship.

In Germany, differences in the savings behavior between entrepreneurs and non-entrepreneurs may be even greater because its social security system plays a more important role. Employees are covered by statutory pension insurance, but entrepreneurs usually are not. Entrepreneurs, therefore, must save for their old age consumption, by paying into life or private pension insurance policies, investing in property, or reinvesting in their own business, all of which adds to their total net worth, our dependent variable. The coefficient of an entrepreneurship dummy variable (strategy 1) captures any additional saving due to the status as entrepreneur instead of their higher income variance. Because entrepreneurship is strongly correlated with more income variance, omitting the entrepreneurship dummy in the pooled sample leads to an upward bias of the estimated coefficient of income risk and thus an overestimation of precautionary savings in the whole population.

Although it solves the omitted variable problem, including an entrepreneurship dummy in x may introduce another endogeneity problem. If credit constraints exist for nascent entrepreneurs, wealthier households may be more likely to enter entrepreneurship (e.g., Evans and Jovanovic, 1989; Blanchflower and Oswald, 1998; Hurst and Lusardi, 2004). Instead of capturing additional savings by entrepreneurs, the coefficient of the entrepreneurship dummy variable in the wealth equation may reflect the reverse causality of wealth on entrepreneurship, which would produce an upward bias. Endogeneity potentially biases all estimated coefficients, including the coefficient of income risk and thus the estimated degree of precautionary saving.

We employ an instrumental variables (IV) technique to deal with the endogeneity of the entrepreneurship dummy in the pooled regression. For the instruments, we use three dummy variables that indicate (i) whether at least one of the partners in a couple household (or the single household head) had a self-employed father when he or she was 15 years old[9] and whether at least one of (ii) their fathers and (iii) their mothers earned the higher secondary school degree 'Abitur', which qualifies a student for university admission in Germany. A self-employed father strongly increases the probability of offspring being an entrepreneur (e.g. Dunn and Holtz-Eakin, 2000; Hout and Rosen, 2000; Fairlie and Robb, 2007). Parents' education also should influence entrepreneurial choice, in that the family background is an important determinant of entrepreneurship (see Table 2.2.1 for descriptive evidence and the cited literature). The values of the instrumental variables all are fixed before the adults in the sample have chosen to be or not to be entrepreneurs and remain fixed over the observation period, which allays the potential reverse-causality concern. The instruments pass the test of overidentifying restrictions (see footnote 20).

The generalized method of moments (GMM) IV-estimation based on the pooled sample assumes that the coefficients are the same for entrepreneurs and non-entrepreneurs. Splitting the sample between them is less restrictive, because the coefficients may differ. The estimation of the non-entrepreneur sub-sample corresponds to strategy 2. For the same reasons that endogeneity emerges in the entrepreneurship dummy in the pooled regression though, splitting the sample between entrepreneurs and non-entrepreneurs may introduce a selectivity bias, because selection into entrepreneurship is non-random.

Instead of simply splitting the sample we thus employ an endogenous switching regression model, in which entrepreneurs ($I = 1$) face a different regime than non-

[9] In Germany, self-employed mothers are rare in the generations of most respondents' parents, and this information is often missing, so only self-employed fathers are used.

entrepreneurs (cf. Maddala, 1983; Lokshin and Sajaia, 2004):

$$I_{it} = 1 \qquad \text{if } \delta z_{it} + v_{it} > 0.$$

$$I_{it} = 0 \qquad \text{if } \delta z_{it} + v_{it} \leq 0.$$

$$\text{Regime 1: } ln(W_{it}) = \alpha_{0,1} + \gamma_1' \omega_{it} + \alpha_{1,1} ln(P_{it}) + \beta_1' x_{it} + u_{1,it} \qquad \text{if } I_{it} = 1. \tag{2.3}$$

$$\text{Regime 2: } ln(W_{it}) = \alpha_{0,2} + \gamma_2' \omega_{it} + \alpha_{1,2} ln(P_{it}) + \beta_2' x_{it} + u_{2,it} \qquad \text{if } I_{it} = 0. \tag{2.4}$$

The explanatory variables z in the criterion function, which determines selection into entrepreneurship, include the variables in x and the dummy variables used as IVs. These additional variables thus serve as an exclusion restriction here. With the assumption that the error terms v, u_1, and u_2 follow a trivariate normal distribution, we can estimate the coefficients, which may differ between entrepreneurs and non-entrepreneurs, using the maximum likelihood method.

As an additional sensitivity check, we estimate a restricted version of the switching regression model, in which the coefficients do not differ between the two regimes. Comparing the results from the restricted and the unrestricted model enables us to test for the significance of the difference between the regimes. The restricted model corresponds to a treatment effects model (Heckman, 1978), in which entrepreneurship represents the treatment.

Finally, as a robustness analysis, we check how excluding business equity from the wealth measure influences the estimate of precautionary savings (strategy 3).

Data

This analysis is based on data from the German Socio-Economic Panel (GSOEP), a representative annual household panel survey in Germany that started in 1984. Wagner et al. (2007) provide a detailed description of the data. We use all waves available

(1984-2007) to estimate permanent income and income uncertainty measures. Because the 2002 and 2007 waves included a special module to collect information about private wealth, our main analysis refers to these two periods. The surveys asked about the market value of personally owned real estate (owner-occupied housing, other property, mortgage debt), financial assets, tangible assets, private life and pension insurance, consumer credit, and private business equity (net market value; own share in case of a business partnership). The wealth balance sheets referred to the personal level, so in the case of jointly owned assets, the survey explicitly asked about each person's individually owned shares. For our analysis, we aggregate wealth and income data to the household level.

Fuchs-Schündeln and Schündeln (2005) also used the GSOEP but only up to 2000, so they did not have access to measures of wealth. Instead, they relied on flows of received amounts of interest and dividend payments to estimate financial wealth according to the yearly average interest and dividend yields in Germany. In addition to the poor precision this method offers with regard to the amount of financial wealth, wealth components other than financial assets cannot be considered with the implications we discuss in Section 2.4.

In a given year, we define an entrepreneurial household as one that currently owns a private business with a positive market value (cf. Hurst et al., 2010). It is thus possible that a household is classified as entrepreneurial in one year and as not entrepreneurial in the other. We do not observe businesses with negative market values; respondents report a zero market value for such over indebted firms, and we classify these households as non-entrepreneurial.[10] To assess if this implies a misclassification, we repeat the estimations using self-employment (of at least one of the partners in a couple household, or the single household head) as an alternative indicator of en-

[10]This state of over indebtedness can only occur temporarily, however, as it would otherwise result in bankruptcy.

trepreneurship, which is independent of the positive or negative market value of the business (see Section 2.3).

We exclude observations where the household heads[11] are younger than 18 years or older than 55 years from the sample, because youth and people in the years immediately preceding their retirement likely do not engage in buffer-stock saving (cf. Carroll, 1997). For a similar reason, households with heads who are pensioners, in education or vocational training, interns, serving in the military or community service, unemployed, or not participating in the labor market, are excluded from the sample.[12] 6,287 observations of household-years without missing values in the relevant variables remain in the 2002 and 2007 waves, 664 of which refer to entrepreneurial households.[13]

We provide in Table 2.2.1 the means of the variables by households' entrepreneurial status, using survey weights provided by the GSOEP. At the bottom of the table, we also show the means of total net worth,[14] net financial wealth (financial assets minus debt from consumer credit), wealth held in private businesses, and the net value of owner-occupied housing. Private business equity equals zero for non-entrepreneurial households, by definition. All monetary variables are deflated using the consumer price index provided by the Federal Statistical Office.

Entrepreneurial households clearly differ from other households. Their total net worth is on average substantially greater than that of non-entrepreneurial households, though this comparison of assets exaggerates the wealth difference, because it does

[11] I.e. the current main earner; Section 2.3 assesses sensitivity of results to alternative definitions.

[12] The results remain qualitatively similar if we use 50 or 65 years as the cut-off point for age and if unemployed household heads and non participants in the workforce appear in the sample (results available from the authors on request). We focus on labor income risk and therefore do not analyze the effect of unemployment benefits on precautionary saving. For this investigation, see Engen and Gruber (2001) and Chapter 5.

[13] For the variables referring to both partners in a couple household, e.g. the instrumental variable indicating self-employment of at least one of the partners' fathers, we use information pertaining to only one partner in case the other partner's information is not available.

[14] Total net worth is the sum of housing and other property (minus mortgage debt), financial assets, the cash surrender value of private life and pension insurance policies, tangible assets, and the net market value of commercial enterprises, minus debt from consumer credit.

Table 2.2.1

Weighted Means of Variables by Households' Entrepreneurial Status.

Variables	*Total*	*Non-entrepreneurs*	*Entrepreneurs*
Characteristics			
age	40.80	40.68	42.59
female	35.84	36.19	30.67
number of children	0.59	0.58	0.76
married	49.19	48.30	62.21
eastern Germany	16.87	16.88	16.70
German nationality	92.11	91.83	96.09
self-employed father*	10.71	10.18	18.30
father has Abitur**	16.30	15.66	25.62
mother has Abitur**	8.08	7.79	12.21
Willingness to take risks			
low	13.42	13.73	8.82
medium	74.17	74.52	68.99
high	12.41	11.75	22.19
Partner's willingness to take risks			
low	20.96	21.20	18.26
medium	70.29	70.39	69.06
high	8.75	8.41	12.68
Highest educational attainment			
apprenticeship	35.95	36.69	24.90
technical school or Abitur***	7.47	7.59	5.73
higher technical college or similar	21.77	21.63	23.74
university degree	26.47	25.57	39.86
Monetary variables (euro in 2002 prices)			
net worth	86,264	57,292	509,924
net financial wealth	7,451	5,914	29,927
wealth in enterprise	15,979	0	249,638
net value of owner-occupied housing	50,761	46,093	119,016
permanent income	32,121	31,889	35,579

Notes: All numbers are in percentages except for age, number of children, and the monetary variables. Individual characteristics refer to the current primary earner in the household, if not otherwise indicated. The means of partner's willingness to take risks is based on couple households only.
Source: Own calculations based on the GSOEP. Statistics are shown for 2002 and 2007; the calculation of permanent income is based on the waves 1984-2007.

* Equals 1 if at least one of the partners' fathers in a couple household or the household head's father in a single household is/was self-employed, and zero otherwise.

** Equals 1 if at least one of the partners' fathers/mothers in a couple household or the household head's father/mother in a single household has the higher secondary school degree Abitur***, and zero otherwise.

*** Abitur refers to the higher secondary school degree that qualifies a student for university admission in Germany.

not consider the statutory pension insurance entitlements of persons in dependent employment in Germany. Frick and Grabka (2010) have estimated the net present value of public pension entitlements of employees in Germany to average between 40,000 euro (low-skilled workers) and 80,000 euro (managers) per person. Thus on average, employees have a lower total net worth than do entrepreneurs, even after we consider public pension wealth. Entrepreneurs also enjoy a higher level of permanent net income, in part because they do not pay social insurance contributions (we describe the construction of the permanent net income variable in the next section).

Another interesting observation involves the large share of private business equity in the total net worth of entrepreneurial households (see also Fossen, 2011). This finding highlights that total wealth holdings may correlate with entrepreneurship for reasons unrelated to precautionary savings.

As we expected, the fraction of entrepreneurial households connected to a self-employed father (18.3%) is much higher than that of non-entrepreneurial households (10.2%). Furthermore, in comparison to non-entrepreneurs, more entrepreneurs have parents with the higher secondary school degree 'Abitur'. These variables thus suggest themselves as potential instruments for entrepreneurship.

It comes as no surprise that a larger portion of entrepreneurs are willing to take higher risks as indicated by the subjective risk measures in Table 2.2.1. Interestingly also their partners report less risk aversion on average.

Construction of Permanent Income and Income Risk Measures

Permanent income and the measures of income uncertainty are estimated on the basis of the household net income information contained in all waves available in the GSOEP. We assume income to depend on trends in demographic and human capital factors x_{it}^1 and a transitory component e_{it}, such that yearly net household income[15] y_{it}

[15] Yearly net household income is approximated by multiplying current monthly net household income by 12.

can be written as

$$ln(y_{it}) = b'x^1_{it} + e_{it}. \tag{2.5}$$

The x^1 vector contains the variables in x mentioned before and dummy variables indicating the household head's highest educational attainment.[16] To approximate permanent income, we predict $y^P_{it} := \hat{y}_{it}$ on the basis of an ordinary least squares (OLS) estimation of equation (2.5),[17] similar to Lusardi (1998).[18]

To estimate the wealth equation (2.2), we require a measure of income uncertainty. Because extant theory lacks an appropriate specification to capture the relationship between uncertainty and wealth, prior literature tends to use atheoretical measures of uncertainty. One crucial difference among proposed quantitative measures is whether to assume that the perceived uncertainty is closer approximated by past realizations, i.e. ex-post, or some prediction of future income risk based on the information available at a specific date, i.e. ex-ante. Geyer (2011) follows the latter approach and simulates ex-ante risk measures in a model of precautionary savings. For this study, we construct several alternative ex-post measures to estimate the amount of precautionary wealth.

For the first measure of income variance, we estimate a heteroscedasticity function. By estimating equation (2.5), we can obtain the squared residuals $(ln(y_{it}) - ln(\hat{y}_{it}))^2 = \hat{\sigma}^2_{it}$. Then to estimate the heteroscedasticity function, we conduct an OLS regression of

[16] We define four educational levels: Apprenticeship, technical school degree or Abitur, higher technical college degree or similar, and university degree. In the specifications that maintain the exogeneity assumption of entrepreneurship in wealth equation (2.2) used primarily to compare the results with extant literature, we include a dummy variable indicating entrepreneurial households in x^1 as well (results from this are reported in Table 2.2.2). The estimation results of these specifications are presented in Table 2.3.3 as Pooled 1 and 2. The dummy gets dropped from x^1 in the preferred IV model with endogenous entrepreneurship, Pooled 3, and the endogenous switching model, to use exogenous variation in earnings risk and permanent income only. Furthermore, the dummy variables indicating the risk attitude are excluded from x^1, because they are available only in 2004 and 2006.

[17] To obtain consistent predictions of $\hat{y}_{it}$, the predicted values from the log model must be exponentiated and multiplied by the expected value of $exp(e_{it})$. A consistent estimator for the expected value of $exp(e_{it})$ is the estimated slope coefficient from a regression of y_{it} on the exponentiated predicted values from the log model through the origin. This procedure does not require normality of $exp(e_{it})$.

[18] We obtain similar levels of permanent income if we use the method suggested by Fuchs-Schündeln and Schündeln (2005).

$ln(\hat{\sigma}_{it}^2)$ on the x^1 variables and thereby gather the fitted values **lvarly I**. This measure contains the logarithm of the expected variance of log income, conditional on observed characteristics, and can be interpreted as a measure of income uncertainty. By applying the exponential function on lvarly I, we obtain **varly I** as an alternative measure.

Table 2.2.2

Estimated Income Risk Measures.

	Total sample	*Non-entrepreneurs*	*Entrepreneurs*
varly I	0.1782	0.1630	0.3072
	(0.0967)	(0.0775)	(0.1384)
	[0.0396]	[0.0382]	[0.0510]
varly II	0.2513	0.2375	0.3681
	(0.0826)	(0.0635)	(0.1237)
	[0.0492]	[0.0480]	[0.0593]
permanent variance	0.0106	0.0105	0.0112
	(0.0687)	(0.0660)	(0.0881)
transitory variance	0.0421	0.0386	0.0720
	(0.1362)	(0.1280)	(0.1892)
Number of observations	6,287	5,623	664

Notes: The plain numbers are the means of the variance measures; their standard deviations are shown below in parentheses; mean coefficients of variation (sd/mean) appear in square brackets. The variance components do not add up to the total variance measures because only the detrended part of the total variance gets decomposed (see Appendix 2.B). The number of observations is lower for the permanent and transitory variance because of missing information (4,670, 4,171, and 499, respectively).

Source: Own calculations based on the GSOEP 1984-2007; statistics shown for 2002 and 2007.

Another approach to measure income uncertainty is to divide the sample into certain cells and to calculate the income variance in these sub-samples. We describe this in Appendix 2.A and refer to this measure as **varly II** and to the logarithm of varly II as **lvarly II**. Carroll and Samwick (1997) and Hurst et al. (2010) both decompose the income variance into permanent and transitory components. In additional specifications, we adopt this method, as presented in Appendix 2.B, to compare the results.

The sample means of the uncertainty measures varly I and varly II, we show in

Table 2.2.2, clearly confirm that entrepreneurial households face higher income risk than do other households. The difference persists even when the estimated variance is normalized by the mean (variation coefficients reported in square brackets). When the variance is decomposed into permanent and transitory components, both components are greater for entrepreneurs.

Compared with Carroll and Samwick (1997) and Hurst et al. (2010), in the total sample, the average permanent variance is higher in the United States than in Germany possibly because of Germany's labor legislation, which may reduce wage risk. The average transitory variance is almost the same though, so idiosyncratic shocks do not seem to differ much between the two countries.

The descriptive analysis reveals that entrepreneurial households possess a greater stock of wealth on average and more volatile labor income compared with other households, which emphasizes the importance of controlling for entrepreneurial status.

2.3. Results

Coefficients of Income Risk Decrease

In Table 2.3.3, we provide the results from estimating equation (2.2) using the two alternative measures of income uncertainty, varly I (upper panel) and lvarly I (lower panel). The five columns refer to different specifications that we describe next. The dependent variable is the logarithm of total net worth.

In addition to the coefficients of each measure of earnings risk, we reveal the estimated coefficients of the logarithm of permanent income and the entrepreneurship dummy variable, if included, for each specification. The estimated coefficients of the control variables x are reported in Table 2.C.1 in the appendix, for the specification Pooled 3 (i.e., IV estimation based on the pooled sample, including an entrepreneurship dummy).[19]

[19]For the other specifications, the estimated coefficients of the control variables are available from

The first column shows the estimates without controls for entrepreneurship on the basis of a pooled sample that includes both entrepreneurial and non-entrepreneurial households (Pooled 1). Specification Pooled 2 is also based on the full sample but controls for entrepreneurial households using a dummy variable.

As we discussed in Section 2.2.2, omitting the entrepreneurship dummy in the Pooled 1 specification may introduce omitted variable bias, and the entrepreneurship dummy in the Pooled 2 specification may be endogenous. Therefore the preferred specification is the IV model Pooled 3, which uses dummy variables indicating self-employed fathers and parental education as IVs for the entrepreneurship dummy.[20] The analysis by Carroll and Samwick (1998) suggests that the logarithm of the variance of log income has a nearly linear relationship with log wealth, so the preferred measure of income risk is lvarly I.

The last two columns report the estimation results from the endogenous switching regression model which is more flexible than the Pooled 3 specification, because it allows the coefficients to differ between the two household types while also accounting appropriately for the endogeneity of entrepreneurship.[21] However, the analysis with this model suffers a disadvantage: The coefficients for the entrepreneurs' regime are imprecisely estimated because of the comparably small size of the sub-sample of entrepreneurs.

the authors on request.

[20]The strength of these excluded instruments seems sufficient. An F-test indicates that they are jointly significant at the 1% level ($F = 16.56$ for varly I; $F = 16.59$ for lvarly I) in the first-stage regression of the entrepreneurship dummy variable on all instruments. The Hansen test of overidentifying restrictions also is not rejected (p-value = 0.53 both for varly I and lvarly I).

[21]The variables excluded from the criterion function, which are identical to the excluded instruments in the Pooled 3 specification, are jointly significant at the 5% level in the selection equation, which is jointly estimated with the regime equations.

Table 2.3.3

Estimates of the Effect of Labor Income Risk on Log Net Worth.

				Endogenous switching model	
	Pooled 1	*Pooled 2*	*Pooled 3 (IV)*	*Non-entrepreneurs*	*Entrepreneurs*
varly I	4.6202***	1.6779**	-0.1732	-0.4000	3.9261
	(0.4250)	(0.7817)	(1.1402)	(0.9668)	(4.0245)
ln perm. income	1.5820***	1.2666***	1.0476***	1.1008***	1.0198*
	(0.1546)	(0.1624)	(0.1826)	(0.1520)	(0.5681)
entrepreneur		0.6973***	3.1108***		
		(0.1311)	(0.5961)		
lvarly I	1.2303***	-0.0066	0.0133	-0.0536	0.7494
	(0.0951)	(0.3634)	(0.3712)	(0.3864)	(1.2688)
ln perm. income	1.3463***	1.2448***	1.0486***	1.1045***	0.9466
	(0.1617)	(0.1624)	(0.1839)	(0.1531)	(0.5844)
entrepreneur		0.9724***	3.1049***		
		(0.2713)	(0.5954)		
observations	6,287	6,287	6,287	6,287	6,287

Notes: Robust standard errors are in parentheses. The Pooled 1 model does not control for entrepreneurship, Pooled 2 controls for entrepreneurship, and Pooled 3 employs an instrumented control variable for entrepreneurship. Right two columns: Endogenous switching model with distinct regimes for entrepreneurial and non-entrepreneurial households.

Source: Model estimations based on the GSOEP 2002/2007; income variable estimations based on waves 1984-2007. ***Significant at 1% level. **Significant at 5% level. *Significant at 10% level.

In Pooled 1, which does not control for entrepreneurship, the relationship between income variance and net worth, which might spuriously be attributed to precautionary saving, is significantly positive for both measures of income uncertainty. These results replicate findings in prior literature. The estimated coefficient for lvarly I of 1.23 implies that when income uncertainty (measured as the variance of log income) doubles, total net worth increases by 123%.

However, when we control for entrepreneurship the picture changes completely. Turning to the specifications other than Pooled 1 that account for entrepreneurship, the point estimates for the income variance coefficients become substantially smaller, and in some cases even negative, regardless of whether we use varly I or lvarly I. There is no longer a significant relationship between income uncertainty and total net worth; the only exception is the Pooled 2 specification using varly I, for which the point estimate is substantially smaller than that attained without controlling for entrepreneurship (i.e. 1.68 versus 4.62), though still significant. As we have argued, lvarly I is a preferable measure because of its better functional fit. Moreover, the coefficient in the Pooled 2 specification may be biased, because we control for the potential endogeneity of the entrepreneurship dummy variable only in the Pooled 3 specification and the endogenous switching models. The point estimate of the coefficient in the entrepreneurs' regime of the switching regression model (3.93) is the only one that does not become substantially smaller than the one in the Pooled 1 specification (4.62). This finding is not inconsistent with the general result though, because for this regime, the estimated coefficient has a large standard error and is not significantly different from zero. Overall the results clearly show that given the heterogeneity between entrepreneurial and non-entrepreneurial households, failing to control for entrepreneurship causes a spurious correlation between income uncertainty and wealth and leads to an upward bias of estimations of precautionary savings.

The point estimate of the coefficient of permanent income is not significantly different from one (except for the biased Pooled 1 specification, which omits the entrepreneurship dummy). A value of one is consistent with a fixed target wealth-to-permanent income ratio, conditional on the other explanatory variables. The coefficient is positive and significantly different from zero across all specifications and income risk measures, except for the entrepreneurs' regime of the switching regression model using lvarly I, for which the coefficient is just insignificant because of the large standard error. Focusing on the Pooled 3 specification with the uncertainty measure lvarly I, the estimated coefficient of the log of permanent net income implies that doubling permanent net income increases total net worth by 105%.

The estimated positive and significant coefficient of the entrepreneurship dummy in all specifications reflects the higher average wealth stock held by entrepreneurial households, holding income risk and the other explanatory variables constant. The dummy variables indicating medium or high risk tolerance of each partner in a couple household or of the single household head (see Table 2.C.1 in the appendix) are jointly not significantly different from zero in the preferred specification Pooled 3. In Pooled 1 and Pooled 2, the risk dummies are jointly significant, but never individually significant.

The results remain similar when the coefficients (except for the intercept) in the endogenous switching model are restricted to be the same in the two regimes. As we mentioned in Section 2.2.2, this restricted model accounts for entrepreneurship by interpreting entrepreneurial status as a treatment in the sense of a treatment effects model (Heckman, 1978). As in the other models that account for entrepreneurship, the coefficient of the earnings variance becomes small and insignificant, regardless of whether we use varly I or lvarly I.[22]

[22]The results are available from the authors on request. We report the results of the more general endogenous switching model only, because the restrictions of equal coefficients in the two regimes are rejected by a likelihood ratio test ($\chi^2_{35} = 579.85$ using lvarly I). The treatment effects model is similar to the IV model Pooled 3, which we prefer, because it does not require the assumption of normally distributed error terms for consistency.

Share of Precautionary Savings in Total Net Worth Reduces

To quantify the amount of precautionary savings based on the estimated parameters, we follow prior literature and compare the predicted net worth of households $\widehat{W}_i$ with the simulated net worth they would possess if they all faced the minimum income risk. The minimum income risk ω^* can be approximated by the minimum predicted risk in the sample. A prediction of $\widehat{W}_i^*$, obtained by substituting households' income risk ω_i by ω^*, can be interpreted as the amount that households would accumulate if they faced the minimum risk. The share of total net worth explained by precautionary saving in the sample thus is given by

$$\frac{\sum_{i=1}^{N} \widehat{W}_i - \sum_{i=1}^{N} \widehat{W}_i^*}{\sum_{i=1}^{N} \widehat{W}_i}. \tag{2.6}$$

Table 2.3.4 contains the estimated share of precautionary savings in total net worth, according to the different specifications and measures of income risk. Without controlling for entrepreneurship (Pooled 1), the large estimated amount of precautionary savings replicates prior results (Carroll and Samwick, 1998). With preferred income risk measure lvarly I, it accounts for as much as 64.6% of total net worth. Including a dummy or applying the switching regression model to control for entrepreneurship substantially decreases the point estimates of the shares (they even become slightly negative in some specifications), except for the entrepreneurs' regime in the switching regression model.

Even in this regime though, the hypothesis that precautionary savings are 0 cannot be rejected, because the coefficients of the income variance are insignificant, as they are in almost all the specifications that account for entrepreneurship.[23] The specification controlling for entrepreneurship that yields a significant coefficient of the measure of income risk, Pooled 2 using varly I, produces a point estimate for the share of precautionary saving of 17.5%, which is much lower than that attained without controlling

[23] This result holds when we decompose income variance into transitory and permantent components.

Table 2.3.4

Percentage of Net Worth Explained by Precautionary Savings.

				Endogenous Switching Model	
	Pooled 1	*Pooled 2*	*Pooled 3 (IV)*	*Non-entrepreneurs*	*Entrepreneurs*
varly I	37.05	17.48	-1.46†	-3.65†	28.84†
lvarly I	64.58	-0.64†	1.07†	-4.58†	45.75†
varly II	42.73	1.39†	5.74†		
lvarly II	36.74	0.79†	3.50†		

Notes: † Calculated on basis of insignificant coefficients.
Source: Model estimations based on the GSOEP 2002/2007; income variable estimations based on waves 1984-2007.

for entrepreneurship (37.1%). With the preferred measure lvarly I, the point estimate for the share is close to zero.

Results are Robust

In this section, we assess the sensitivity of the results with respect to various modeling choices taken.[24] First, we consider the third potential strategy for dealing with entrepreneurial households described in Section 2.2.2, i.e. we use total net worth minus the value of private businesses as the dependent variable, as we show in the two leftmost columns of Table 2.C.2 in the appendix. The effect of controlling for entrepreneurship does not change: When we plug the modified dependent variable into specification Pooled 1 (first column), which does not include an entrepreneurship dummy variable, the estimated coefficients are positive and significant (3.00 for varly I and 0.75 for lvarly I), albeit smaller than those obtained when total net worth serves as the dependent variable in the same specification (4.62 and 1.23, respectively, see Table 2.3.3). Again, regardless of the measure of income risk used, the estimated coefficients of income risk are small and insignificant when we include an entrepreneur-

[24]We thank an anonymous referee and the editor for suggesting several of these robustness tests to us.

ship indicator (second column). However, if the only channel for entrepreneurs' additional savings were investments in their own business, removing business wealth from the wealth measure would be sufficient to avoid the upward bias in the coefficient of earnings risk that results from not accounting for entrepreneurship. The results from this test show that this is not the case, at least in Germany, and invalidate the third potential strategy mentioned above. It is plausible that the additional savings of entrepreneurs, unrelated to a precautionary motive are not exclusively concentrated in their businesses, but also include other assets such as property; Section 2.5 sheds more light on these portfolio choices.

The main results from further robustness checks are reported in Table 2.C.3 in the appendix. Apart from specific changes described below, we use the preferred specification Pooled 3 with varly I (upper panel) and lvarly I (lower panel) as measures of income risk. Overall, the results confirm the findings from the baseline estimations: Income risk has no significant effect on household wealth once entrepreneurship is controlled for. Permanent income has a positive and in almost all cases significant relationship with wealth. Its coefficient is not significantly different from one, and entrepreneurship, treated as endogenous, is always positively and significantly related to wealth in these IV regressions.

Specifically, the first two columns assess alternative definitions of the household head. Instead of the household member with the highest income in the year of observation, column 1 defines the household member who was the main earner in 2002 as the household head both in 2002 and 2007, thus avoiding changing household heads. The second column uses the household head as defined in the GSOEP, i.e. the person identified by the trained interviewers who is most likely to know about the overall situation of the household and who is at the same time likely to be able to answer the survey questions concerning the household every year.

The next three columns refer to alternative definitions of an entrepreneurial household. First, we define only those households as entrepreneurial households where both partners are entrepreneurs in the sense that both of them own personal shares in a private business. As this avoids classifying mixed households as entrepreneurial, this definition can be regarded as referring to households with a very strong entrepreneurial spirit. Here, the positive correlation between entrepreneurship and wealth is much larger than in the baseline specification. Second, we exclude mixed households from the sample altogether, i.e. we keep only couple households where both partners either indicate being or not being entrepreneurs, and single households. Third, we use self-employment instead of business ownership as our indicator of entrepreneurship. This includes self-employed persons whose business has zero or even a negative market value. The household is then classified as entrepreneurial if at least one of the partners in a couple household or the single household head reports self-employment as their primary occupation.

Finally, the last two columns deal with issues potentially arising from couple households where risk attitudes differ between partners. First, additionally to the dummy variables indicating medium or high willingness to take risks for each partner, we include two interaction terms, one indicating couple households where the household head (i.e. the current main earner) has high and the partner low risk tolerance, and one marking the opposite situation. The coefficient of the first interaction turns out to be positive and significant with a point estimate of 0.27, which suggests that such preference heterogeneity within households leads to increased savings. Whether this result reflects the outcome of bargaining within the household needs more detailed investigation and is left to future research. Second, we re-estimate the main wealth equation using single households only. As mentioned before, the results with respect to our conclusions are robust across all these specifications.

2.4. Comparison to the Literature

The results from this analysis are in line with findings described by Hurst et al. (2010), for the United States, in which they showed that estimates of precautionary savings decline dramatically once entrepreneurship is accounted for. They still find some evidence that precautionary savings exist in form of a small fraction of wealth, because the coefficient of income risk is positive and significant, albeit small, in some of their specifications. In contrast, our analysis of German data reveals no significant effects after controlling for entrepreneurship (except for one, less preferred specification). The insignificance of income risk cannot be attributed to the sample size, because our German sample contains more observations than does the U.S. sample used by Hurst et al. (2010). The failure to control for entrepreneurship in an estimation of precautionary savings yields high estimates in both countries, but it seems to produce estimated coefficients of earnings risk that are even more upward biased in Germany than in the United States. Thus, country differences could explain this distinction.

Other estimations of precautionary savings in Germany have relied on measures of financial wealth instead of total net worth as the dependent variable. Specifically, Fuchs-Schündeln and Schündeln (2005) and Bartzsch (2008) estimate precautionary savings of approximately 20% when they use different strategies to control for heterogeneity in risk aversion. They excluded self-employed persons and thus, avoided the spurious correlation problem that arises from pooling non-entrepreneurial and entrepreneurial households without controlling for entrepreneurship. To allow for a comparison, in the three rightmost columns of Table 2.C.2 in the appendix, we provide the estimation results when we use net financial wealth as the dependent variable. The column labelled "non-entrepreneurs" excludes entrepreneurs, as in the two studies cited. Focusing on lvarly II as the measure of income risk, which it is very similar to one of the measures used in these two studies, we find that the coefficient of income risk is positive and significant (0.50). Positive and mostly significant results also emerge when we use the other measures of income risk, and also when we include entrepreneurial households in the sample and control for their status in specification Pooled 2 and the preferred IV specification, Pooled 3. The positive effect thus seems to arise when financial wealth is the dependent variable.

These findings show that households with higher income risk hold more of the assets that comprise financial wealth such as savings accounts, bonds, and stocks. Considering the fact that these assets are liquid relative to the other asset components of total wealth, makes interpretation of these holdings as evidence of precautionary saving problematic. Our results from using total net worth as the dependent variable indicate that total net worth does not react significantly to changes in income risk, which implies that the changes in financial assets could rather be interpreted as portfolio decisions. The larger amount of financial assets that households hold when confronted with higher income risk must be offset by lesser amounts of other assets, such as property, whereas total net worth remains constant. It seems plausible that households with more volatile income keep a larger share of their wealth in liquid assets. In the light of the findings from this study though, this distribution of wealth does not mean that these households save more.

2.5. Income Risk and Portfolio Choice

In the previous section, we found that households with higher income risk hold a higher amount of financial assets without holding more net worth in total. In this section, we will therefore further investigate the effects of income risk and entrepreneurial status on portfolio decisions of households. One of the aims is to find which other asset classes high risk households reduce in their portfolios to offset the higher amount of financial assets; another aim is to shed more light on differences between entrepreneurial and non-entrepreneurial households.

We consider six asset categories: Financial assets, tangible assets, private life and pension insurance, private business equity, owner-occupied housing, and other property. For each asset class, we calculate the portfolio share in gross wealth, which is the sum of the six classes. Thus gross wealth is defined as wealth that is convertible into cash on the market, and does not include human capital or statutory pension insurance entitlements. Mortgage debt on owner-occupied housing and other property and consumer credits are not deducted, as we are interested in the portfolio split rather than the leverage decision. This ensures that the six portfolio shares calculated, which we will use as dependent variables, lie in the interval from 0 to 1 for all households.

The main explanatory variables are income risk, where we use our preferred measure lvarly I, and entrepreneurial status. Since business ownership as an indicator for entrepreneurship, as used in the main analysis, is directly connected to positive private business equity by definition, we instead use a binary variable for self-employment as the primary occupation of at least one of the partners in a couple household or the single household head as our indicator for entrepreneurship. We employ the same control variables x as in the main analysis. In addition we control for total net worth, i.e. gross wealth minus mortgage debt and consumer credits, and its square.

As before, we consider entrepreneurship (i.e. self-employment here) as endogenous and use parental self-employment and parental education as excluded instruments (see Section 2.2.2). Since the dependent variable is always between 0 and 1, and many observations for some of the asset classes are zero, we estimate two-limit IV tobit models. We estimate the equations separately for each asset class using the Full Information Maximum Likelihood estimator.[25]

[25] Our methodological approach is similar to Poterba and Samwick (2002), who use the tobit specification to estimate a portfolio choice model of various financial assets in the US (they also estimate the asset demand equations separately), and related to King and Leape (1998), who estimate the asset portfolio composition of US households. Both studies exclude private business equity. Fossen (2011) similarly uses the GSOEP and focuses on the share of private business equity in individual persons'

Table 2.5.5 shows the estimated tobit coefficients with heteroscedasticity robust standard errors.[26] Each column refers to the portfolio share of one of the six asset classes, roughly ordered from the most liquid (financial assets) to the least liquid (owner-occupied housing) as the dependent variable. The mean portfolio shares appear at the bottom of the table.

Income risk, as measured by lvarly I, has significant effects on the portfolio shares of two assets only. Higher income risk increases the share of financial assets (coeff. 0.39) in total gross wealth, which is consistent with our earlier result, and it decreases the share of owner-occupied housing (coeff. -0.42). Households with higher income risk thus shift their portfolio away from the most illiquid component towards the most liquid component.[27] A plausible interpretation is that the portfolio shift towards liquid assets allows households with higher income risk to smooth the fluctuations in their income while avoiding liquidity problems and high transaction costs. Together with the finding from the main analysis, namely that total net worth remains unchanged, this completes the picture: Income risk does not induce households to save more overall, but rather to hold their wealth in more liquid form.

Self-employment obviously increases the portfolio share of private business equity. Apart from that, households engaged in self-employment hold significantly larger shares of financial assets (such as stocks and bonds), tangible assets (such as gold, jewelry, and collections), and rental property, i.e. assets most households in Germany do not own at all or only in small quantities.

wealth portfolios.

[26]The coefficients of the control variables not displayed are available from the authors on request.

[27]Quantitatively, the marginal effects, evaluated at the sample means of the explanatory variables, indicate that when income uncertainty doubles, the portfolio share of financial assets, conditional on holding a positive amount, increases by 26 percentage points, and the probability of having positive financial assets increases by 11 percentage points. At the same time, the portfolio share of owner-occupied housing, conditional on a positive value, decreases by 6.9 percentage points, and the probability of owning any such property decreases by 4.9 percentage points. Households may also adjust other asset classes, but in smaller quantities, which are not significantly different from zero. The marginal effects of the other variables are available from the authors on request.

Table 2.5.5

Estimates of the Effect of Labor Income Risk on Asset Class Shares.

	Financial assets	*Tangible assets*	*Life- & priv. pension ins.*	*Private business*	*Not owner-occ. property*	*Owner-occ. property*
lvarly I	0.3868**	-0.0299	-0.1186	-0.0414	0.3107	-0.4151**
	(0.1227)	(0.1444)	(0.1171)	(0.2572)	(0.2356)	(0.2001)
ln perm. income	0.2785***	0.1529**	-0.0549	0.0207	0.3571**	-0.1543
	(0.0573)	(0.0685)	(0.0506)	(0.1275)	(0.1124)	(0.1023)
self-employed	0.4582**	1.0513***	-0.1573	2.0769***	1.1912**	-1.6250***
	(0.2250)	(0.3121)	(0.1812)	(0.4435)	(0.3943)	(0.4476)
ln net worth	-0.0154***	-0.0106**	-0.0078**	0.0012	0.0128*	0.0357**
	(0.0047)	(0.0053)	(0.0037)	(0.0072)	(0.0071)	(0.0116)
squared ln net worth	0.0000***	0.0000**	0.0000**	0.0000	-0.0000**	-0.0001**
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
further controls	✓	✓	✓	✓	✓	✓
mean portfolio shares	0.2099	0.0121	0.2427	0.0329	0.0730	0.4295
observations	6,287	6,287	6,287	6,287	6,287	6,287

Notes: Robust standard errors are in parentheses. Parental self-employment and parental education used as excluded instruments for the endogenous self-employment dummy variable.

Source: Model estimations based on the GSOEP 2002/2007; income variable estimations based on waves 1984-2007.

***Significant at 1% level. **Significant at 5% level. *Significant at 10% level.

Entrepreneurial households offset these larger portfolio shares by a significantly smaller share of owner-occupied housing. The absolute net value of owner-occupied housing is still larger for entrepreneurial households, however, because of their larger average wealth (see Table 2.2.1). The finding that unlike non-entrepreneurs, entrepreneurial households tend to diversify their assets must be explained by reasons other than entrepreneurs' higher average wealth and their lower risk aversion, as we are controlling for these factors; perhaps entrepreneurial experience induces the self-employed to invest in a broader set of assets than non-entrepreneurs. As there is no significant effect of self-employment on the value of private life- and pension insurance policies, the self-employed do not seem to substitute public pension insurance, which they lack, by private insurance, but rather invest in other assets to save for their old age, i.e. their own businesses, financial and tangible assets, and rental property.[28]

2.6. Conclusion

Empirical estimates of significant precautionary savings disappear once the heterogeneity between entrepreneurial and non-entrepreneurial households is accounted for, as reported by Hurst et al. (2010) using data from the United States. We confirm their results in a different country and revise estimates of precautionary savings in Germany. Hurst et al. (2010) find some evidence that precautionary savings account for a small fraction of wealth in the United States; in contrast, when we use the preferred specifications, our results show that no significant estimates of precautionary savings remain in Germany after controlling for entrepreneurship.

Therefore, we assert that the failure to account for entrepreneurship in an estimation of precautionary savings is even more misleading in Germany than in the

[28] The instruments seem to be sufficiently relevant, as the F-statistic of joint significance of the excluded instruments, obtained from the first stage regression of the endogenous self-employment dummy on all instruments, is 18.33.

United States. The difference in the savings behavior of entrepreneurial versus non-entrepreneurial households may become especially pronounced in countries with an extensive social security system, such as Germany, where employees receive statutory pension insurance, but entrepreneurs have to save individually for their old age consumption. Extra savings by entrepreneurs likely reflect their exclusion from the social security system. Pooling household types without controlling for entrepreneurship, therefore, misleadingly connects the higher savings of entrepreneurs to their higher income risk and leads to an upward bias in estimates of precautionary savings.

Prior studies that estimated precautionary savings in Germany, particularly Fuchs-Schündeln and Schündeln (2005) and Bartzsch (2008), have analyzed the effect of income risk on certain components of wealth, such as net financial wealth. They interpreted their results as evidence of precautionary savings, but even though their results can be replicated we demonstrate the lack of significant effects of income risk on total net worth. Instead, we show that higher income risk is associated with a portfolio shift from less liquid toward more liquid assets, but not with more saving.

Methodologically, the main innovation of our study involves our recognition of entrepreneurship as being endogenous with wealth, in line with substantive literature on the credit constraints faced by nascent entrepreneurs. This study employs IV estimators and an endogenous switching regression model, which acknowledges that entrepreneurial and non-entrepreneurial households face different regimes, to deal with this endogeneity. Moreover, we account for the self-selection of less risk-averse persons into occupations with higher income risk by controlling for new and experimentally validated measures of individual risk attitudes, separately for each partner in couple households.

Estimates of precautionary savings are important for policy design, especially for labor market, social insurance, and taxation policies, which directly affect variance in households' net income. Many governments have been tending to reduce the coverage of social insurance systems in recent decades. At the same time, collective labor agreements have lost importance in some countries such as Germany. Prior estimates of precautionary savings suggested that households would considerably increase their savings due to the rising income uncertainty. In contrast, the new findings we offer in this study, which account for the important role of entrepreneurship, imply that policy makers should expect no significant effects on the saving rate, but rather a shift of savings towards more liquid assets.

Appendix 2.A: Alternative Measures of Income Risk

To construct the income risk measure **varly II**, we divide the sample into four occupational groups (civil servants, self-employed, white-collar workers, and blue-collar workers) and five categories of education (university, higher technical college or similar, technical school or Abitur, apprenticeship, and other), both referring to the household member with the highest current income. In this way we construct 20 cells associated with a cell-specific income uncertainty, measured as the variance of the logarithm of income. Carroll and Samwick (1998) additionally consider industry sector groups. They demonstrate that the relationship between the logarithm of the variance of log income and the logarithm of the target wealth ratio, as predicted by the buffer stock-model, can be fitted well linearly. Fuchs-Schündeln and Schündeln (2005) also use this as a conventional risk measure.

Because varly II, lvarly II, and the decomposed variance components could entail substantial measurement errors, we employ, in line with prior literature, a GMM IV estimator in the wealth equations that rely on these measures and use dummy variables indicating the highest educational attainment of the household's current main earner as the excluded instruments.

The results from the IV estimations using these alternative measures of income uncertainty appear in Table 2.A.1. The findings confirm the preceding results that we obtained using the variance measures varly I and lvarly I. In Pooled 1, without accounting for entrepreneurship, the estimated coefficient of earnings risk is positive and significant both for varly II and lvarly II. When the variance is decomposed into permanent and transitory components (see below), the coefficients of both components are positive, but significant only for the transitory variance. For all the uncertainty measures, again the significance disappears and the point estimates become substantially smaller when we control for entrepreneurship by including an entrepreneurship dummy that is assumed to be exogenous (Pooled 2) or endogenous (Pooled 3, with the same additional instruments as before).

The Hansen test of overidentifying restrictions does not indicate any invalidity of the instrumental variables in the specifications that include the entrepreneurship indicator in the wealth equation, i.e. Pooled 2 and Pooled 3.[29] In specification Pooled 1, which imitates prior literature, the null hypothesis of the Hansen test is rejected. This again confirms that omitting the entrepreneurship dummy variable (and using it as an *excluded* instrument instead) leads to inconsistent results.

The instruments seem sufficiently strong for the income risk measures varly II and lvarly II, with Shea's partial R^2 of 0.16 and 0.21, respectively, in Pooled 3. For the entrepreneurship indicator, Shea's partial R^2 is only 0.016 for both variance measures. A likely reason for the higher correlation of the instruments with the variance measures is that the educational dummy IVs also define the cells to construct these variance measures, so the indicator may not be very informative. The strength of the instruments for the decomposed variance measure is unsatisfactory, as indicated by a partial R^2 of 0.0023 for the variance of permanent shocks and 0.0021 for the variance of transitory shocks. Hurst et al. (2010) report similar weak instrument problems. The results based on these variance measures therefore must be interpreted with caution; it is the main reason we prefer varly I and lvarly I, which are unaffected by these problems, over varly II, lvarly II, and decomposed variance as measures of income risk.

[29] The *p*-value of this test is 0.43 (0.41) using varly II (lvarly II) and 0.28 for the decomposed variance measures in specification Pooled 3.

Table 2.A.1

IV Estimates of the Effect of Labor Income Risk on Log Net Worth.

	Pooled 1	*Pooled 2*	*Pooled 3*
varly II	4.5642***	0.1134	0.3287
	(0.5588)	(0.7339)	(0.7421)
ln perm. income	1.3135***	1.2295***	1.0305***
	(0.1983)	(0.1913)	(0.2038)
entrepreneur		0.9574***	2.8175***
		(0.0971)	(0.5766)
observations	6,287	6,287	6,287
lvarly II	1.0942***	0.0179	0.0606
	(0.1628)	(0.1924)	(0.1952)
ln perm. income	1.5439***	1.2358***	1.0439***
	(0.1952)	(0.1901)	(0.2029)
entrepreneur		0.9631***	2.8399***
		(0.0863)	(0.5731)
observations	6,287	6,287	6,287
permanent variance	28.1237	-6.2705	-10.7988
	(23.7998)	(27.3712)	(13.0624)
transitory variance	29.3754***	5.1650	-1.3279
	(6.5946)	(16.5148)	(7.0955)
ln perm. income	0.6280	1.2504**	1.2744***
	(0.5223)	(0.5266)	(0.2674)
entrepreneur		0.7375	2.9917**
		(0.4879)	(1.2075)
observations	4,670	4,670	4,670

Notes: Robust standard errors are in parentheses. The Pooled 1 specification does not control for entrepreneurship, Pooled 2 uses controls for entrepreneurship, and Pooled 3 employs instrumented controls for entrepreneurship.

Source: Model estimations based on the GSOEP 2002/2007; income variable estimations based on waves 1984-2007. ***Significant at 1% level. **Significant at 5% level. *Significant at 10% level.

Appendix 2.B: Decomposition of Income Risk

By exploiting the panel structure of income observations contained in the GSOEP data set, we can separate the variance of innovations to permanent income from transitory shocks to income. We follow the method proposed by Carroll and Samwick (1997) for comparability.

The income process is characterized by three components. Specifically,

$$ln(y_t) = ln(G_t) + ln(y_t^P) + \varepsilon_t, \tag{2.7}$$

where $ln(G_t)$ represents demographic and human capital factors, $ln(y_t^P)$ is a permanent component, and ε_t refers to a transitory white noise component of income with variance σ_ε^2. Permanent income is modeled as a random walk:

$$ln(y_t^P) = ln(y_{t-1}^P) + \eta_t, \tag{2.8}$$

where the variance of a shock to permanent income is σ_η^2. The shocks η_t and ε_t are assumed to be uncorrelated in all periods.

To estimate σ_η^2 and σ_ε^2, we first remove the trend $ln(G_t)$ by a cross-sectional OLS regression of $ln(y_t)$ on the variables included in x^1, which yields as residuals the detrended income $\hat{y}_t$. The next step is to calculate the d-year differences of detrended income: $r_d = \hat{y}_{t+d} - \hat{y}_t$, which can be written using equations (2.7) and (2.8), after the trend has been removed, as

$$r_d = \sum_{s=1}^{d} \eta_{t+s} + \varepsilon_{t+d} - \varepsilon_t. \tag{2.9}$$

Now we can estimate the variance $r_d^2 = d\sigma_\eta^2 + 2\sigma_\varepsilon^2$. To extract all information available, we conduct household-by-household OLS regressions of r_d^2 on d and a constant using all possible differences at least three years apart (see Table 2.B.1). Thus, each household's permanent and transitory variance components can be estimated using up to 210 observations, in contrast with only 9 observations in Carroll and Samwick (1997) and Hurst et al. (2010). Households for which 3 or fewer observations are available are not considered.

Table 2.B.1

Observations Used to Estimate Components of Labor Income Risk.

d=3	*d=4*	···	*d=23*
1987-1984	1988-1984	···	2007-1984
1988-1985	1989-1985		
⋮	⋮		
2006-2003	2007-2003		
(2007-2004)			
20	19	···	1

Appendix 2.C: Additional Estimation Results

Table 2.C.1

Complete Estimation Results Using the Preferred Specification.

Dep. Variable: Log Net Worth	*varly I*	*lvarly I*	*varly II (IV)*	*lvarly II (IV)*	*decomp IV*
d2007	-0.1142**	-0.1062	-0.1112**	-0.1111**	-0.0281
	(0.0557)	(0.0806)	(0.0413)	(0.0413)	(0.0553)
female	-0.1905**	-0.1968**	-0.2035***	-0.2024***	-0.0795
	(0.0635)	(0.0754)	(0.0578)	(0.0589)	(0.1067)
Region (Base: West)					
east	-0.1942**	-0.1928**	-0.1949**	-0.1928**	-0.1286
	(0.0654)	(0.0653)	(0.0658)	(0.0657)	(0.0843)
south	0.2353***	0.2371***	0.2381***	0.2374***	0.2262**
	(0.0506)	(0.0521)	(0.0496)	(0.0496)	(0.0987)
north	0.0226	0.0252	0.0255	0.0252	0.0243
	(0.0697)	(0.0713)	(0.0680)	(0.0680)	(0.0952)
age	-0.0224	-0.0172	-0.0190	-0.0184	-0.0458
	(0.0468)	(0.0520)	(0.0385)	(0.0385)	(0.0876)
age sq.	0.0006	0.0006	0.0006	0.0006	0.0007
	(0.0006)	(0.0007)	(0.0005)	(0.0005)	(0.0010)
work exp. (10 yrs)	0.4453**	0.4518**	0.4619**	0.4558**	0.2253
	(0.1594)	(0.1714)	(0.1611)	(0.1612)	(0.3554)

Continued on next page

	varly I	*lvarly I*	*varly II (IV)*	*lvarly II (IV)*	*decomp IV*
work exp. sq. (100 yrs)	-0.0913**	-0.0909**	-0.0946**	-0.0935**	-0.0120
	(0.0393)	(0.0392)	(0.0396)	(0.0396)	(0.0923)
unemployment exp.	-0.1707**	-0.1699**	-0.1732**	-0.1724**	-0.1275
	(0.0542)	(0.0540)	(0.0530)	(0.0530)	(0.0942)
unemployment exp. sq.	0.0065	0.0064	0.0071	0.0070	0.0035
	(0.0083)	(0.0083)	(0.0081)	(0.0081)	(0.0110)
disabled	0.1045	0.1070	0.1018	0.1011	0.0233
	(0.0915)	(0.0940)	(0.0893)	(0.0893)	(0.1345)
German	0.2967**	0.3029**	0.3087**	0.3063**	0.3708**
	(0.1219)	(0.1298)	(0.1170)	(0.1168)	(0.1534)
Number of children (Base: no child)					
one child	0.0885	0.0940	0.0952*	0.0954*	0.0350
	(0.0618)	(0.0745)	(0.0569)	(0.0570)	(0.0774)
two children	0.2411**	0.2495**	0.2501***	0.2499***	0.2147*
	(0.0754)	(0.1102)	(0.0662)	(0.0662)	(0.1142)
three or more	0.3957***	0.4051**	0.4147***	0.4142***	0.3317*
	(0.1039)	(0.1367)	(0.0953)	(0.0954)	(0.1724)
Marital status (Base: Single)					
married	-0.0616	-0.0285	-0.0360	-0.0400	-0.2161
	(0.1805)	(0.2854)	(0.0886)	(0.0884)	(0.2022)
divorced	-0.3794***	-0.3713***	-0.3672***	-0.3668***	-0.3594**
	(0.0983)	(0.1015)	(0.0898)	(0.0898)	(0.1492)
separated	-0.4134**	-0.3948*	-0.3907**	-0.3894**	-0.3197
	(0.1824)	(0.2032)	(0.1557)	(0.1557)	(0.2878)
Willingness to take risks (Base: lowrisk – risk averse)					
medrisk	-0.0989	-0.0989	-0.0908	-0.0906	-0.1593
	(0.0675)	(0.0674)	(0.0663)	(0.0663)	(0.1039)
highrisk	-0.0887	-0.0885	-0.0680	-0.0662	-0.0485
	(0.1058)	(0.1057)	(0.1028)	(0.1027)	(0.1340)
Partner's characteristics					
cohabiting partner	-1.3287*	-1.3154*	-1.3958**	-1.3894**	-2.1902**
	(0.7249)	(0.7152)	(0.7031)	(0.7036)	(1.0019)
age	0.0302	0.0295	0.0332	0.0329	0.0645
	(0.0369)	(0.0364)	(0.0358)	(0.0358)	(0.0523)
age sq.	-0.0002	-0.0002	-0.0002	-0.0002	-0.0005
	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0006)
work exp. (10 yrs)	0.3487**	0.3498**	0.3559**	0.3565**	0.3897**
	(0.1245)	(0.1245)	(0.1225)	(0.1225)	(0.1800)
work exp. sq. (100 yrs)	-0.0856**	-0.0858**	-0.0874**	-0.0874**	-0.1000**
	(0.0349)	(0.0349)	(0.0344)	(0.0344)	(0.0475)

Continued on next page

	varly I	*lvarly I*	*varly II (IV)*	*lvarly II (IV)*	*decomp IV*
unemployment exp.	-0.1313***	-0.1313***	-0.1298***	-0.1301***	-0.1332**
	(0.0352)	(0.0352)	(0.0348)	(0.0348)	(0.0456)
unemployment exp. sq.	0.0040	0.0040	0.0036	0.0037	0.0059
	(0.0043)	(0.0043)	(0.0043)	(0.0043)	(0.0053)
disabled	0.0675	0.0677	0.0589	0.0591	0.0978
	(0.1094)	(0.1094)	(0.1074)	(0.1074)	(0.1774)
German	0.4055**	0.4050**	0.3985**	0.3983**	0.4182**
	(0.1271)	(0.1270)	(0.1242)	(0.1243)	(0.1684)
Partner's willingness to take risks (Base: lowrisk – risk averse)					
medrisk	-0.0298	-0.0296	-0.0257	-0.0260	-0.0468
	(0.0615)	(0.0614)	(0.0602)	(0.0603)	(0.0753)
highrisk	0.0333	0.0338	0.0457	0.0449	0.1268
	(0.1030)	(0.1029)	(0.1004)	(0.1004)	(0.1289)
entrepreneur	3.1108***	3.1049***	2.8175***	2.8399***	2.9917**
	(0.5961)	(0.5954)	(0.5766)	(0.5731)	(1.2075)
ln perm. income	1.0476***	1.0486***	1.0305***	1.0439***	1.2744***
	(0.1826)	(0.1839)	(0.2038)	(0.2029)	(0.2674)
Measures of income uncertainty					
varlyI	-0.1732				
	(1.1402)				
lvarlyI		0.0133			
		(0.3712)			
varlyII			0.3287		
			(0.7421)		
lvarlyII				0.0606	
				(0.1952)	
permanent variance					-10.7988
					(13.0624)
transitory variance					-1.3279
					(7.0955)
constant	-1.0727	-1.1999	-1.0991	-1.0748	-2.1688
	(2.1150)	(2.0149)	(2.1011)	(2.3192)	(2.6452)
observations	6,287	6,287	6,287	6,287	4,670

Notes: Robust standard errors are in parentheses. The Pooled 3 specification uses instrumented controls for entrepreneurship.

Source: Model estimations based on the GSOEP 2002/2007; income variable estimations based on waves 1984-2007. ***Significant at 1% level. **Significant at 5% level. *Significant at 10% level.

Table 2.C.2

Estimates of the Effect of Labor Income Risk on Log Non-Business Net Worth (NBNW) and Log Net Financial Wealth (NFW).

Dependent var.	*Pooled 1* *NBNW*	*Pooled 3 (IV)* *NBNW*	*Non-entrepreneurs* *NFW*	*Pooled 2* *NFW*	*Pooled 3 (IV)* *NFW*
varly I	3.0012***	-0.4276	1.8453	1.2524	1.7534
	(0.4374)	(1.1244)	(1.1530)	(0.8278)	(1.3356)
ln perm. income	1.3680***	0.9977***	1.6670***	1.7205***	1.3800***
	(0.1537)	(0.1834)	(0.1651)	(0.1564)	(0.2472)
entrepreneur		2.5378***		-0.0514	4.9327***
		(0.6465)		(0.1444)	(1.2191)
lvarly I	0.7486***	-0.0250	0.9333**	0.9682**	0.7227
	(0.0954)	(0.3703)	(0.3437)	(0.3319)	(0.4597)
ln perm. income	1.2600***	1.0020***	1.6479***	1.7124***	1.3445***
	(0.1608)	(0.1846)	(0.1644)	(0.1559)	(0.2455)
entrepreneur		2.5301***		-0.5537**	4.8892***
		(0.6450)		(0.2540)	(1.2179)
varly II	2.6302***	0.1648	1.9395**	2.0152**	2.0697**
	(0.5471)	(0.7395)	(0.6823)	(0.6710)	(0.8138)
ln perm. income	1.2648***	1.0054***	1.4207***	1.4411***	1.1879***
	(0.1922)	(0.2035)	(0.1803)	(0.1789)	(0.2286)
entrepreneur		2.2792***		-0.0489	3.4713***
		(0.6154)		(0.1036)	(0.9658)
lvarly II	0.6147***	0.0249	0.5000**	0.5301**	0.5118**
	(0.1601)	(0.1942)	(0.1778)	(0.1770)	(0.2168)
ln perm. income	1.4026***	1.0145***	1.4095***	1.4460***	1.2075***
	(0.1902)	(0.2029)	(0.1820)	(0.1778)	(0.2285)
entrepreneur		2.2931***		0.0037	3.5594***
		(0.6126)		(0.0932)	(0.9645)

Notes: Robust standard errors are in parentheses. Non-entrepreneurs refers to a sub-sample restricted to households which are not engaged in a private business. The Pooled 1 specification does not control for entrepreneurship, Pooled 2 controls for entrepreneurship, and Pooled 3 employs an instrumented control variable for entrepreneurship.

Source: Model estimations based on the GSOEP 2002/2007; income variable estimations based on waves 1984-2007. ***Significant at 1% level. **Significant at 5% level. *Significant at 10% level.

Table 2.C.3

Further Robustness Checks.

	Household head 2002	*GSOEP household-head*	*Both partners are entrepreneurs*	*Excluding mixed households*	*Self-employment indicator*	*Interacted risk dummies*	*Singles only*
varly I	1.0190	-0.4077	-0.3258	-0.0876	-0.8994	-0.0863	-0.2502
	(1.1416)	(1.1769)	(1.7026)	(1.2931)	(1.2017)	(1.1403)	(1.8302)
ln perm. income	0.9296***	1.0824***	0.5410	0.8881***	1.0577***	1.0384***	1.0787**
	(0.2016)	(0.1994)	(0.3604)	(0.2521)	(0.1974)	(0.1827)	(0.3610)
entrepreneur/	2.9987***	2.8499***	12.3879**	6.6974**	2.8316***	3.1212***	4.4090***
self-employed	(0.6255)	(0.6109)	(3.8720)	(2.2646)	(0.6103)	(0.5965)	(1.0857)
lvarly I	-0.0271	0.0742	-0.1130	0.0059	-0.0859	0.0243	-0.4432
	(0.4351)	(0.3319)	(0.5132)	(0.4093)	(0.3991)	(0.3701)	(0.6218)
ln perm. income	0.9717***	1.0501***	0.5466	0.8887***	1.0672***	1.0384***	1.0789**
	(0.2281)	(0.2099)	(0.3634)	(0.2535)	(0.1984)	(0.1839)	(0.3626)
entrepreneur/	3.0047***	2.8332***	12.4043**	6.6934**	2.8234***	3.1157***	4.4403***
self-employed	(0.6252)	(0.6129)	(3.8770)	(2.2694)	(0.6084)	(0.5958)	(1.0919)
observations	5,437	5,513	6,287	5,801	6,287	6,287	2,018

Notes: Robust standard errors are in parentheses. The estimated models are variants of the preferred Pooled 3 specification with an endogenous entrepreneurship (or self-employment) dummy variable.

Source: Model estimations based on the GSOEP 2002/2007; income variable estimations based on waves 1984-2007. ***Significant at 1% level.

**Significant at 5% level. *Significant at 10% level.

3 Do Tax Cuts Increase Consumption?[1]

The question whether people behave in accordance with the Ricardian Equivalence proposition has been tested in numerous econometric settings. While the excellent survey by Seater (1993) suggests that the data support Ricardian Equivalence, other studies are less favorable (Bernheim (1987), Shapiro and Slemrod (1995), Shapiro and Slemrod (2003), Souleles (1999), Souleles (2002), Summers and Carroll (1987)).

However, it is no surprise that the presence of progressive taxation, political uncertainty, liquidity constraints, heterogeneity in preferences and uncertainty, etc., lead to a violation of Ricardian Equivalence in survey data. Therefore, we analyze the Ricardian Equivalence proposition in a laboratory experiment where confounding factors may be controlled.

Previous experimental evidence on Ricardian Equivalence suggests that subjects' behavior in the laboratory is inconsistent with Ricardian Equivalence (Cadsby and Frank (1991), Slate et al. (1995), Di Laurea and Ricciuti (2003), Adji et al. (2009)). However, to our knowledge, all existing experimental studies on Ricardian Equivalence use overlapping generations (OLG) models as a theoretical basis for the experimental design. In contrast, we use a life cycle model of consumption to test Ricardian Equivalence in richer experimental environment that involves multi-period optimization. An important feature of our research design is that we repeat the experiment for a total of eight experimental life cycles. This allows us to study a more specific research question that has been rarely addressed in the literature in addition to testing Ricardian Equivalence in general: do consumers *learn* to behave according to the Ricardian Equivalence proposition? Assessing learning behavior is important for the implemen-

[1]This chapter is based on Meissner and Rostam-Afschar (2014).

tation of reforms such as tax cuts. For example, if people learn not to react to tax cuts, the effect of fiscal policy may decrease.

In our experiment, a Ricardian tax scheme is implemented as a tax cut in early periods of the experiment, followed by a tax increase of the same magnitude in later periods. Introducing such a tax scheme may increase the difficulty to smooth consumption for subjects.[2] Hence, any observed effects could potentially result from increased difficulty rather than a violation of the Ricardian proposition. We therefore introduce two different taxing schemes, one that increases the difficulty to smooth consumption and one that decreases it relative to a control treatment with constant taxation. In this way we can analyze the effects of difficulty and Ricardian taxation separately. This is a novel approach with regard to existing experimental studies on Ricardian Equivalence.

Our first main finding is that Ricardian taxation *does* influence consumption decisions. A nonparametric analysis shows that deviations from optimal consumption appear to be larger with the tax scheme that increases the difficulty to smooth consumption compared to the one that decreases the difficulty. Overall, deviations from optimal behavior are lowest in the treatment with constant taxation. This implies that both difficulty and Ricardian taxation affect consumption behavior.

Using structural panel data methods to estimate consumption functions allows to quantify the effect that taxation has on consumption: our second main result is that a tax benefit in early periods increases consumption by about 17% of the tax benefit on average, while a tax increase reduces consumption by 22% of the tax increase. These results are robust to variations in the difficulty to smooth consumption.

Our third main finding from individual by individual regressions is that about 32% of the subjects show behavior that is inconsistent with Ricardian Equivalence using significant reaction to tax cuts as criterion.

[2]See section 2.1 for an example.

Finally, by comparing behavior across the eight repetitions of the experiment we analyze learning effects. While subjects in our experiment appear to learn to improve their consumption decisions, our fourth main finding is that subjects do not learn to behave according to the Ricardian Equivalence proposition even after repeating the experimental life cycle eight times.

Our findings have implications for fiscal policy. Our analysis rejects the hypothesis that tax cuts do not influence consumption behavior. With the caveat that more theoretical and empirical research is needed to precisely quantify the effects of tax cuts, we conclude that the rejection of Ricardian Equivalence implies that fiscal policy could use tax cuts in times of economic slowdown as a means to stimulate consumption.

The remainder of this chapter is structured as follows. Section 3.1 describes the experimental design and the underlying theory. Section 3.2 reports our results. Section 4.6 concludes.

3.1. Theory and Experimental Design

The experiment described in the following section is based on an adapted version of the life cycle model of consumption used in Meissner (2015). One experimental life cycle lasts for $T = 25$ periods. In each period $t = (1, ..., T)$, subjects decide how much to consume (c_t) and implicitly how much to save or borrow. There is no discounting, and no interest is paid on savings or debt. Period income y_t follows an i.i.d. stochastic process and takes the values of 120 or 250 with equal probability in each period. Subjects have to pay a lump sum tax τ_t in every period. The government's budget constraint requires the amount of total taxes to be collected during the experiment to equal ϑ. The subjects' intertemporal budget constraint requires period consumption plus period savings (a_{t+1}) plus period taxes to equal period wealth, which is defined as $w_t = y_t + a_t$. Period savings are allowed to be both positive and negative. Savings in the last period (a_{T+1}) must equal zero, which implies that remaining wealth must be consumed in that period. Subjects start with initial savings, $a_1 = 1000$.[3] These two conditions ensure that the intertemporal budget constraint is binding, i.e. $\sum_{t=1}^{T} y_t + \sum_{t=1}^{T} a_t = \sum_{t=1}^{T} c_t + \sum_{t=1}^{T} \tau_t$.

Induced preferences are given by a time-separable CARA utility function: $u(c_t) = 338(1 - e^{(-0.0125c_t)})$, where the coefficient of absolute risk aversion θ is set to 0.0125.[4] We chose the parameters of our model in order to make the incentives for subjects to behave optimally as salient as possible. This requires sufficient curvature of the utility function around optimal consumption. Moreover, our parametrization ensures that the payoff function is easy to understand and guarantees an average hourly wage that complies with the rules of the laboratory.[5] Note that optimal consumption is not very sensitive to variations of θ around our parameter choice.

The subjects' objective is to choose consumption in every period to maximize the expected utility of life-time consumption. The decision problem subjects face at any period t can be written as:

$$\max_{c_t} E_t \sum_{j=0}^{T-t} u(c_{t+j}) \tag{3.1}$$

$$\text{s.t. } c_t + a_{t+1} + \tau_t = w_t, \tag{3.2}$$

$$a_1 = 1000,\ a_{T+1} = 0, \tag{3.3}$$

$$\sum_{t=1}^{T} \tau_t = \vartheta. \tag{3.4}$$

[3]One often-stated reason for the violation of Ricardian Equivalence is borrowing constraints. In order to avoid a failure of Ricardian Equivalence by design, our model has no borrowing constraints. Implicit borrowing constraints, such as debt aversion (see Meissner (2015)), might have a similar effect. To rule out these effects, we endow subjects with a positive level of wealth at the beginning of the experiment.

[4]CARA utility was chosen because this class of utility functions is defined in the negative domain. Why this is of importance will be explained later in this section. Using CARA preferences we connect to Caballero (1990, 1991) and other studies on experimental life cycle consumption/savings problems that also make use of CARA utility. See, for instance, Carbone and Hey (2004).

[5]see Section 3.1.2 and Appendix 3.B.

With CARA utility, this optimization problem can be solved analytically (Caballero (1990, 1991)). Optimal consumption in period t is equal to[6]:

$$c_t^*(w_t) = \frac{1}{T-t+1}\left[w_t + (T-t)y_p - \mathscr{T}_t - \Gamma_t(\theta\sigma_y)\right]. \tag{3.5}$$

$$\Gamma_t(\theta\sigma_y) = \sum_{j=0}^{T-t}\sum_{i=1}^{j}\frac{1}{\theta}\log\cosh\left[\frac{\theta\sigma_y}{T-t+1-i}\right]. \tag{3.6}$$

$$\mathscr{T}_t = \sum_{j=0}^{T-t}\tau_{t+j} = \vartheta - \sum_{j=1}^{t-1}\tau_j. \tag{3.7}$$

In equation (3.5), y_p denotes permanent income, which is equal to the mean of the income process, i.e. 185. $\sigma_y = 65$ is one standard deviation of the income process. Equation (3.6) is the term for precautionary saving.

Note that with respect to tax payments, optimal consumption only depends on the *sum* of current and all future tax payments $\mathscr{T}_t$. Therefore, a tax cut in period t will not affect current optimal consumption. This is because any tax cut must be followed by a later increase in taxes of the same magnitude to permit the government intertemporal budget constraint to hold. In the period after a tax cut, wealth will be higher compared to the same situation without a tax cut in the previous period. This higher wealth, in turn, is offset by the sum of current and future tax payments $\mathscr{T}_t$ which increases by the same amount, leaving optimal consumption unchanged. This implies that the size and order of each of the single lump sum tax payments $\tau = (\tau_1, \tau_2, ..., \tau_T)$ plays no role with respect to optimal consumption, as long as the sum of tax payments over the life cycle is kept constant. This is the definition of Ricardian Equivalence in our experimental environment.

In order to test Ricardian Equivalence, we vary the temporal structure of tax payments, while keeping the sum of taxes to be paid over the experimental life cycle

[6]See Appendix 3.A for the derivation of optimal consumption.

constant. Since optimal consumption is not affected by this variation, subjects have no incentive to react to tax cuts or increases and we can directly compare consumption decisions under different tax schemes.

3.1.1. Treatments

The basic idea of a Ricardian experiment in our framework is a tax cut in early periods of the experimental life cycle that is financed by a tax increase in later periods (Seater (1993)). To isolate the effect of Ricardian taxation we first run a control treatment in which tax payments are kept constant at 120 in all periods ($\vartheta = 3000$). This treatment will be compared to treatments that resemble a Ricardian tax scheme specified in more detail below.

A potential concern in our experiment is that Ricardian taxation may influence the difficulty to smooth consumption. Consider the following two-period example: in each period income can take on the values 0 and 10 with equal probability. Suppose the income realizations $y = \{0, 10\}$ are observed in periods 1 and 2, respectively. If the government introduces a tax scheme $\tau^1 = \{-5, 5\}$, net income becomes $y^{net} = y - \tau = \{5, 5\}$. In this case smoothing consumption may appear to be easier with taxation than without taxation, because taxation smoothes (net) income. On the other hand, if the government decides to do the opposite and asks for a tax scheme $\tau^2 = \{5, -5\}$, net income equals $y^n = \{-5, 15\}$ and smoothing consumption might appear more difficult with taxation than without taxation. Of course, taxation does not influence optimal consumption since lifetime income remains unchanged. In particular, the uncertainty of net income is not changed because taxation is deterministic.

In our experiment, differences in behavior between the Control and the Ricardian treatment could arise from the increased level of difficulty to smooth consumption. It would be misleading to interpret this observation as evidence against Ricardian Equivalence.

Table 3.1.1

Experimental Design of Tax Schemes for Treatments.

	Income	Control		Ricardian 1		Ricardian 2		
Period	Realization	Taxes	Net Income	Taxes	Net Income	Taxes	Net Income	$c_t^*(w_t^*)$
1	120	120	0	0	120	120	0	98.53
2	120	120	0	0	120	120	0	95.87
3	120	120	0	0	120	120	0	93.09
4	120	120	0	120	0	120	0	90.19
5	250	120	130	120	130	0	250	93.35
6	250	120	130	120	130	0	250	96.67
7	120	120	0	120	0	120	0	93.32
8	120	120	0	120	0	120	0	89.79
9	250	120	130	120	130	0	250	93.70
10	120	120	0	120	0	120	0	89.74
11	250	120	130	120	130	120	130	94.19
12	250	120	130	120	130	120	130	98.97
13	250	120	130	120	130	120	130	104.13
14	120	120	0	120	0	120	0	98.89
15	250	120	130	120	130	120	130	105.02
16	120	120	0	120	0	120	0	98.79
17	120	120	0	120	0	240	−120	91.89
18	250	120	130	240	10	120	130	100.43
19	250	120	130	240	10	120	130	110.25
20	250	120	130	240	10	120	130	121.81
21	250	120	130	120	130	120	130	135.87
22	250	120	130	120	130	120	130	153.75
23	120	120	0	120	0	240	−120	134.99
24	250	120	130	120	130	120	130	173.91
25	120	120	0	120	0	240	−120	132.84
$E[(y-\mu_y)^2]$	4,225		4,225		4,225		4,225	

Source: One exemplary realization of the income stream of own experimental design.

To account for this, we design two Ricardian treatments that differ with respect to the difficulty to smooth consumption. This enables us to distinguish the effect of Ricardian taxation from the difficulty of smoothing consumption.

In the first Ricardian treatment (Ricardian 1) tax cuts in the beginning of the experiment are only given when subjects observe a *low* (i.e. $y_t = 120$) income realization (see Table 3.1.1). Analogously, tax increases in the later periods of the experiments are only implemented when subjects observe a *high* (i.e. $y_t = 250$) income realization. If subjects react to changes in net income, this treatment should be easier to play than the Control treatment, because this taxing scheme essentially smooths net income.

In the second Ricardian treatment (Ricardian 2) tax cuts in the beginning of the experiment are only received when subjects observe a *high* income realization. Tax increases in later periods are only implemented when subjects observe a *low* income realization. This makes net income less smooth and therefore may make it harder for subjects to smooth consumption. Table 3.1.1 shows the different tax schemes for one exemplary realization of the income stream.

Note that the timing of the incidence of these tax rates is unknown and varies with the stochastic income process. However, this does not introduce additional uncertainty because, as shown above, only the sum of taxes over one life cycle is relevant for optimal consumption. This sum is deterministic and kept constant across treatments.

We repeat the experiment for a total of eight independent life cycles (rounds) consisting of 25 periods. Each subject plays eight repetitions of the same treatment, though with a different realization of the income process in each round. Using this approach we are able to assess learning behavior. Moreover, we increase the robustness of our findings by ensuring that observed behavior is not merely an artifact of one particular realization of the income process. At any given period during the experiment, subjects in the different treatments observe the same realization of the income process. In this way, we can directly compare behavior between subjects across treatments. This is because optimal consumption is the same across treatments when the same realization of the income stream is observed.

3.1.2. Experimental Procedures

The experiment was programmed and conducted with the software z-Tree (Fischbacher (2007)). The experimental software is an adapted version of the software used in Meissner (2015).[7] In the instructions, consumption was explained to the subjects as buying "points" by spending the experimental currency "Taler", in which income was denoted. The experimental currency was converted to points by the utility function specified above. Subjects were informed about the exact form of the utility function. Furthermore, they were given a graph of the function and a table with relevant function values. The advantage of framing consumption as buying points is that negative consumption can be explained as selling points in return for experimental currency.

At the beginning of the experiment, subjects were given time to read the instructions, which were then read aloud by the experimenter. After this, subjects completed a quiz about the content of the instructions. The correct answers to all questions were then read aloud before subjects started the actual experiment.

In each period of the experiment, subjects were asked to input consumption decisions in an interface that displayed period income, savings from the last period, wealth, and taxes. The interface showed the history of all previous decisions and relevant values, such as savings, wealth, taxes, the sum of taxes paid so far, and the number of purchased points and accumulated points. Before a consumption decision was submitted, subjects were informed about how it would translate into points and the amount of savings that would be available in the next period. After this information was displayed, subjects had the opportunity to start over; that is, they could specify a different level of consumption and check its implications. In the final period of each life cycle, the program automatically spent that period's wealth minus taxes as consumption.[8] Then, subjects were informed on a separate screen about the amount of points they purchased during the round. At the end of the experiment, two of the eight experimental life cycles were randomly chosen to be payoff relevant. After the actual experiment, subjects

[7] A screenshot of the experimental interface is provided in Appendix 3.B.
[8] This is a consequence of our final period condition given in (3.3).

were asked to fill out a questionnaire that contained incentivized lottery choices, which assessed individual risk aversion.

Subjects' payoffs were determined by a pre-announced linear function of the amount of points purchased in the two relevant rounds. Subjects received a show-up fee of 5 Euro and earned 17.79 Euro on average.

The experiment was conducted at the laboratory of the Technical University of Berlin. Subjects were recruited using ORSEE (see Greiner (2004)). A total of 133 subjects participated. Most of the subjects were undergraduate students in the field of economics or engineering. About one third of the subjects were female.

3.2. Data Analysis

To identify the effect that a tax cut has on consumption, we employ two strategies. First, we directly compare deviations from optimal behavior across treatments to identify treatment effects. Second, we run panel regressions to measure the effect of taxes on the deviation from optimal consumption. We drop all rounds in which subjects consume less than -100 ($<$ 1st percentile) or more than 500 ($>$ 99th percentile) in any period of the round.[9]

3.2.1. Deviations from Optimal Behavior

As a first step in analyzing our experimental data, we examine deviations from optimal behavior.[10] Deviations from optimal consumption can be assessed with the following measure (see Ballinger et al. (2003), Meissner (2015)):

[9]Subjects who consume above 500 or below -100 in any period of one round could hardly recover from the associated utility loss in that round, and therefore had no incentive to choose one spending decision over another. Since consumption choice is dependent within rounds, we had to drop all consumption choices of the round in which subjects consumed more than 500 or less than -100. The amount of dropped rounds is roughly equally distributed across all three treatments.

[10]Recall that the intertemporal budget constraint implies that total consumption is the same for each subject in a given round and depends only on the realization of net income plus initial endowment, i.e. $\sum_{t=1}^{T} c_t = \sum_{t=1}^{T} y_t - \sum_{t=1}^{T} \tau_t + \sum_{t=1}^{T} a_t$.

$$m_1 = \sum_{t=1}^{T} |c_t^*(w_t) - c_t| \tag{3.8}$$

where $c_t^*(w_t)$ is conditionally optimal consumption (depending on current wealth w_t), and c_t is observed consumption in period t. This measure is the sum of absolute deviations from conditionally optimal consumption for one subject and over one experimental life cycle. Indices for subjects and rounds are dropped to facilitate legibility. As already discussed, all subjects observe the same realizations of the income stream. Therefore we can also compare deviations from unconditionally optimal consumption. We do this by use of the following measure:

$$m_2 = \sum_{t=1}^{T} [u(c_t^*(w_t^*)) - u(c_t)], \tag{3.9}$$

where $c_t^*(w_t^*)$ denotes unconditionally optimal consumption at period t as a function of optimal period wealth w_t^*. This measure can be interpreted as the utility loss that results from suboptimal consumption. With this measure we can assess the effect of Ricardian taxation on welfare in our experimental environment.

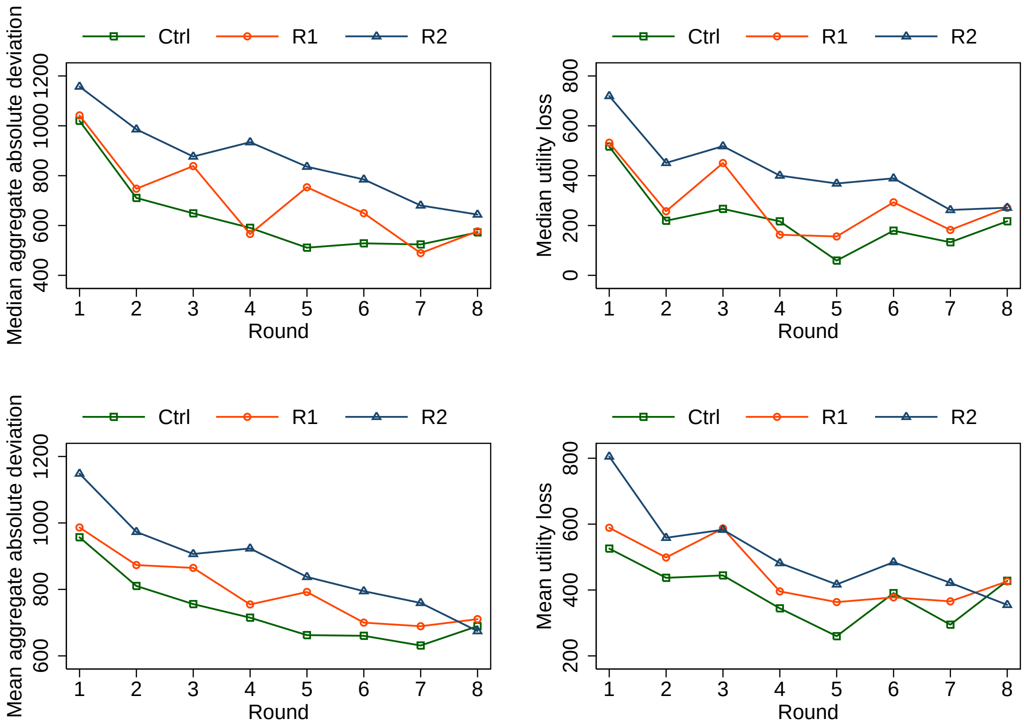
Figure 3.1 shows the medians and means of the measures m_1 and m_2 by treatments and rounds. At first glance subjects appear to perform best in the Control treatment. Subjects in the Ricardian 2 treatment have higher deviations from optimal consumption and a higher utility loss compared to subjects in the Control treatment. Subjects in the Ricardian 1 treatment seem to be somewhere between the Control and Ricardian 2 treatments.

This intuition can be confirmed by examining the total effect; that is, the measures m_1 and m_2 averaged for each subject over the eight rounds of the experiment. For both measures, subjects perform significantly better in the Control treatment compared to subjects in Ricardian 1 (p-values from a Mann-Whitney U-test are provided in Table 3.2.2). Subjects in the Ricardian 2 treatment have significantly higher absolute deviations from optimal consumption and higher utility loss compared to both Ricardian 1 and Control (see column *Total* in Table 3.2.2).

Figure 3.1

Deviations from Optimal Consumption and Utility Loss.

Source: Own calculations based on the data collected in this experiment.



Examining the differences across treatments in the specific rounds reveals that this relationship is significant for most, but not all rounds. Absolute differences from optimal consumption (measure m_1) are significantly higher in Ricardian 2 compared to Control in all but the last rounds. The picture is not as clear when comparing m_1 between Ricardian 1 and Control. Here, m_1 is significantly higher in Ricardian 1 compared to Control in four out of eight rounds. Comparing m_1 between Ricardian 1 and Ricardian 2 reveals that absolute deviations from optimal consumption are significantly higher in Ricardian 2 in all but the last round. Overall this finding confirms the above intuition, though the evidence is not very strong in comparing Ricardian 1 and Control at the round level.

Comparing measure m_2 (utility loss) at the round level across the three different treatments yields similar results. Utility loss is significantly higher in Ricardian 2 than in Control in all but the last round. Measure 2 is significantly higher in Ricardian 1 compared to Control in three out of eight rounds. With respect to the Ricardian treatments, utility loss in Ricardian 2 is significantly higher than in Ricardian 1 in six out of eight rounds.

Deviations from optimal consumption as well as utility loss appear to decline over the eight rounds of the experiment. This finding would imply that subjects learn to improve their consumption decisions by repeating the experiment. This effect might be important. Therefore, we investigate learning behavior in more detail in Section 3.2.3.

Table 3.2.2

Deviations from Optimal Consumption and Utility Loss.

		Round							
	Total	1	2	3	4	5	6	7	8
Median									
m_1 Ctrl	586.37	1020.06	710.63	648.85	590.71	511.04	528.51	524.14	572.39
m_1 R1	696.93	1041.94	747.77	838.44	565.97	753.62	649.57	489.26	576.53
m_1 R2	848.90	1157.44	985.97	876.65	934.42	835.99	785.01	680.49	644.13
Mean									
m_1 Ctrl	732.89	956.95	810.44	755.91	715.01	662.57	660.47	631.25	689.43
m_1 R1	788.37	986.54	873.30	864.78	754.91	792.37	700.07	689.25	710.61
m_1 R2	866.04	1148.53	973.18	906.70	923.39	837.70	794.79	759.42	674.53
p-Value									
R1-Ctrl	0.00	0.82	0.00	0.00	0.52	0.00	0.04	0.25	0.23
R2-Ctrl	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67
R1-R2	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.25
Median									
m_2 Ctrl	210.79	516.72	219.06	266.78	216.78	59.27	179.26	132.85	216.98
m_2 R1	288.05	532.20	257.17	450.73	162.96	156.07	293.17	182.22	271.07
m_2 R2	389.49	719.71	451.17	518.33	400.28	368.53	389.49	262.35	271.44

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	Total	Round							
		1	2	3	4	5	6	7	8
Mean									
m_2 Ctrl	389.79	525.78	437.03	444.28	344.41	259.92	390.52	294.73	427.96
m_2 R1	444.73	589.00	498.80	587.03	395.80	363.34	377.77	365.57	426.21
m_2 R2	502.01	805.39	558.59	583.06	481.79	417.04	484.61	421.83	354.83
p-Value									
R1-Ctrl	0.00	0.18	0.00	0.00	0.35	0.00	0.91	0.19	0.82
R2-Ctrl	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.71
R1-R2	0.00	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.78

Notes: Medians and means of the measures m_1 and m_2 by treatments and rounds. P-values were calculated by use of Mann-Whitney U-tests.

Source: Own calculations based on data collected in this experiment.

In summary, subjects in treatments with Ricardian taxation have higher deviations from optimal consumption and a higher utility loss than subjects in the Control treatment. Moreover, subjects with a net income stream that is difficult to smooth (Ricardian 2) appear to perform worse than subjects with a net income stream that is easy to smooth. These findings imply that subjects react to both difficulty to smooth consumption and Ricardian taxation. However, the finding that subjects in Ricardian 1 appear to perform worse than subjects in the Control treatment suggests that the effect of Ricardian taxation outweighs that of the decreased difficulty to smooth consumption. One mechanism that would result in such a finding is that subjects do not internalize the government budget constraint but instead treat a tax benefit as additional wealth.

3.2.2. Panel Regression

In order to assess the magnitude of the effect that Ricardian taxation has on consumption, we run structural panel regressions. Our baseline specification derived from equation (3.5) is

$$c_{itr} = \beta_1 \tilde{y}_{tr} + \beta_2 \tilde{a}_{itr} + \beta_3 (T-t) \tilde{y}_p - \beta_4 \tilde{\mathscr{T}}_{itr} + \beta_5 \tilde{\Gamma}_{tr}(\theta \sigma_y), \tag{3.10}$$

for all subjects $i = 1,\ldots,127$, periods $t = 1,\ldots,25$, and rounds $r = 1,\ldots,8$ where $\tilde{\mathcal{F}} = \frac{1}{(T-t+1)}\mathcal{F}$, and $\mathcal{F}$ represents the variables of equation (3.5), where $w_t = y_t + a_t$. We transform the regressors that are derived from the theoretical consumption function in this way to account for the time dependency of optimal consumption. Moreover, this simplifies the interpretation of the corresponding coefficients. If subjects behave optimally, or deviate randomly from optimal consumption, e.g. due to calculation errors, the estimated coefficients β_1 to β_5 should be time invariant and equal to one. In equation (3.11), we extend our baseline specification to account for tax effects by including dummy variables indicating a tax rebate $d_{0.\text{tx}}$ and a tax increase $d_{240.\text{tx}}$. Moreover, we control for treatment using treatment dummies ($dR1, dR2$) and subject characteristics X_i such as risk preference, gender, and subject of academic study[11]. Finally, we include round dummies, a constant, period, and period squared. The latter two variables should capture any time trend that is beyond the theoretical.

Since all these additional regressors do not show up as variables in the optimal consumption function, the corresponding coefficients should not be significantly different from zero if subjects behave optimally or deviate randomly from optimal consumption.

$$
\begin{aligned}
c_{itr} \quad = \quad & \beta_1 \tilde{y}_{tr} + \beta_2 \tilde{a}_{itr} + \beta_3 (T-t)\tilde{y}_p - \beta_4 \tilde{\mathscr{T}}_{itr} + \beta_5 \tilde{\Gamma}_{tr}(\theta\sigma_y) \\
& + \beta_{0.\text{tx}} \text{d}_{0.\text{tx}} + \beta_{240.\text{tx}} \text{d}_{240.\text{tx}} + \beta_6 \text{dR1}_i + \beta_7 \text{dR2}_i \\
& + \beta_8 \text{X}_i + \sum_{k=1}^{8} \beta_{r.k} \text{d}_{r.k} + \beta_9 t + \beta_{10} t^2 + \text{constant.}
\end{aligned} \tag{3.11}
$$

Table 3.2.3 shows what factors are associated with observed consumption (c_{itr}).[12] Individual specific characteristics, such as ability to use computer software, could bias our estimates. To obtain consistent results, we estimate a fixed effects (FE) specification that is presented along with the OLS specification. In both regressions the same

[11] Subjects who are not students, i.e. unemployed or employees, are subsumed under *other* in Table 3.2.3.

[12] We suppress henceforth subject and round indices to facilitate legibility.

set of regressors are included. Moreover, both specifications are estimated with robust standard errors clustered at the subject level.

Our specification allows us to test whether subjects behave according to the theoretical prediction of our life cycle model of consumption. In both specifications the estimated coefficients are similar. In the following analysis we will therefore focus on the more robust FE estimation. Recall that if subjects behave optimally or deviate randomly from optimal consumption, the estimated coefficients β_1 to β_5 should equal one.

Table 3.2.3

Panel Regression on Observed Consumption.

	OLS		FE	
$\tilde{y}$	1.152***	(0.04)	1.204***	(0.04)
$\tilde{a}$	0.701***	(0.01)	0.892***	(0.02)
$-\tilde{\mathscr{T}}$	0.294***	(0.04)	0.425***	(0.04)
$\tilde{\Gamma}(\theta\sigma_y)$	1.138	(0.62)	1.571	(0.58)
$(T-t)\tilde{y}_p$	1.052	(0.07)	1.190***	(0.07)
d_0.tx	19.88***	(3.72)	20.53***	(3.72)
d_240.tx	−26.35***	(2.68)	−26.60***	(2.68)
t	−1.271***	(0.46)	−1.110**	(0.44)
t^2	0.0204	(0.02)	0.0229	(0.02)
Treatment (base: Control):				
dR1	−8.350***	(2.24)		
dR2	−11.73***	(2.82)		
Round dummies (base: round 1):				
$d_{r.2}$	5.825***	(2.17)	5.395**	(2.49)
$d_{r.3}$	−1.665	(2.26)	1.730	(2.68)
$d_{r.4}$	3.758*	(2.22)	2.923	(2.69)
$d_{r.5}$	5.119**	(2.16)	5.304**	(2.55)
$d_{r.6}$	0.455	(2.22)	3.341	(2.56)
$d_{r.7}$	2.145	(2.24)	3.255	(2.51)
$d_{r.8}$	1.031	(2.10)	4.556*	(2.47)
Risk aversion (base: low):				
high	−3.007	(2.46)		

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	OLS		FE	
medium	−2.331	(2.63)		
Gender (base: male):				
female	4.078*	(2.09)		
Subject (base: economics):				
engineering	1.524	(2.49)		
otherscience	6.014**	(2.85)		
other	4.234	(2.89)		
Constant	−68.36***	(12.86)	−90.28***	(13.23)
Adjusted R^2	0.355		0.407	
Overall R^2				0.338

Notes: The dependent variable is observed consumption (c_{itr}). Cluster robust (subject level) standard errors are in parentheses. Significance levels of the first five regressors refer to tests of the H_0 that the respective variable is equal to 1, significance levels are * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All other significance levels refer to tests of the H_0 for which the respective variable is equal to zero; significance levels are * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Source: Own calculations based on data from our experiment.

For β_1, the data reject this hypothesis. Table 3.2.3 shows that the coefficient for current income is significantly higher than one. This implies that individuals react to changes in current income more strongly than optimal. While this finding conflicts with the theory, it is consistent with the notion of excess sensitivity from the empirical literature.[13] Subjects consistently do not only consume too much out of current income, but also out of expected income. The estimate for the coefficient on $(T-t)\tilde{y}_p$ is of similar size and statistically different from one in the FE specification. Subjects do not seem to have correct intuition about what the levels of current and expected income imply for their decision problem, or they simply overreact to income changes.

The coefficient on savings indicates that subjects do not spend enough out of wealth since the estimate is statistically smaller than one. This could again stem from diffi-

[13] See e.g. Flavin (1981); Hall and Mishkin (1982); Souleles (1999); Shea (1995); Parker (1999). Several explanations for excess sensitivity are debated in the literature; in particular, myopic behavior, liquidity constraints, and buffer-stock saving.

culties in assessing magnitudes, or it could reflect a social norm that deems parsimony as a good thing.

The amount of future due taxes might not have been assessed correctly either. The coefficient is about half of what theory predicts. A ceteris paribus interpretation implies that one Taler less (the variable is defined as -1 times the original variable) of future taxes to be paid increases spending by 0.425 Taler instead of one.

The impact of precautionary saving on consumption should be captured by the coefficient on $\tilde{\Gamma}(\theta\sigma_y)$. While the estimated coefficient is approximately twice as high as theory would predict, it is not statistically different from one in both specifications.

The coefficients of our particular interest are $\beta_{0.tx}$ and $\beta_{240.tx}$ because they indicate how subjects react to a tax rebate ($\tau_t = 0$) and a tax increase ($\tau_t = 240$), respectively. In the FE specification, the estimated coefficient $\beta_{0.tx}$ is 20.53 (p-value: < 0.01). This implies that a tax rebate of 120 Taler is associated with an increase in consumption of 20.53 Taler, or 17% of the tax rebate. In turn, the estimated coefficient corresponding to a tax increase ($\beta_{240.tx}$) is -26.6 (p-value:< 0.01), implying that an increase in taxes of 120 Taler is associated with a decrease in consumption of 26.6 Taler, or about 22% of the tax increase. These results give account of the average effect of taxation in both Ricardian treatments.

However, we are also interested in whether reactions to taxation differ by treatment. We can identify the effects of Ricardian taxation separately by including interaction terms of $d_{0.tx}$ and $d_{240.tx}$, with binary variables indicating treatment Ricardian 1 and Ricardian 2, respectively.

In treatment Ricardian 1, the estimated coefficient corresponding to a tax rebate is 12.09 (p-value:< 0.01) and the coefficient corresponding to a tax increase is -29.30 (p-value:< 0.01).[14] In treatment Ricardian 2 the coefficient corresponding to a tax rebate is 28.37 (p-value:< 0.01) and that corresponding to a tax increase is -24.39 (p-value:< 0.01).[14] These estimates indicate that subjects react to taxes in a similar way in both treatments. However, the coefficient associated with a tax rebate is significantly

[14]Not reported in Table 3.2.3 to avoid cluttering the exposition.

higher in the Ricardian 2 treatment compared to Ricardian 1. No significant difference is observed between the coefficients corresponding to a tax increase.

Our results suggests that taxes have a significant and strong effect on consumption. This is in stark contrast with the theoretical predictions, and thus we conclude that the Ricardian proposition is resoundingly rejected by the experimental data. An early tax benefit causes a significant increase in consumption on average. The corresponding later increase in taxation causes a significant decrease in consumption on average.

Our findings account for the average effect of Ricardian taxation on consumption. However, there appears to be some heterogeneity in our experimental data that cannot be controlled for, even with a fixed effects specification. Generally, this occurs when subjects employ different strategies to choose consumption. To identify the share of subjects that behaves in accordance with Ricardian Equivalence, we therefore run individual OLS regressions for each subject, using the same specification as above. We classify the subjects' behavior as follows: if either the coefficient associated with a tax benefit ($\beta_{0.tx}$), the coefficient associated with a tax increase ($\beta_{240.tx}$), or both are significantly different from zero at the 5% level, a subject's behavior is inconsistent with Ricardian Equivalence. In this conservative way, we find that the behavior of approximately 62% of our subjects can be classified as being not consistent with Ricardian Equivalence. If we only require the coefficient associated with a tax benefit ($\beta_{0.tx}$) not to be statistically different from zero at the 5% level, about 32% of our subjects are classified as being not consistent with Ricardian Equivalence.

We repeat the individual by individual regressions, this time testing whether our subjects follow a simple heuristic (rule-of-thumb) instead of behaving fully rational. In particular, we test whether subjects consume a constant fraction out of their current level of net wealth, i.e. $a_t + y_t - \tau_t$. We do this by interacting current net wealth with period dummies and regress this variable along with round dummies on observed current consumption.[15] Testing whether the coefficients of the interaction terms are the same, we find that consuming a constant fraction out of net wealth is rejected

[15]Note that we drop the interaction with period 24 and 25 from this test to avoid end game effects.

for about half of the subjects for whom Ricardian behavior is also rejected. In total, rule-of-thumb behavior is rejected for about half of our subjects. For about 1/3 of our subjects, we reject both, rule-of-thumb behavior and behavior consistent with Ricardian Equivalence and conclude that these subjects follow other rules. For about 16% of the subjects neither Ricardian behavior nor rule-of-thumb can be rejected.

3.2.3. Learning

It has been shown in many experiments on intertemporal optimization that subjects tend to improve their decision-making towards optimality when playing the experiment repeatedly.[16] Figure 3.1 of Section 3.2.1 suggest that this may also be the case in our experiment. In order to formally test whether subjects improve their consumption decisions, we analyze within subject differences of absolute deviations from optimal consumption (Measure m_1) across rounds.

Table 3.2.4 contains the median of within subject differences in absolute deviations from optimal consumption between round r and the first round ($m_1^1 - m_1^r$), as well as the median difference in absolute deviations from optimal consumption between two consecutive rounds ($m_1^{r-1} - m_1^r$). There is a significant reduction in deviations from optimal consumption between rounds one and two, and a marginal significant reduction between rounds six and seven (p-value = 0.0687). However, all rounds show significant improvement of consumption decisions in comparison to the first round. Hence subjects seem to be able to improve their consumption decisions with repetition of the experiment.

A question that has not been answered in existing experimental studies on the Ricardian Equivalence so far is whether subjects learn to behave according to the prediction of the Ricardian Proposition. That is whether they learn *not* to react to tax cuts and tax increases with their consumption choices. To answer this question, we ran two additional specifications of the panel regressions introduced in Section 3.2.2. In spec-

[16] See for instance Ballinger et al. (2003), Carbone and Hey (2004), Brown et al. (2009), Meissner (2015).

Table 3.2.4

Change of Deviations from Optimal Consumption over Rounds.

Round	Median $m_1^1 - m_1^r$	p-Value	Median $m_1^{r-1} - m_1^r$	p-Value
2	118.66	(0.00)	118.66	(0.00)
3	140.31	(0.00)	22.08	(0.26)
4	154.91	(0.00)	44.99	(0.11)
5	243.16	(0.00)	31.14	(0.19)
6	287.02	(0.00)	9.87	(0.49)
7	288.44	(0.00)	44.6	(0.07)
8	301.09	(0.00)	7.34	(0.88)

Notes: Median differences in m_1 between consecutive rounds and to the first round. P-Values of Wilcoxon matched-pairs signed-ranks test in parentheses. The null hypothesis is that both distributions are the same.

Source: Own calculations based on data from our experiment.

ification (1) in Table 3.2.5 we include interaction terms of the tax dummy for a tax cut and a tax increase with a dummy indicating each round, respectively. This allows to see whether there is a reduction in the reaction to a tax cut or tax increase, relative to the baseline. Only two of the coefficients on these interaction terms are significant at the 5% level (both tax cut and tax increase interacted with round eight). This implies that we observe a significant reduction in the reaction to tax cuts and tax increases, relative to the first round, in only the last of eight rounds.

Obviously, a reduction in the reaction to tax cuts and tax increases does not imply that reactions disappear entirely. Therefore we also run specification (2) in which we exclude as regressors the dummies for tax cuts and tax increases, respectively. The coefficients of the interactions of the dummies for a tax-cut and a tax-increase with round dummies may then be interpreted as the absolute effect taxation has on consumption in each particular round. The absolute values of the coefficients on these interactions are decreasing over rounds. However, all coefficients are significantly different from zero. This implies that taxation affects consumption in all eight rounds.

Summing up, we observe that subjects generally improve their consumption decisions towards optimality when repeating the experiment. We find some evidence that the extend to which subjects react to tax increases and tax cuts decreases with rounds. However, even after eight rounds of learning, tax cuts and increases have a significant impact on consumption choices. This implies that subjects do not learn to comply with the Ricardian Equivalence in the eight repetitions of our experiment.

Table 3.2.5

Change of Tax Effect in Panel Regression on Observed Consumption.

	FE (1)		FE (2)	
$\tilde{y}$	1.205***	(0.04)	1.212***	(0.04)
$\tilde{a}$	0.895***	(0.02)	0.890***	(0.02)
$-\tilde{\mathscr{T}}$	0.427***	(0.05)	0.525***	(0.04)
$\tilde{\Gamma}(\theta\sigma_y)$	1.627	(0.58)	1.532	(0.58)
$(T-t)\tilde{y}_p$	1.199***	(0.07)	1.195*	(0.07)
$d_{0.tx}$	30.66***	(8.81)		
$d_{240.tx}$	−30.48***	(5.48)		
Interaction of tax cut and round (base: round 1):				
$d_{r.2} \times d_{0.tx}$	−8.692	(8.72)	20.33***	(6.16)
$d_{r.3} \times d_{0.tx}$	−7.156	(8.73)	21.58***	(5.02)
$d_{r.4} \times d_{0.tx}$	−10.46	(7.10)	18.44***	(5.01)
$d_{r.5} \times d_{0.tx}$	−7.114	(8.18)	21.91***	(5.38)
$d_{r.6} \times d_{0.tx}$	−15.83*	(8.83)	13.21***	(4.23)
$d_{r.7} \times d_{0.tx}$	−13.27	(8.62)	15.78***	(4.34)
$d_{r.8} \times d_{0.tx}$	−15.65**	(7.84)	13.20***	(3.94)
Interaction of tax increase and round (base: round 1):				
$d_{r.2} \times d_{240.tx}$	−2.568	(5.89)	−30.84***	(3.91)
$d_{r.3} \times d_{240.tx}$	7.632	(5.27)	−18.29***	(4.22)
$d_{r.4} \times d_{240.tx}$	0.0378	(5.95)	−27.94***	(3.61)
$d_{r.5} \times d_{240.tx}$	3.030	(5.57)	−25.17***	(3.59)
$d_{r.6} \times d_{240.tx}$	7.243	(5.06)	−21.07***	(3.39)
$d_{r.7} \times d_{240.tx}$	2.985	(5.54)	−25.21***	(3.15)
$d_{r.8} \times d_{240.tx}$	10.43**	(5.16)	−17.45***	(3.21)
Round dummies (base: round 1):				
$d_{r.2}$	6.304**	(2.41)	5.825**	(2.49)
$d_{r.3}$	1.696	(2.74)	1.454	(2.72)
$d_{r.4}$	3.747	(2.71)	3.368	(2.79)
$d_{r.5}$	5.619**	(2.50)	5.113*	(2.60)
$d_{r.6}$	4.077	(2.46)	3.528	(2.52)

Continued on next page

	FE (1)		FE (2)	
$d_{r.7}$	4.117^{*}	(2.39)	3.554	(2.50)
$d_{r.8}$	5.001^{**}	(2.40)	4.631^{*}	(2.45)
t	-1.147^{***}	(0.44)	-0.958^{**}	(0.43)
t^2	0.0257	(0.02)	0.0134	(0.02)
Constant	-91.91^{***}	(13.43)	-77.84^{***}	(12.45)
Adjusted R^2	0.408		0.403	
Overall R^2	0.339		0.337	

Notes: Notes: The dependent variable is observed consumption (c_{itr}). Cluster robust (subject level) standard errors are in parentheses. Significance levels of the first five regressors refer to tests of the H_0 that the respective variable is equal to 1, significance levels are * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All other significance levels refer to tests of the H_0 for which the respective variable is equal to zero; significance levels are * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Source: Own calculations based on data from our experiment.

3.3. Concluding Remarks and Discussion

In this chapter we test whether the Ricardian Equivalence proposition holds in a life cycle consumption laboratory experiment.

Our first main finding is that Ricardian Equivalence does not hold generally. A non-parametric analysis shows that deviations from optimal consumption as well as utility loss appear to be larger with the tax scheme that increases the difficulty to smooth consumption compared to the one that decreases difficulty to smooth consumption. Overall, deviations from optimal behavior are lowest in the treatment with constant taxation. This implies that both difficulty and Ricardian taxation affect consumption behavior.

Our second main result from panel data estimations is that Ricardian taxation has a significant and strong effect on consumption in our sample. A tax benefit in early periods increases consumption by about 17% of the tax benefit on average, while a tax increase causes a reduction by 22% of the tax increase.

Our third main result is that the behavior of a significant portion of our subjects can be classified as inconsistent with the Ricardian Equivalence proposition. A conservative estimation suggests that this portion is about 62%. This finding uses evidence on both tax cuts and increases. In survey or register data, often only a tax cut is observed for any one individual. If we test for compliance with Ricardian Equivalence based only on tax cuts, about 32% of our subjects are classified as being not consistent with Ricardian Equivalence.

This finding is similar to those in other studies that employ very different methods. For instance, Campbell and Mankiw (1991) use aggregate data to find the fraction of consumers who respond to changes in current disposable income to be in the range of 35% to 50% for the United States and lower fractions in other countries. Shapiro and Slemrod (1995) find from a telephone survey that 43% of those who responded said they would spend most of the extra take-home pay.

A novel feature of our experiment is that it allows to analyze learning behavior. Our fourth main result is that subjects do not learn to behave in accordance to Ricardian Equivalence. Although subjects in our experiment appear to learn to improve their consumption decisions, their reaction to tax cuts and tax increases remain significant, even after eight repetitions of the experiment.

These results have important implications for theoretical models that build on households's intertemporal consumption choices. Not accounting for a substantial portion of consumers reacting to tax cuts would bias any conclusion based on the assumption of pure Ricardian Equivalence and understate the role fiscal policy plays. Among the studies that recognize this fact and explicitly model two types of consumers are Mankiw (2000) and Galí et al. (2004). The latter study shows that the Taylor principle may become too weak a criterion for stability when the share of rule-of-thumb consumers is large.

The finding that consumers increase consumption when taxes are cut has important policy implications. In our experimental environment, Ricardian taxation leads to welfare losses compared to constant taxation. However, this does not necessarily need to be the case in the real world, where general equilibrium effects—deliberately abstracted from in our model—may play a role. Therefore, future research is needed that appropriately describes the role of fiscal policy to give policy advice. In particular, the magnitude of effects on consumption needs to be quantified. This future research could corroborate the conjecture that in times of economic slowdown, tax cuts could serve as a means to get the economy back on track.

Appendix 3.A: Optimal Consumption with CARA Preferences

Following Caballero (1990, 1991), assume that optimal consumption follows an AR(1)-Process:

$$c_{t+1} = c_t + \Gamma_t + \nu_{t+1}, \tag{3.12}$$

Since the income generating process follows a discrete uniform distribution, the error of the consumption process should follow the same distribution. Define the stochastic error as $\nu_{t+1} = \zeta_{t+1}\varepsilon_{t+1}$ with

$$\varepsilon_{t+1} = \begin{cases} 1 & \text{with probability } 1/2 \\ -1 & \text{with probability } 1/2. \end{cases}$$

Where ζ_t is the standard deviation of consumption in period t. From the numerical solution[17], we observe that ζ_t grows between periods t and $t+1$ in the following way:

$$\zeta_{t+1} = \frac{T-t+1}{T-t}\zeta_t. \tag{3.13}$$

We can therefore write:

$$c_{t+1} = c_t + \Gamma_t + \frac{T-t+1}{T-t}\zeta_t\varepsilon_{t+1}, \tag{3.14}$$

Now we need to pin down Γ_t. We start from the Euler equation

$$1 = E_t[\exp^{-\theta(c_{t+1}-c_t)}]. \tag{3.15}$$

Plugging (3.12) in (3.15) yields

$$\Gamma_t = \frac{1}{\theta}\log\{E_t[\exp^{-\theta\nu_{t+1}}]\} = \tag{3.16}$$

[17] We followed Carroll (2011a) to obtain the numerical solution.

$$= \frac{1}{\theta} \log[1/2 \exp^{-\theta \zeta_{t+1} \varepsilon_{t+1}} + 1/2 \exp^{\theta \zeta_{t+1} \varepsilon_{t+1}}] \tag{3.17}$$

$$= \frac{1}{\theta} \log \cosh[\theta \zeta_{t+1}]. \tag{3.18}$$

$$\Gamma_t = \frac{1}{\theta} \log \cosh \left[\theta \frac{T-t+1}{T-t} \zeta_t \right]. \tag{3.19}$$

Iteration of (3.12) from t to $t+j$ gives

$$c_{t+j} = c_t + \sum_{i=1}^{j} \Gamma_{t+i-1} + \sum_{i=1}^{j} \nu_{t+i}, \tag{3.20}$$

where

$$\sum_{i=1}^{j} \Gamma_{t+i-1} = \sum_{i=1}^{j} \frac{1}{\theta} \log \cosh \left[\theta \frac{T-t+1}{T-t+1-i} \zeta_t \right], \tag{3.21}$$

$$\sum_{i=1}^{j} \nu_{t+i} = \sum_{i=1}^{j} \frac{T-t+1}{T-t+1-i} \zeta_t \varepsilon_{t+i}. \tag{3.22}$$

Iteration of (3.20) from $t+j$ to $T-t$ gives

$$\sum_{j=0}^{T-t} c_{t+j} = (T-t+1)c_t + \sum_{j=0}^{T-t} \sum_{i=1}^{j} \Gamma_{t+i-1} + \sum_{j=0}^{T-t} \sum_{i=1}^{j} \nu_{t+i}. \tag{3.23}$$

The iterated intertemporal budget constraint is

$$\sum_{j=0}^{T-t} c_{t+j} = a_t + \sum_{j=0}^{T-t} y_{t+j} - \sum_{j=0}^{T-t} \tau_{t+j}, \tag{3.24}$$

where $E_t[\sum_{j=0}^{T-t} y_{t+j}] = y_t + (T-t)y_p$ and $y_p = E[y_t]$.

Therefore, taking expectations gives

$$(T-t+1)c_t + \sum_{j=0}^{T-t} \sum_{i=1}^{j} \Gamma_{t+i-1} + \sum_{j=0}^{T-t} \sum_{i=1}^{j} \frac{T-t+1}{T-t+1-i} \zeta_t \underbrace{E_t[\varepsilon_{t+i}]}_{=0}$$

$$= a_t + y_t + (T-t)y_p - \sum_{j=0}^{T-t} \tau_{t+j}. \tag{3.25}$$

Solving for c_t gives

$$c_t = \frac{1}{T-t+1}\left(a_t + y_t + (T-t)y_p - \sum_{j=0}^{T-t}\tau_{t+j} - \sum_{j=0}^{T-t}\sum_{i=1}^{j}\frac{1}{\theta}\log\cosh\left[\theta\frac{T-t+1}{T-t+1-i}\zeta_t\right]\right). \tag{3.26}$$

From equation (3.13) we know that

$$\zeta_t = \frac{\zeta_T}{T-t+1}. \tag{3.27}$$

Since the marginal propensity to consume in the last period is 1, we know that the standard deviation of the consumption process must equal the standard deviation of the income process, $\zeta_T = \sigma_y$. Therefore we can write:

$$c_t^* = \frac{1}{T-t+1}[a_t + y_t + (T-t)y_p - \mathscr{T}_t - \Gamma_t(\theta\sigma_y)], \tag{3.28}$$

$$\Gamma_t(\theta\sigma_y) = \sum_{j=0}^{T-t}\sum_{i=1}^{j}\frac{1}{\theta}\log\cosh\left[\frac{\theta\sigma_y}{T-t+1-i}\right], \tag{3.29}$$

$$\mathscr{T}_t = \sum_{j=0}^{T-t}\tau_{t+j} = \vartheta - \sum_{j=1}^{t-1}\tau_j. \tag{3.30}$$

Appendix 3.B: Instructions

This section contains the instructions of the experiment.[18] Subjects in all treatments received the same instructions.

Instructions

Welcome to this experiment!
During this experiment you are not allowed to use electronic devices or to communicate with other participants. Please only use programs provided for this experiment. Please do not talk to other participants. If you have a question, please raise your hand. We will then come to you and answer your question individually. Please do not ask your question out loud. If your question is relevant for all participants, we will repeat your question out loud.

Overview. First you will have time to read the instructions. After that we will go through the instructions together, and you will complete a quiz in order to make sure you understood the instructions. The experiment consists of 8 rounds, each of which consists of 25 periods. The duration of the experiment is around 1.5 hours. Instructions, quiz, and a questionnaire will take around 30 minutes. The remaining hour is dedicated to the actual experiment. After the last round, your experiment payoff will be displayed. Please raise you hand when you have finished the last period. You will then be handed a short questionnaire. After filling out the questionnaire, please raise your hand again. You will then receive your experiment payoff in the adjacent room.

Your task is to decide in every period how many *points* you want to purchase. The sum of all points purchased in one round is that period's result. Your payoff depends on the results from two randomly drawn rounds.

[18] The instructions printed here are a translation of the original German version.

Income, Savings and Wealth. In every period you obtain a certain *income*, denoted in the experimental currency “Taler”. From this income you have to pay a certain amount of taxes to the government. Your task is to choose how many Taler to spend in order to purchase points. Thereby you (implicitly) also choose how many Taler you want to save or borrow. We call your income minus spending and taxes in one period *savings*.

Your *wealth* in the first period of every round is 1,000 Taler (initial wealth). The wealth in every later period equals the wealth of the previous period plus savings (=income-spending-taxes) of the previous period.

Please note that the sign of the savings can be either positive or negative. If you decide to spend fewer Taler than you have as income minus taxes, your savings have a positive sign. In this case your wealth in the next period is your wealth in this period plus the absolute amount of savings in this period. Should you decide to spend more Taler than you have as income, your savings have a negative sign. In this case your wealth in the next period is your wealth in this period minus the absolute amount of savings.

Example: assume your income in one period is 50 Taler and you have to pay 10 Taler in taxes. If you spend 30 Taler to purchase points, your savings are 10 Taler. In case you instead spend 70 Taler with the same income, your savings are -30 Taler. In the first case your wealth in the next period is the wealth in this period plus 10 Taler. In the latter case your wealth in the next period is this period’s wealth minus 30 Taler.

Your wealth may take positive or negative values as well, depending on whether your savings from previous periods plus your initial wealth were positive or negative. In the last period, your wealth plus income minus taxes will be spent automatically in order to purchase points. This implies that the sum of Taler spent in all periods of one round equals the sum of income obtained in all periods of this round minus the sum of all taxes paid in this round. In other words: you may spend more or less than your income in one round. However, over one round, the sum of income plus initial wealth always equals the sum of Taler spent plus the sum of all taxes.

Determination of Income and Taxes. Your income is randomly determined. In every period, your income can take the values of either 250 Taler or 120 Taler. Both values occur with the equal probability of 50%. It is very important to understand that income is truly randomly determined. The value the income takes in one period does not depend on the values it had in previous periods or how you behaved in previous periods.

The government has fixed costs of 120 Taler in every period, which you have to finance through taxes. This implies that the government collects a total of $120 \times 25 = 3000$ Taler from you in the course of one round. The government is free to collect more or less than 120 Taler in taxes in any period. Before you decide how much to spend in every period you learn the amount of taxes the government collects from you in the respective period.

Taler and Points. Your task to decide in every period how many Taler you want to spend in order to purchase points. Taler are transformed to points as follows:

$$\text{Points} = 338 \times \left(1 - e^{-0.0125 \times (\text{chosen amount of Taler})}\right)$$

A graph of this function, as well as a table with relevant function values is attached to the instructions.[19] Please note that the above function is defined in the positive as well as the negative domain. If you choose to spend a negative amount of Taler, you receive a negative amount of points. In this case you "sell" points and gain Taler. Should your wealth plus income in the last period be negative, you will have to automatically sell points in order to make sure that your Taler account is balanced.

[19] Omitted here.

Payoff. For your participation you will receive a fixed amount of 21 Euro. Additionally you will receive an amount that depends on the results of two randomly drawn rounds. This amount is calculated as follows:

$$\text{Payoff in Euro} = \frac{(\text{Result1} - 5000) + (\text{Result2} - 5000)}{100}$$

where Result1 is the first randomly drawn result and Result2 is the second randomly drawn result.

Example: suppose the first randomly drawn result is 5500 points and the second randomly drawn result is 6000 points. Your payoff is then:

$$\frac{(5500 - 5000) + (6000 - 5000)}{100} = \frac{1500}{100} = 15 \text{ Euro.}$$

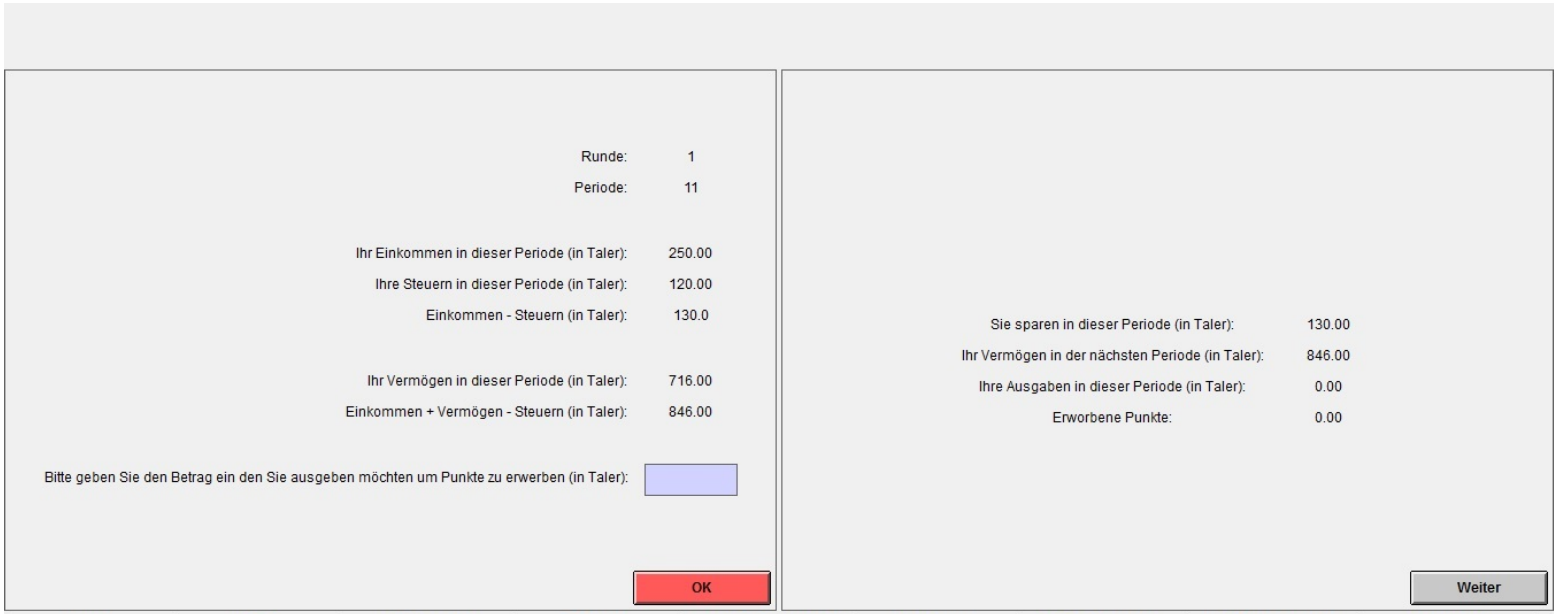
Should the payoff calculated according to the formula above fall below 0 Euro this will be counted as 0 Euro. In any case you will receive the fixed amount of 5 Euro. This implies that you will earn *at least* 5 Euro.

Quiz and Questions. You will now be asked to answer a short quiz regarding the contents of these instructions. In case you have questions after that, please raise your hand. An experimenter will then come to you and answer your question.

Figure 3.B.1

Screenshot of the Experimental Interface.

Source: Own interface based on z-Tree.



Periode	Runde	Einkommen	Steuern	Summe der gezahlten Steuern	Vermögen	Ausgaben (Taler)	Erworbene Punkte	Punktestand
1	1	120.00	0.00	0.00	1000.00	98.00	238.71	238.71
2	1	120.00	0.00	0.00	1022.00	100.00	241.16	479.87
3	1	120.00	0.00	0.00	1042.00	100.00	241.16	721.03
4	1	120.00	120.00	120.00	1062.00	98.00	238.71	959.74
5	1	250.00	120.00	240.00	964.00	100.00	241.16	1200.90
6	1	250.00	120.00	360.00	994.00	105.00	247.03	1447.93
7	1	120.00	120.00	480.00	1019.00	110.00	252.54	1700.47
8	1	120.00	120.00	600.00	909.00	110.00	252.54	1953.01
9	1	250.00	120.00	720.00	799.00	108.00	250.38	2203.39
10	1	120.00	120.00	840.00	821.00	105.00	247.03	2450.42

4 Progressive Taxation and Precautionary Saving[1]

4.1. Introduction

A classical argument for progressive taxation of household labor income is that progressivity provides social insurance. However, at the same time, precautionary saving is a way for households to shield against uninsurable labor income risks. This chapter studies the interaction between precautionary savings and tax progressivity in a life cycle model. Taking Germany as an example, we use this model to assess the importance of precautionary saving under a typical progressive taxation system.

The objective of this chapter is twofold. First, we identify how progressive taxation affects precautionary saving behavior in general. Second, we quantify the welfare effects of progressive taxation for the case of Germany by comparing two situations. We compare the actual tax and transfer system in Germany—which is progressive—to a counter-factual tax system in which no social insurance occurs, i.e. a flat tax system in our analysis. This comparison gives us a measure of how important social insurance through progressive taxation is.

We address our research question from the perspective of a partial equilibrium life cycle model using data from the German Socio-Economic Panel (GSOEP). In particular, we develop an incomplete markets life cycle model that includes progressive taxation explicitly. In our setup, households understand the structure of the tax schedule and choose their consumption/savings optimally. Social insurance occurs because income risks that households face are subject to progressive taxation. Therefore, we can trace the effect of social insurance through progressive taxation on precautionary saving in our model.

[1]This chapter is based on Rostam-Afschar and Yao (2015).

We shut down the effect that progressive taxation has on labor supply to isolate the social insurance effect. It is beyond the scope of this chapter to analyze optimal taxation which is done, e.g., in Krueger and Perri (2011). Our results rather complement other papers which focus on the distortionary effects of progressive taxation on labor supply (e.g. Mirrlees (1971)). This chapter contributes to the literature that quantifies the importance of precautionary saving abstracting from taxation (e.g., Carroll and Samwick, 1998; Gourinchas and Parker, 2002; Cagetti, 2003). Closely related to this chapter is previous work that studied how asset-based, means-tested welfare programs such as unemployment insurance affect precautionary saving (Hubbard et al., 1995; Engen and Gruber, 2001).

We identify at least two channels through which progressive taxation affects households' saving behavior over the life cycle.[2] First, progressive taxation reduces after-government income uncertainty mechanically. Positive income realizations will be taxed more than negative. A cross section of a cohort at any point in time would have dampened income and consumption inequality under progressive taxation compared to a revenue-neutral flat taxation. We refer to this effect as *cross-sectional effect*. Second, progressive taxation induces an *intertemporal effect* because households will adjust their saving behavior upon observing the reduction in after-government labor income uncertainty. In particular, the desire to hold wealth as a precaution will be smaller under progressive taxation and therefore a smoother consumption path can be chosen.

The overarching effect is that progressive taxation crowds out part of savings by households. Our first main result is that progressive taxation crowds out 24.6% of wealth for a median household on average over the life cycle. Depending on the growth and the risk profiles of pre-government income, however, the effect of progressive

[2]In this analysis we assume inelastic labor supply to keep the focus on income uncertainty and saving behavior. Adjustments in working hours in response to uncertainty would provide additional insurance and thus confound our analysis. In a companion paper, we compare the effects with inelastic labor supply to the case where labor supply is chosen flexibly. Preliminary results show that annual household labor supply does not change much in response to variations of progressivity around the level that we used in this analysis.

taxation on savings varies across households of different subgroups. For instance, the share of savings crowded out by progressive taxation is only 19.1% for college graduates whereas it is 60.0% for blue collars.

Our second main result is that progressive taxation provides more insurance than revenue-neutral flat taxation for all the subgroups we consider. For the total sample, our simulated economy shows that approximately 60% of permanent shocks and 90% of transitory shocks to pre-government labor income are insured against under progressive taxation. In comparison, only 30% of permanent shocks and 70% of transitory shocks are insured against in an economy with a revenue-neutral flat taxation. It is important to recognize the tension between social insurance provided by progressive taxation and self insurance in the form of wealth accumulation. Our results suggest that despite the reduced incentive to do self insurance in an economy with progressive taxation, households are still better insured against pre-government income shocks.

Third, our results show considerable heterogeneity in welfare gains for different subgroups of the population when comparing the equivalent income under progressive taxation to that under revenue-neutral flat taxation. For instance, whereas blue collars need to be compensated with 16.5% of equivalent income under progressive taxation to be indifferent under revenue-neutral flat taxation, college graduates would ask for 0.1% more equivalent income under progressive taxation to be indifferent. The results highlight the need to discuss policy implications of progressive taxation for different subgroups separately. In fact, redesigning the tax and transfer system to account for differences in labor income risks, e.g. by age, could be a fruitful endeavor.

This chapter is structured as follows. In Section 4.3, we outline a simple incomplete markets model with taxes and transfers and discuss the mechanism through which the tax and transfer system might affect household saving and consumption. Section 4.4 introduces our extended model and briefly describes data, estimation procedure and results of key parameters and variables. Our main results are reported in Section 4.5. Section 4.6 concludes.

4.2. Related Literature

The simulation experiments in this chapter study progressive tax schedules using a hypothetical flat tax as benchmark for two reasons. First, the main motivation for this study is to quantify the social insurance effect of progressive taxation. Opposed to this is the extreme case of a flat tax without deductions or transfers, where there is no social insurance. This effect was investigated already in Mirrlees (1974) and Varian (1980) but not with an explicit focus on precautionary saving. A closely related series of studies on precautionary saving in partial equilibrium models with exogenous labor income, (e.g., Carroll and Samwick, 1998; Gourinchas and Parker, 2002; Cagetti, 2003), abstracts from modeling taxation and transfers explicitly and emphasizes the importance of precautionary saving. At the same time, an older literature showed that precautionary behavior is influenced strongly by the tax and transfer system, usually with a focus on transfers (Hubbard et al., 1995; Gruber and Yelowitz, 1999; Engen and Gruber, 2001). However, the interaction between a progressive system of both taxation and transfers and precautionary saving is rarely quantified using microdata. In particular there is no evidence for countries other than the US. Therefore, we connect the findings in this literature and provide a comprehensive examination of the interdependencies between taxes and transfers on the one hand and precautionary saving behavior on the other hand.

Our analysis uses the concept of partial insurance developed in Blundell et al. (2008) and relates to studies quantifying partial insurance like Heathcote et al. (2014b) who find that 39 percent of permanent wage shocks pass through to consumption. Moreover, the estimation technique used to measure idiosyncratic shocks is closely related to those used in Hryshko (2012) and Blundell et al. (2014).

Second, reform proposals suggesting the implementation of a flat tax system are put forth usually not considering implied costs of removing social insurance. For Germany, Paul Kirchhof proposed a marginal tax rate of 25 percent in Kirchhof (2003). He reiterated this proposal in Kirchhof (2011) by proposing a modified flat tax which is actually progressive but less progressive than the status quo. In particular all incomes above 18,000 Euro are proposed to be taxed by 25 percent. All incomes between 13,000 and 18,000 Euro, 8,000 and 13,000 are supposed to be taxed by 20 percent and 15 percent, respectively.

In the US, Hall and Rabushka (2007) proposed a 19 percent flat-rate tax on wages and pension benefits above an exemption of 25,500 dollar for a family of four. No other income is taxable, and no other deductions are allowed.

By quantifying and comparing the welfare effects of a more extreme flat tax without transfers and deductions and a progressive tax, our study contributes to this debate.

Other papers that are more broadly related to our study include Fehr et al. (2013). The focus of this study is not on precautionary saving but on optimal taxation of pensions. The authors find from simulations exercises that the optimal system involves higher progressivity, since insurance benefits over-compensate additional labor market distortions. Conesa et al. (2009) (Conesa and Krueger (2006)) study the tradeoff between efficiency and insurance under progressive taxation and find that a proportional income tax with a constant marginal tax rate of 23 (17.2) percent and a deduction of roughly 7,200 (9,400) dollar is optimal for the US. A further result of Conesa and Krueger (2006) is that a pure flat tax without deduction reduces welfare by about 1 percent. For a study that investigates the optimal progressivity of capital income taxes see Saez (2002).

The following papers (like our analysis) do not pursue normative exercises: Ventura (1999) explicitly models the general equilibrium implications of a revenue neutral tax reform in which the status quo in the U.S. is replaced by a flat tax, as proposed by a previous edition of Hall and Rabushka (2007). This study and Castañeda et al. (1999) who also compare the status quo progressive system in the US to a flat tax find that labor supply does hardly change due to this reform.

Finally, our study is related to Caucutt et al. (2003) as they study the effects of progressive taxation using a flat tax as a benchmark and to Bénabou (2002) as we similarly specify a tax function in our analysis. Our analysis is different because these studies do not focus on precautionary saving but on human capital and growth.

4.3. A Three-Period Framework

Before delving into a full-fledged life cycle model, it is useful to consider the effect of progressive taxation using a simple yet informative three-period model. We divide households' life cycle into three periods: early age, middle age and retirement. Informed by the data, we assume that the first period features low income with large permanent shocks, the second period high income with small permanent shocks, and the third period deterministic income. Specifically, the dynamics of permanent income are

$$\begin{aligned} P_1 &= P_0\Psi_1 & \log\Psi_t &\sim N(-1/2\sigma^2_{\psi,1}, \sigma^2_{\psi,1}), \\ P_2 &= (1+g_2)P_1\Psi_2 & \log\Psi_t &\sim N(-1/2\sigma^2_{\psi,2}, \sigma^2_{\psi,2}), \\ P_3 &= (1+g_3)P_2, & & \end{aligned}$$

where P_t is permanent income, shocks Ψ_t are drawn from a log-normal distribution with standard deviation $\sigma_{\psi,1} > \sigma_{\psi,2}$, and income growth is $g_2 > 0 > g_3$ for $t = 1,2,3$.

For simplicity, we abstract from transitory shocks for now and assume that pre-government income is equal to permanent income, i.e., $Y_t = P_t$. We define the tax and transfer scheme by

$$TX(Y) = Y - \lambda Y^{1-\tau}, \tag{4.1}$$

where λ measures the level of tax and transfer payments and τ measures the degree of progressivity.[3] Y_t^{at} denotes after-government income. Households have constant relative risk aversion (CRRA) felicity function, $u(C) = C^{1-\rho}/(1-\rho)$ and zero

[3] Heathcote et al. (2014b) show that this functional form approximates the tax and transfer scheme in the U.S. quite well with $\tau = 0.15$. As will be clear soon, it approximates the German tax and transfer scheme closely as well with a slight modification. Two special cases are worth noting: $\tau = 0$ is a flat tax and $\tau = 1$ is a progressive tax that provides perfect insurance.

initial wealth. Their objective is to maximize expected discounted utility in the three periods. Note that households are ex-ante identical but are ex-post heterogeneous due to permanent shocks to income. To summarize, households' optimization problem is

$$\max_{C_1,C_2,C_3} E[u(C_1)+\beta u(C_2)+\beta^2 u(C_3)],$$
$$C_1+\frac{C_2}{1+r}+\frac{C_3}{(1+r)^2}=\lambda Y_1^{1-\tau}+\frac{\lambda Y_2^{1-\tau}}{1+r}+\frac{\lambda Y_3^{1-\tau}}{(1+r)^2}.$$

For the numerical exercise below, we assume $g_2 = 0.50$, $g_3 = -0.50$, $\sigma_{\psi,1} = 0.06$, $\sigma_{\psi,2} = 0.02$, $P_0 = 40,000$, gross interest factor $R = 1.06$, discount factor $\beta = 0.96$, coefficient of relative risk aversion $\rho = 1.5$, and we simulate 1,000 households. Appendix 4.B provides additional details for the numerical solution. To focus on the effect of progressivity, for each τ we choose the level of λ such that the total tax revenue of all households over the three periods stays fixed.

Cross Sectional Effect

We start by looking at the effect of progressive taxation on the distribution of income and consumption in each period. Figure 4.1a shows that as the degree of progressvity increases, consumption inequality and after-government income inequality in each period fall. This is not surprising, because progressive taxation penalizes positive shocks to income while it compensates negative shocks, tightening the after-government income distribution and therefore the consumption distribution.

Intertemporal Effect

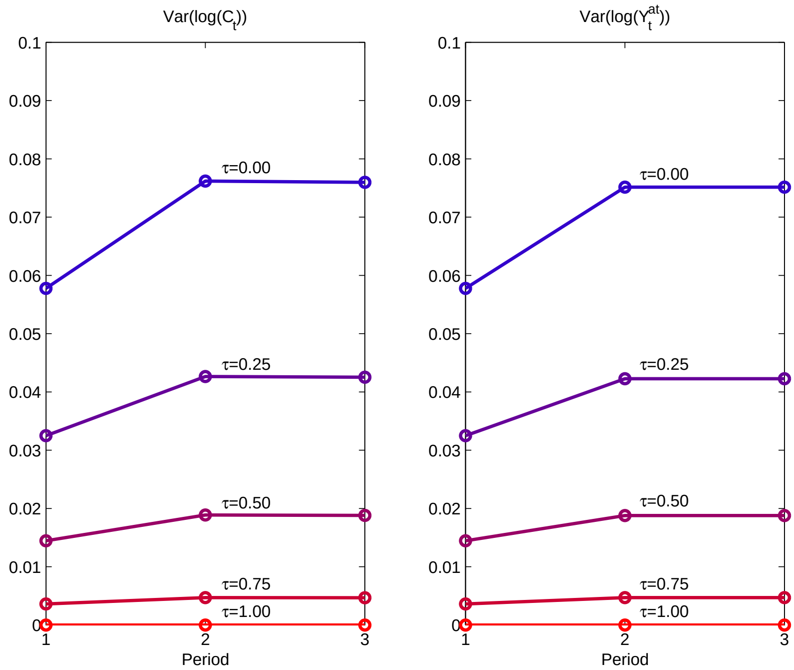
An often overlooked aspect of progressive taxation is its intertemporal effect, which stems from the interaction of progressivity and uncertainty. It is tempting to think, as we control for the total tax revenue, the mean consumption path would be the same regardless of the degree of progressivity. However, Figure 4.1b shows that this is not true.

Figure 4.1

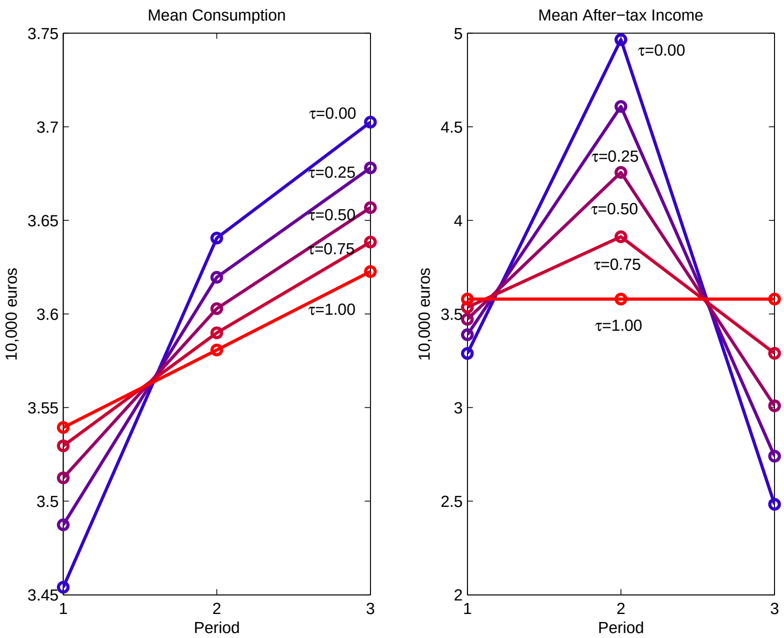
Consumption and After-Government Income Inequality.

Source: Own simulation.

(a) *Cross Sectional Effect.*



(b) *Intertemporal Effect.*



In particular, as the degree of progressvity increases, a smoother consumption path is optimal (see Appendix 4.A for more details). The key here is after-government income uncertainty. With an increasing degree of progressivity, after-government income uncertainty decreases, households do less precautionary saving and therefore the consumption path becomes smoother.[4]

The simple three-period model captures two effects progressive taxation has on saving: it tightens the cross-sectional distribution of wealth at a given age and it diminishes wealth accumulation over the life cycle. The three-period model is very stylized, as there is not enough time for wealth accumulation, no borrowing constraint and no bequest motive. To quantify the effect of progressive taxation on saving, we turn to the full-fledged consumption-saving model of households with progressive taxation in the following.

4.4. Evidence from the Multi-Period Model

4.4.1. Household's Problem

This section introduces a discrete-time incomplete markets model of household consumption, which will be the basis of our analysis of the effect of progressive taxation on precautionary savings.[5] The economy consists of a finite number of households indexed by i.[6] We assume that households start their economic life in period t_0 and live for T years. Households work for T^{work} years in their life and then enter the stage of retirement when there is a positive probability of death. We assume that the unconditional probability of survival until time t is S_t, so that $S_t = 1$ for $t \leq t_0 + T^{work}$ during households' working life and $S_t < 1$ after retirement. All households die at time $T + t_0$

[4]Note that when there is full insurance, consumption growth is $(\beta R)^{1/\rho} = 1.012$ in each period, which follows from the Euler equation.

[5]See Heathcote et al. (2014a) for a review.

[6]In contrast to labor supply decisions that are known to be different in single and couple households, we argue that consumption and saving decisions of single and couple households are negligibly similar.

with certainty[7]. Households have time-separable expected discounted utility from annual consumption C_{it} given by

$$E_{t_0}\left[\sum_{t=t_0}^{T+t_0} S_t\beta^{t-t_0}u(C_{it})+W(A_{iT+t_0+1})\right]. \tag{4.2}$$

We assume that households have a CRRA felicity function

$$u(C_{it})=\frac{C_{it}^{1-\rho}}{1-\rho}, \tag{4.3}$$

and a bequest motive that shares the coefficient of relative risk aversion of the felicity function

$$W(A_{iT+t_0+1})=\alpha\frac{A_{iT+t_0+1}^{1-\rho}}{1-\rho}. \tag{4.4}$$

Each household is endowed in period t_0 with an initial stock of a risk-free asset A_{t_0} that bears a constant real interest rate r. Capital income is taxed at a rate τ_A. At every age t, asset accrues and the household receives an exogenous stochastic annual real income Y_{it} where either tax is deducted or benefits are transferred. We combine tax and transfer payments and model the tax and transfer system as a function $TX(\cdot)$ that depends on pre-government labor income Y_{it}, so $TX(Y_{it})$ can be thought of as the real net tax collected by the government when the household's pre-government labor income is Y_{it} (see Subsection 4.4.3). In each period, having realized income from assets, the household chooses C_{it}, which is taxed at a rate τ_C, to maximize its expected discounted utility given in equation (4.2) subject to the transition equation

$$A_{it+1}=A_{it}(1+r(1-\tau_A))+Y_{it+1}-TX(Y_{it+1})-(1+\tau_C)C_{it+1}. \tag{4.5}$$

The borrowing constraint can have a large impact on the consumption and saving of households with low income and/or wealth. We assume that the maximum amount

[7] In practice, we set $t_0=25$, $T^{work}=40$, and $T=65$.

that households can borrow depends on their permanent income. In particular, we assume

$$A_{it} \geq \underline{a} P_{it}.^{8} \tag{4.6}$$

4.4.2. Income Process

We assume that the labor income process has a deterministic component common to all households and an idiosyncratic component. The idiosyncratic component can be decomposed into a permanent and a transitory component as is standard in the literature since Friedman and Kuznets (1954). In particular, we assume that the gross income of each household[9] follows the process

$$Y_{it} = P_{it}\Xi_{it}, \tag{4.7}$$

$$P_{it} = P_{it-1}\Gamma_t\Psi_{it}. \tag{4.8}$$

P_{it} is the permanent component of gross labor income. Γ_t is the observed deterministic component of gross labor income and is assumed to be common for all households. We assume that the transitory shocks and the permanent shocks are mutually independent. For simplicity, we further assume that after retirement, pre-government income becomes deterministic with shocks in equations (4.7) and (4.8) being unity.

Dating back to Lillard and Willis (1978), Lillard and Weiss (1979), MaCurdy (1982), and Abowd and Card (1989), there is a history of fitting ARMA models to panel data[10] to estimate the labor income risk facing individuals. Many models assume labor income is the sum of a transitory and persistent shocks, where often the

[8] In addition to the natural borrowing constraint here, we also considered the artificial borrowing constraint that binds at zero, however our main results turned out to be similar.

[9] Recall that we assume a joint process for all household members, see Haan and Prowse (2010) for an example where different income processes for singles and couple households are specified.

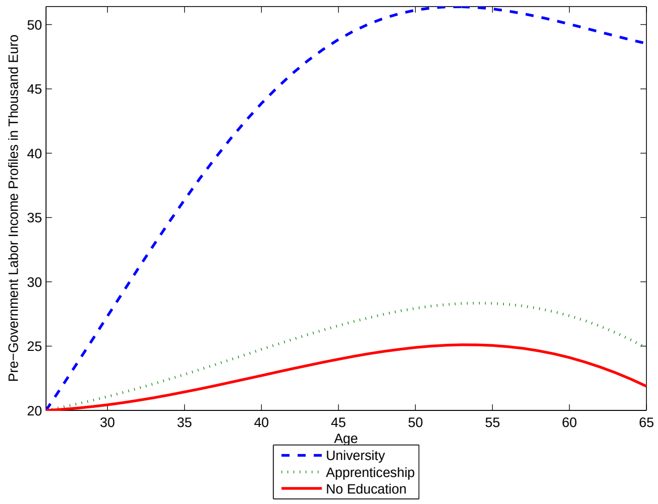
[10] For estimates based on German data, see e.g. Biewen (2005); Myck et al. (2011); Bönke et al. (2014).

persistent shock is assumed to be a random walk.[11] We follow this literature and allow for a transitory component that is ARMA(1,1). In addition, we allow for age-varying variances of both transitory and permanent shocks, which have been identified to play an important role (see Blundell et al. (2014)).

Figure 4.2

Predicted Income Growth by Education.

Source: Authors' calculations based on the GSOEP (1984-2012).



While the German Socio-Economic Panel (GSOEP) provides consistent information on wealth only for 2002, 2007, and 2012, we use information on household labor income from the waves 1984 to 2012. A detailed description of the data and the construction of wealth and income variables is provided in Appendix 4.F. To calibrate the model, in a first step, we estimate the median income growth rate. Since growth rates differ for heterogeneous groups, we repeat the entire calibration exercise for subgroups that differ by employment (employees, self-employed), education (college graduates, apprenticeship, low education), kind of occupation (blue collar, white collar, civil ser-

[11] MaCurdy (1982), Abowd and Card (1989), Gottschalk and Moffitt (1994), Carroll and Samwick (1997), Meghir and Pistaferri (2004), and Blundell et al. (2008) all assume a unit root in the persistent component.

vant), and marital status (married with and without children, single). In the main text, we focus on the total sample and point out differences for subgroups. Generally, as shown in Figure 4.2, pre-government income rises until age 55 and from then on stays roughly constant or declines modestly.

In a second step we estimate pre-government labor income risks for each of the groups (complete estimation results are provided in Tables 4.F.3 to 4.F.6 in the Appendix). In particular, the process for idiosyncratic log labor income $y_{it} = log(Y_{it})$ for each household is after removing the deterministic component Γ_t

$$y_t = p_t + \xi_t.^{12} \tag{4.9}$$

In our specification, the permanent component follows a random walk with innovation ψ_t

$$p_t = p_{t-1} + \psi_t.$$

The transitory component is described by the following ARMA(1,1) process where L is the lag operator

$$\xi_t = \frac{1+\theta L}{1-\varphi L}\varepsilon_t.$$

Shocks are assumed to be uncorrelated across calendar time, cohort, and age. They are drawn from mean-zero normal distributions with age varying variance according to

$$\psi_t \sim N(0, \sigma^2_{\psi,t}),$$

$$\varepsilon_t \sim N(0, \sigma^2_{\varepsilon,t}).$$

The parameters to be identified are $\Theta = \{\theta, \varphi, \sigma^2_{\Delta\xi,24}, \sigma^2_{\varepsilon,25}, \dots, \sigma^2_{\varepsilon,65}, \sigma^2_{\psi,26}, \dots, \sigma^2_{\psi,64}\}$.

We can identify these parameters using the variance-covariance matrix from ages 25 to 65. As we cannot identify $\sigma^2_{\psi,25}$ and $\sigma^2_{\psi,65}$, we restrict these variances to be equal to $\sigma^2_{\psi,25}$ and $\sigma^2_{\psi,64}$, respectively. In Appendix 4.F we derive the theoretical moments $\gamma_k = E[\Delta y_t \Delta y_{t-k}]$ as

[12] We omit the household index i in what follows for legibility.

$$\gamma_0 = \sigma^2_{\psi,t} + \sigma^2_{\Delta\xi,t}, \tag{4.10}$$

$$\gamma_1 = \varphi\sigma^2_{\Delta\xi,t} + (\theta-1)\sigma^2_{\varepsilon,t} - \theta(\varphi+\theta-1)\sigma^2_{\varepsilon,t-1}, \tag{4.11}$$

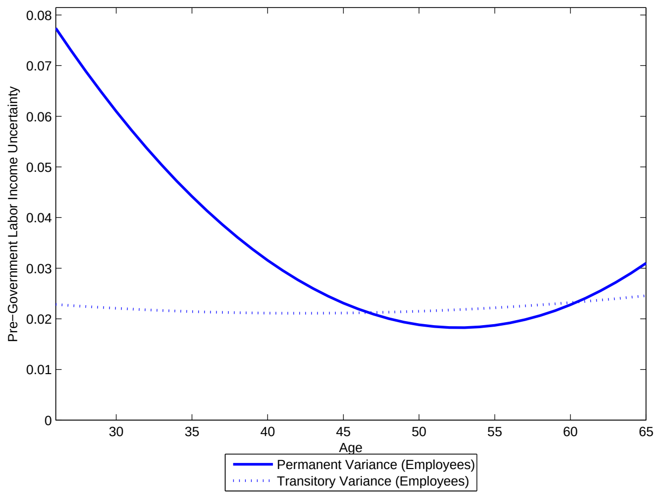
$$\gamma_k = \varphi^{(k-t)}\sigma^2_{\Delta\xi,t} + (\varphi^{(k-t-1)}(\theta-1) - \varphi^{(k-t-2)}\theta)\sigma^2_{\varepsilon,t} - \varphi^{(k-t-1)}\theta(\varphi+\theta-1)\sigma^2_{\varepsilon,t-1}\forall k \geq 2. \tag{4.12}$$

For estimation, we use the GMM procedure with identity weight matrix.[13] Given a vector of 81 parameters Θ, we can generate a (theoretical) variance-covariance matrix of the vector $(\Delta y_t, \ldots, \Delta y_{t+40})$, denoted by Ω. We compute the empirical variance covariance matrix of the same vector and denote it by $\hat{\Omega}$. Then our objective is to find the set of parameters that minimize $(\Omega - \hat{\Omega})'(\Omega - \hat{\Omega})$.

Figure 4.3

Permanent and Transitory Uncertainty Over the Life Cycle.

Source: Authors' calculations based on the GSOEP (1984-2012).



[13]We use equally weighted minimum distance for reasons explained in Altonji and Segal (1996).

We present estimates along with standard errors for all groups in Appendix 4.F. As we are interested in the life cycle patterns of uncertainty, it is instructive to investigate visually how labor income risks evolve over age for the different subgroups introduced above. Figure 4.3 illustrates the uncertainty profiles of permanent and transitory shocks for employees. In this exposition the estimates are smoothed using a second order polynomial. The general pattern that we find, and which is documented in a growing literature, is that permanent uncertainty is decreasing: it is high in young years, possibly increasing towards the end of the life cycle. In our life cycle model, we want to abstract from business cycle effects. Thus, we take out year effects. This leads to a flat profile of transitory uncertainty over age for most groups.

4.4.3. Progressive Taxation

Our main focus is on how the progressivity of the tax and transfer system affects precautionary saving. Therefore, we specify a parsimonious tax function which we take from the public finance literature (see Feldstein (1969)) following Bénabou (2002). Taxes or Transfers are given by

$$TX(Y) = Y - \lambda Y^{1-\tau}.\text{[14]} \tag{4.13}$$

With this tax function, disposable (post-government) income $\tilde{Y}$ is a function of pre-government income Y with the parameters τ and λ.

$$\tilde{Y} = \lambda Y^{1-\tau}. \tag{4.14}$$

The parameter of particular interest is τ because it determines the degree of progressivity of the tax system. $(1-\tau)$ is the coefficient of residual income progression, which is defined as the elasticity of post-government income with respect to pre-government income.

[14] The age index t is omitted for legibility.

The standard definition of a progressive tax-transfer function in applied in public economics is that the marginal tax rate is larger than the average tax rate for every level of pre-government income.

$$TX'(Y) > TX(Y)/Y.$$

Applying this definition to our specific tax function implies

$$1 - \lambda(1-\tau)Y^{-\tau} > 1 - \lambda Y^{-\tau}.$$

If $\tau > 0$, the tax and transfer system is progressive because the marginal tax rate is greater than the average tax rate. Conversely, the tax-transfer function is defined as regressive if the marginal tax rate is smaller than the average tax rate for every level of income. The parameter λ shifts the tax function and determines the average level of taxation. Note also that this function has a break-even income level below which in a progressive system the average tax rate is negative. In this case, households receive transfers from the government.

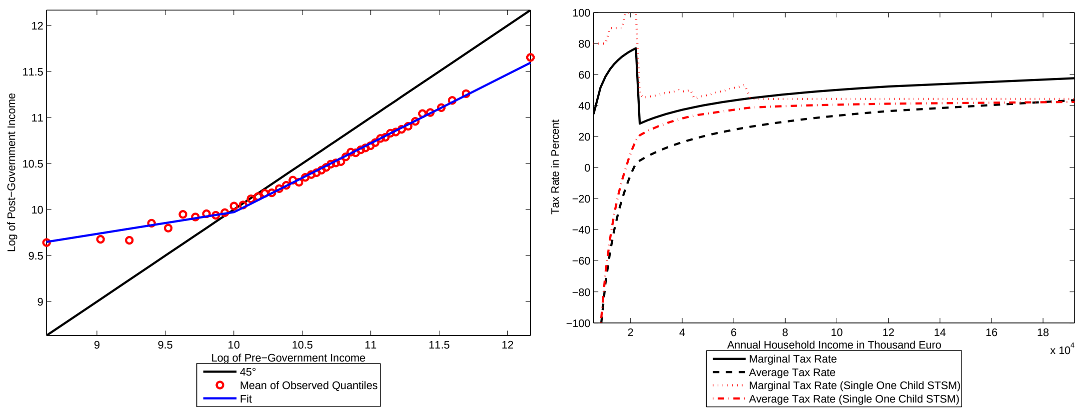
A special case of particular interest is $\tau = 0$. Then, the tax and transfer function becomes a flat tax system with the rate of $1 - \lambda$. In this system, all social insurance effects that progressive taxation implies are turned off. Therefore, it is the natural benchmark to study how progressivity of the tax and transfer system affects precautionary saving. In the main analysis, we compare the actual progressivity of the German tax and transfer system to the flat tax case because the latter is directly comparable to the setting in studies that abstract from social insurance.

Although this function is parsimonious in its parametrization, it gives us a remarkably good representation of the actual tax and transfer system in Germany. To estimate the two parameters, we use data on household pre-government labor income from the GSOEP and of post-government income using the tax transfer calculator "Steuer-Transfer-Mikrosimulationsmodell" (STSM) for wave 2012 (see Steiner et al. (2012)). Pre-government household income includes labor earnings, private transfers like alimony, pension incomes, and income from interests, dividends, and rents. Post-government income equals pre-government income minus income taxes computed using the STSM (including solidarity surcharge, social security contributions, etc.), plus public transfers (unemployment benefits, unemployment assistance etc.).

Figure 4.4

Estimation of Tax and Transfer Function and Implied Tax Rates.

Source: Authors' calculations based on the GSOEP (2012).



The left graph in Figure 4.4 shows our estimates and is constructed as follows. We collapse our data into 50 quantiles. We associate each mean of a quantile of pre-government income to the mean post-government income across the observations in that same quantile. These points are shown as circles in the figure. Then we estimate equation (4.14) in logs using OLS. Because transfers have a different slope and intercept, we interact $log(Y)$ with a dummy indicating whether transfers have been received or not. The point estimate is $\tau = 0.25$ for the region where no transfers are paid.[15] This is well above the estimate of $\tau^{US} = 0.15$ that Heathcote et al. (2014b) find for the USA. This simple model fits the data well with R^2 as high as 0.994. In the figure the solid kinked line shows the model fit and the solid 45 degree line points where pre- and post-government income are identical.

[15] In the region where transfers are paid, $\tau = 0.76$.

The right graph in Figure 4.4 displays the implied marginal and average tax rates which we obtain from our estimates of τ and λ. The solid line shows the marginal tax rate, while the dashed line is the average tax rate. For comparison, the dotted line shows marginal tax rates of a single person with one child and the dash-dotted line shows the average tax rates for this person. Note that these lines are actually not comparable because one is a specific household type and the other is calculated on basis of many different household types. Nevertheless, the comparison gives a rough idea how well our estimates are. The red dashed line displays the average tax rate for the same household. Obviously, the function represents the tax and transfer system quite well.

Of course, equation (4.14) is not useable to identify the effect of a certain reform. However, as our aim is to investigate progressivity and not a specific reform, this function is advantageous.[16] One important advantage is that the model remains simple using this function. Another important advantage is that it is possible to increase or reduce progressivity unambiguously and the effects from this are transparent.

4.4.4. Calibration of Preferences and Other Parameters

The distribution of wealth, and hence the insurance effect of progressive taxation, depends on households' preferences. In particular, the discount factor affects the amount of wealth accumulation on average and the risk aversion determines the allocation of wealth over the life cycle due to the strength of the precautionary motive and consumption smoothing. Despite the importance of households' preferences, the literature remains inconclusive about their magnitude.[17] As the values of households' preferences are central to our results, we estimate the risk aversion and the discount factor simultaneously by matching the median wealth profiles of households. We find the coefficient of relative risk aversion to be 0.6529 for the entire sample and the discount

[16] See Chapter 5 for an evaluation of a specific reform.

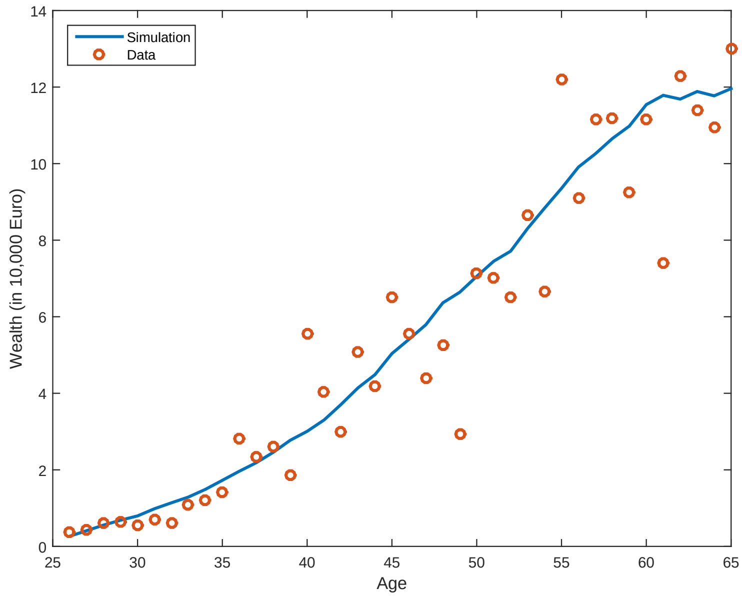
[17] For instance, Cagetti (2003) estimates $\rho > 2$ by targeting the median wealth of households, Gourinchas and Parker (2002) find $\rho < 2$ by targeting the mean consumption of households, Chetty (2006), using the effects of wage changes on labor supply, finds that $\rho < 2$.

factor 0.9633. Appendix 4.C shows how we use the method of simulated moments to estimate households' preferences.

Figure 4.5

Simulated and Observed Wealth Profile.

Source: Authors' calculations based on the GSOEP (2012).



In general, the discount factor is tightly estimated whereas the standard error of the coefficient of relative risk aversion is large for subgroup samples. For this reason, we set the coefficient of relative risk aversion for each subgroup to be the same for the entire sample, and estimate the discount factor by targeting the median wealth profiles. In Appendix 4.E, we do a robustness check where we choose a range of coefficient of relative risk aversion and estimate the discount factor to target the median wealth profiles.

Figure 4.5 shows that we match the median wealth profile of households reasonably well. The presence of labor income uncertainty is the source of separate identification of the coefficient of relative risk aversion and the discount factor. We discuss details of the identification strategy in Appendix 4.D.

The calibration procedure of the wealth and income distribution at the beginning of the life cycle, the mortality rates and the interest rate are reported in Appendix 4.F. For the main results, we set the borrowing constraint $\underline{a} = 0$ and the bequest motive parameter $\alpha = 0$. However, our results are not sensitive to reasonable choices of the borrowing constraint and the bequest motive. Following Fehr et al. (2013), we use a gross replacement rate of 48 percent for pension incomes.

4.5. Results

In this section, we quantitatively evaluate the effect of progressive taxation on precautionary saving over the life cycle. Throughout, we compare a simulated economy under the stylized German progressive tax and transfer schedule with one under a revenue-neutral flat tax schedule. As in the three-period model, we control for the total tax revenue on the economy and focus on the quantitative effect of progressivity on saving. First, we study how progressive taxation affects the distribution and accumulation of wealth over the life cycle. Second, we investigate whether progressive taxation provides additional insurance or crowds out households' self-insurance. In particular, we calculate the partial insurance coefficients of permanent and transitory shocks over the life cycle. Finally, we present the welfare implication of the current progressive taxation in Germany. We present our results for the entire sample and for subgroups defined by household characteristics.

4.5.1. Progressive Taxation and Precautionary Savings

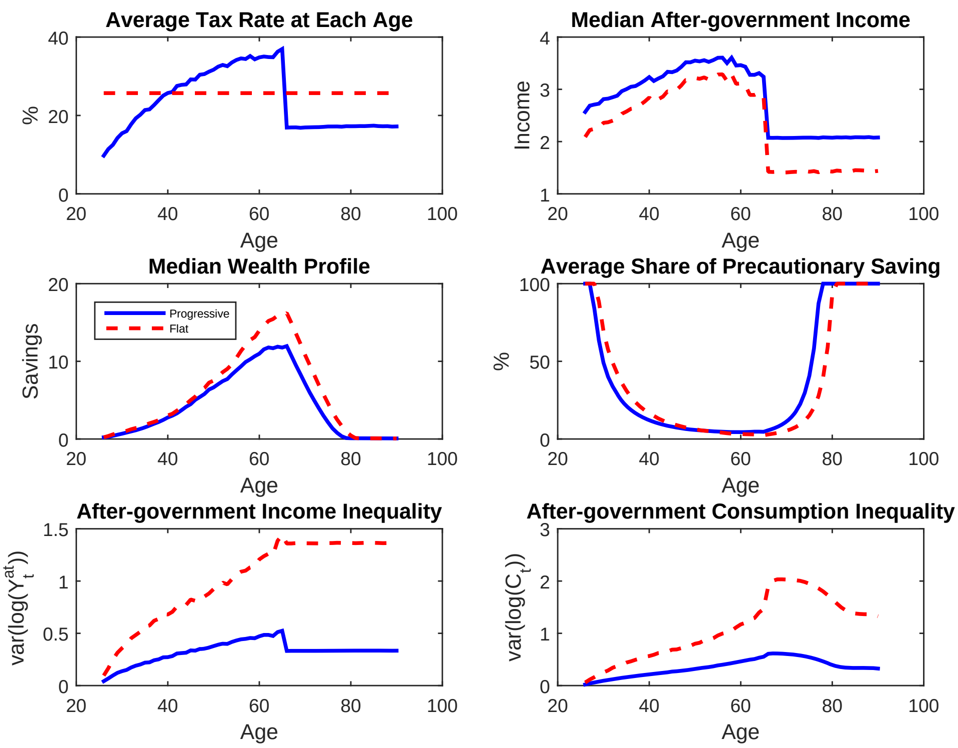
Our benchmark is a model with a flat tax rate comparable to the German progressive tax schedule. Concretely, we do a Monte Carlo simulation of the income process under the parameter estimates reported in the previous section and calculate the average total tax revenue from the economy. We then take the average of the tax revenues from each

Figure 4.6

Effects of Progressive Taxation.

Note: The unit of levels is 10,000 Euro.

Source: Own simulation.



household as the flat tax rate. Our estimated comparable flat tax rate is 25%.

The upper left graph in Figure 4.6 displays the average tax rate at each age over the life cycle under the two tax schemes. Progressive taxation essentially reallocates the tax burden from the young and the old to their middle ages. Again, as long as the present discounted value of after-government income is fixed, the degree of progressivity would not change the life cycle profiles of consumption and saving on average in the case of certainty. It is precisely through the presence of uncertainty that progressive taxation plays a role. The upper right graph shows that the median household has higher income under progressive taxation than under flat taxation as pre-government income of this household is rather low (see Figure 4.4).

The left graph in the second row in Figure 4.6 shows that there is less wealth accumulation under progressive taxation over the life cycle. On average, the median household would hold 24.6% less wealth. This is not surprising as progressive taxation reduces after-government income uncertainty and obviates the need for a wealth buffer as big as under flat taxation. However, this does not mean the precautionary *motive* is diminished under progressive taxation. Two forces are at work here: reduced after-government income uncertainty leads to a reduced precautionary motive given a fixed wealth level, reduced wealth accumulation, on the other hand, intensifies the precautionary motive given a fixed degree of uncertainty. In fact, as the right graph in the second row shows, the average share of precautionary saving in total saving at each age is quantitatively not much different under two tax schemes.

After-government income inequality and after-government consumption inequality are both considerably smaller under progressive taxation, as shown in the bottom two graphs in Figure 4.6. As a result, the distribution of consumption becomes tighter for each cohort under progressive taxation.

Importantly, the effect of progressive taxation on savings differs across the income and wealth distribution of households. For each subgroup of the population, we calculate the average savings crowded out by progressive taxation, presented in Table 4.5.1.

Table 4.5.1

Share of Savings Crowded Out by Progressive Taxation.

	Pre-Government Income in 10,000 Euro	Wealth in 10,000 Euro	Reduction in Savings (%)
Total	4.453	3.900	24.6
Employees	4.417	3.300	37.7
Self-Employed	5.187	11.000	-11.0
College graduates	6.012	7.850	19.1
Apprenticeship	4.117	2.871	48.5
Low educated	3.561	1.617	60.0

Continued on next page

	Pre-Government Income in 10,000 Euro	Wealth in 10,000 Euro	Reduction in Savings (%)
Blue collar	3.620	1.950	27.9
White collar	4.840	3.792	33.9
Civil servant	5.123	7.584	22.4
Married with children	5.042	6.558	24.9
Married without children	5.020	7.584	44.8
Single	3.391	1.625	26.7

Notes: The first two columns report the median income and wealth in the data among various subgroups. Unit is 10,000 Euro. The last column shows the average reduction in savings over the life cycle for a household with median wealth.

Source: Own calculations.

Average reduction in savings would depend on each subgroup's income growth, income risk profile, and preferences. For instance, self-employed households tend to accumulate more wealth over the life cycle than other groups, indicating that they might be more patient. Progressive taxation would actually discourage their wealth accumulation because the saving motive for consumption smoothing outweighs the effect of reduction in uncertainty.

4.5.2. Partial Insurance of Permanent and Transitory Shocks

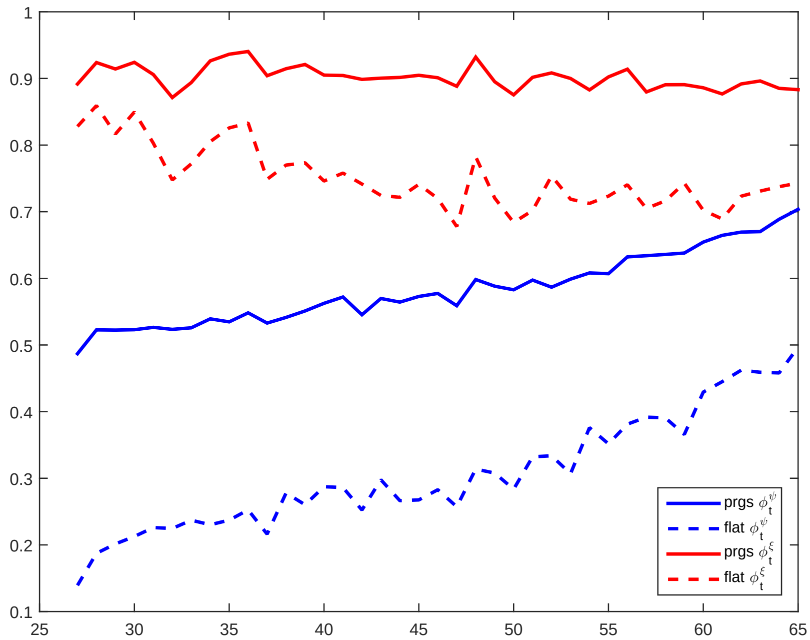
An important measure of consumption insurance against idiosyncratic labor income shocks in the literature is the partial insurance coefficients of permanent and transitory shocks (see Blundell et al. (2008), Kaplan and Violante (2010), for instance). The idea is to measure how much income shocks translate into consumption movements. In this section, we use our calibrated model to assess the effect of progressive taxation on consumption insurance.

As in Kaplan and Violante (2010), we define the partial insurance coefficients of permanent and transitory shocks as

Figure 4.7

Partial Insurance Coefficients of Permanent and Transitory Shocks.

Source: Own simulation.



$$\phi_t^\psi = 1 - \frac{cov(\Delta \log C_{it}, \psi_{it})}{var(\psi_{it})} \tag{4.15}$$

$$\phi_t^\xi = 1 - \frac{cov(\Delta \log C_{it}, \xi_{it})}{var(\xi_{it})} \tag{4.16}$$

When $\phi_t = 1$, there is perfect insurance; when $\phi_t < 1$, there is only partial insurance. The benefit of a structural model is that it allows us to directly calculate the insurance coefficients by simulation.

Figure (4.7) presents the partial insurance coefficients of permanent and transitory shocks over the life cycle under the two tax schemes.[18] Apparently, there is more

[18]The partial insurance in Figure (4.7) is the insurance against shocks to pre-government income, whereas it is the insurance against shocks to after-government income in most of the literature (Blun-

insurance against transitory as well as permanent shocks under progressive taxation. However, this is not obvious because under flat taxation there is more wealth accumulation. Indeed, by crowding out part of savings of households, progressive taxation reduces self insurance; but it reduces after-government income uncertainty as well and thus increases social insurance more than enough for the reduction in self-insurance. Interestingly, the insurance coefficients under flat taxation catch up but never exceed those under progressive taxation. This is due to the limited life span which, in turn, limits wealth accumulation and hence the degree of self-insurance.

Table 4.5.2 compares the average insurance coefficients for different subgroups between the two tax schemes. For every subgroup, progressive taxation provides more insurance against income shocks. In particular, by replacing the flat tax with progressive taxation, the insurance against permanent shocks raises from approximately 30% to 60%, while the insurance against transitory shocks increases from about 70% to 90% on average.

Table 4.5.2

Insurance Effect of Progressive Taxation.

	Progressive System		Flat System	
	$\bar{\phi}^{\psi}$	$\bar{\phi}^{\xi}$	$\bar{\phi}^{\psi}$	$\bar{\phi}^{\xi}$
Total	0.589	0.902	0.305	0.745
Employees	0.576	0.906	0.300	0.761
Self-Employed	0.716	0.893	0.413	0.662
College graduates	0.573	0.836	0.298	0.642
Apprenticeship	0.548	0.907	0.291	0.791
Low educated	0.630	0.919	0.326	0.789
Blue collar	0.550	0.895	0.267	0.764
White collar	0.548	0.880	0.266	0.724
Civil servant	0.614	0.943	0.355	0.818
Married with children	0.581	0.942	0.322	0.828

Continued on next page

dell et al. (2008), Kaplan and Violante (2010)). This distinction vanishes under flat taxation, because variances of shocks to pre- and after-government income are the same. The magnitude of the presented insurance coefficients associated with flat taxation is in line with results in the previous literature.

	Progressive System		Flat System	
	$\bar{\phi}^{\psi}$	$\bar{\phi}^{\xi}$	$\bar{\phi}^{\psi}$	$\bar{\phi}^{\xi}$
Married without children	0.451	0.886	0.255	0.846
Single	0.619	0.924	0.325	0.752

Notes: The insurance coefficients are calculated as the average over ages 26-65 for each subgroup.

Source: Own calculations.

4.5.3. Welfare Effect of Progressive Taxation

We measure welfare as the present discounted value of certain income that yields the same expected utility as when there is income uncertainty. To be specific, we calculate the present discounted value Y_{PDV} such that the optimal consumption stream $\{\tilde{C}_{it}\}$ chosen with initial wealth Y_{PDV} and no future labor income uncertainty satisfies

$$\sum_{t=t_0}^{T+t_0} \beta^{t-t_0} u_t(\tilde{C}_{it}) = E_{t_0}\left[\sum_{t=t_0}^{T+t_0} \beta^{t-t_0} u_t(C_{it})\right].$$

Table 4.5.3 shows that the median household is indifferent between the revenue neutral flat tax under uncertainty and 631 thousand Euro which he receives with certainty; in contrast, the median household is indifferent between the revenue neutral progressive tax under uncertainty and 734 thousand Euro which he receives with certainty. Thus, the household has to be compensated with 103,000 Euro or 14% to choose the revenue neutral flat tax under uncertainty.

Table 4.5.3

Impact of Social Insurance on Welfare.

	Progressive	Flat	Difference (%)
Total	73.4	63.1	14.0
Employees	74.6	64.7	13.2
Self-Employed	86.1	78.8	8.5
College graduates	101.8	102.6	-0.1

Continued on next page

	Progressive	Flat	Difference (%)
Apprenticeship	77.1	68.8	10.8
Low educated	56.0	41.1	26.6
Blue collar	68.3	57.1	16.5
White collar	83.3	76.6	8.1
Civil servant	72.8	62.3	14.4
Married with children	74.2	65.5	11.8
Married without children	92.2	90.5	1.8
Single	65.4	53.8	17.8

Notes: Unit of income is 10,000 Euro.

Source: Own calculations.

The results for subgroups reveal considerable heterogeneity in welfare gains under progressive taxation. Consistent with a principle implied by vertical equity, i.e. that those who are more able to pay taxes should contribute with higher rates than those who are not, households with low income gain most from progressive taxation. Most households have welfare gains under progressive taxation, however, the magnitude of the gains and its variation across subgroups underscore the need for understanding the welfare implication on various groups of households when studying progressive taxation and designing reform proposals.

4.6. Conclusion

This chapter contributes to the understanding of the role of progressive taxation for precautionary saving behavior. We estimate idiosyncratic labor income risk profiles over the life cycle for heterogeneous household groups. Using an incomplete-markets life cycle model with estimated preference parameters, we show that progressive taxation, compared to a revenue-neutral flat tax, reduces the average savings by 24.6% for a household with median wealth. In our simulated economy under progressive taxation, 60% of permanent shocks and 30% of transitory shocks to pre-government labor income are insured against, while only 30% of permanent shocks and 70% of transitory shocks are insured against in an economy with a revenue-neutral flat taxation.

There are sizable welfare gains on average with progressive taxation but considerable heterogeneity among different subgroups.

The results of this study have two important implications. First, studies that abstract from social insurance overemphasize precautionary savings in countries like Germany. Second, reform proposals that imply a reduction of social insurance should discuss the consequences on saving behavior.

Appendix 4.A: Progressive Taxation and Income Uncertainty

The following formalization completes the arguments in the main analysis. A broader treatise of the fact that redistributive taxation helps to insure against individual risk is provided, for example, in Mirrlees (1974); Varian (1980).

After rewriting the tax function as $TX(Y_t) = \tau(Y_t)Y_t$, where $\tau : \mathbf{R}_+ \mapsto \mathbf{R}$ is the average tax rate function, we assume for ease of exposition that $\tau(Y)$ is continuous and piece-wise differentiable and that the corresponding marginal tax rate $\frac{d[Y\tau(Y)]}{dY} = \tau(Y) + Y\tau'(Y)$ is between $[0,1)$. The immediate implication is that the tax function is non-decreasing. In particular, progressive taxation where the marginal tax rate is positive and increasing satisfies this assumption.

Given that the stochastic part of log pre-government income is

$$y_{it} - y_{it-1} = \varepsilon_{it}, \tag{4.17}$$

where ε_{it} is the uninsurable idiosyncratic component, we can think of after-government income as a new income process $\{X_t\}$, where $X_t = (1-\tau(Y_t))Y_t$. Then it follows that the log after-government income process is different from log gross income process only in the stochastic terms

$$x_{it} = x_{it-1} + f_{Y_{it-1}}(\varepsilon_{it}) + \varepsilon_{it}, \tag{4.18}$$

where $x_{it} = \log X_{it}$, and $f_{Y_{it-1}}(\varepsilon_{it})$ is the effect of taxation on the variation of after-government income. Under the assumption that marginal tax rate is between $[0,1)$, it is easy to show that $0 < |f_{Y_{it-1}}(\varepsilon_{it}) + \varepsilon_{it}| < |\varepsilon_{it}|$. Thus progressive taxation reduces the size of after-government income shocks. Similarly, one can show that progressive taxation reduces the conditional variance of after-government income shocks.

If we make further the assumption that the marginal tax rate is non-decreasing, that is, $\frac{d^2[Y\tau(Y)]}{dY^2} \geq 0$, we can show that expected human wealth is concave. Suppose, a household has permanent income P_t at age t and could potentially have pre-government income Y_{t+s} at the age $t+s$. Then

$$Y_{t+s} = P_t \left(\prod_{w=1}^{s} \Gamma_{t+w} \Psi_{t+w} \right) \Xi_{t+s} = P_t \left(\prod_{w=1}^{s} \Gamma_{t+w} \right) \Upsilon_{t+s},$$

where $\Upsilon_{t+s} = \left(\prod_{w=1}^{s} \Psi_{t+w} \right) \Xi_{t+s}$ is a mean-zero cumulative shock. Because of Jensen's inequality, we have

$$\begin{aligned} E[\tau(Y_{t+s})Y_{t+s}] &= \int \tau(Y_{t+s})Y_{t+s} d\Upsilon_{t+s} \\ &\geq \tau(\int Y_{t+s} d\Upsilon_{t+s}) \int Y_{t+s} d\Upsilon_{t+s} \\ &= \tau(E[Y_{t+s}])E[Y_{t+s}]. \end{aligned}$$

Hence,

$$\begin{aligned} E\left[(1-\tau(Y_{t+s}))Y_{t+s})\right] &= E[Y_{t+s}] - E[\tau(Y_{t+s})Y_{t+s}] \\ &\leq E[Y_{t+s}] - \tau(E[Y_{t+s}])E[Y_{t+s}] \\ &= (1-\tau(E[Y_{t+s}]))E[Y_{t+s}]. \end{aligned}$$

That is, expected after-government income at any future period is concave in current permanent income. Since human wealth is simply the sum of discounted future incomes,

$$H_t = Y_t + \frac{Y_{t+1}}{1+r} + \frac{Y_{t+2}}{(1+r)^2} + \cdots,$$

it is straightforward that the expected human wealth is also concave in current permanent income.

Appendix 4.B: Numerical Solution to the Consumer's Problem

For ease of notation, we suppress the household index i. The consumer's optimization problem in our model is

$$\max_{C_t} E_{t_0}\left[\sum_{t=t_0}^{T+t_0} S_t \beta^{t-t_0} u(C_t)\right],$$

subject to

$$\begin{aligned} A_t &= M_t - (1+\tau_C)C_t, \\ M_{t+1} &= A_t R + (1-\tau(Y_{t+1}))Y_{t+1}, \\ Y_{t+1} &= P_{t+1}\Xi_{t+1}, \\ P_{t+1} &= P_t \Gamma_{t+1}\Psi_{t+1}, \end{aligned}$$

where $R = (1+r(1-\tau_A))$ is the gross interest factor.

There are two state variables in this problem, market wealth M_t and pre-government income Y_t. The only place where the level of permanent income plays a role is inside the tax function. Had there been no tax or a flat tax, we could reduce one state variable by normalization. However, the specialty of our problem is that the tax function is progressive, and hence the solution of the consumption function crucially depends upon the level of permanent income.

The consumer's optimization problem can be solved recursively with the Euler equations for $t < T$

$$u'(C_t(M_t,P_t)) = R\beta\frac{S_{t+1}}{S_t}E_t[(\psi_{t+1}\Gamma_{t+1})^{-\rho}u'(C_{t+1}(M_{t+1},P_{t+1}))], \tag{4.19}$$

where $C_t(M_t,P_t)$ represents the optimal consumption rule in period t and $C_T(M_T,P_T) = M_T$. To enhance speed and to ensure accuracy, we take several steps in numerically solving for $c_t(m_t,P_t)$. For each period, we specify the grid for the level of permanent income and construct the grid for market wealth at each level using the method of endogenous grid points (Carroll (2006)). The grid for permanent income (200 points) is spaced such that there are more points closer to zero, since the tax schedule tends to be more progressive (hence highly nonlinear) at lower levels of income. The grid for assets (30 points) is chosen such that there are more points closer to the borrowing constraint. Cross-sectional distributions are obtained by simulation with 10,000 agents in each period.

Table 4.B.1

Summary of Variables and Parameters.

Parameter	Definition
β	time invariant discount factor
ρ	coefficient of relative risk aversion
$\underline{A}$	borrowing constraint
R	gross real interest rate
A_{t_0}	initial asset
Y_{t_0}	initial income
Variable	**Definition**
Y_t	pre-government income
M_t	market wealth
A_t	beginning-of-period asset
P_t	permanent income
S_t	unconditional probability of survival
Γ_t	deterministic growth factor of permanent income
Ξ_t	transitory shocks to gross income
Ψ_t	permanent shocks to gross income
y_t	log gross income
g_t	deterministic growth rate of permanent income
p_t	log permanent income
ξ_t	transitory shock to gross income growth rate
ψ_t	permanent shock to gross income growth rate
σ_{ξ_t}	standard deviation of transitory shocks
σ_{ψ_t}	standard deviation of permanent shocks

Appendix 4.C: Method of Simulated Moments

The method of simulated moments was first introduced by McFadden (1989) and Pakes and Pollard (1989) for the estimation of discrete choice models. Lee and Ingram (1991) extended this method to a time-series setting and Duffie and Singleton (1993) to Markov models. Since the results of this chapter rely on the distribution of income and wealth, we use an extension of the method of simulated moments to match households' median wealth (see Powell (1994)).

Let $\theta = [\rho, \beta]$ be the set of parameters to be estimated and m_{it} market wealth of household i at age t. We simulate the model for a large number of agents using some initial θ. Denoting the simulated wealth distribution of households at age t by $F_t^m(\theta)$ and the empirical wealth distribution at time t by $\hat{F}_t$, we can compute the distance between $F_t^m(\theta)$ and $\hat{F}_t$. The distance between the simulated and the empirical wealth distribution is minimized to obtain the parameters θ. We define the distance as the difference between the πth quantile of the wealth distribution.

Suppose, θ_0 is the true parameter values, then the πth quantile of wealth distribution at time t would be $m_t(\theta_0)$, satisfying the moment condition

$$E\left[\pi - \mathbf{1}(m_{it} \leq m_t(\theta_0))|t\right] = 0, \tag{4.20}$$

where $\mathbf{1}$ is the indicator function. To estimate θ, we solve the loss function

$$\min_{\theta} E\left[(m_{it} - m_t(\theta))(\pi - \mathbf{1}(m_{it} \leq m_t(\theta)))|t\right]. \tag{4.21}$$

The above moment condition (4.20) is conditional on time t. Because we are not only interested in the wealth distribution at a particular age but also the accumulation of wealth over lifetime. Aggregating the moment conditions over time, we obtain the loss function[19]

$$\min_{\theta} E\left[(m_{it} - m_t(\theta))(\pi - \mathbf{1}(m_{it} \leq m_t(\theta)))q(t)\right], \tag{4.22}$$

[19]We use a minimization procedure that does not rely on the existence of the gradient (simplex).

where $q(t)$ is a weighting function used to account for the evolution of wealth over time. An efficient choice would be $q(t) = f(m_t(\theta_0))$, the density of the distribution of wealth at the πth quantile at time t, under which the estimator $\hat{\theta}$ has a distribution

$$\sqrt{N}(\hat{\theta} - \theta_0) \xrightarrow{d} N(0, \Omega), \tag{4.23}$$

and

$$\Omega = \pi(1-\pi)\left(E\left[f^2(m_t(\theta_0))\frac{\partial m_t(\theta_0)}{\partial \theta}\frac{\partial m_t(\theta_0)}{\partial \theta'}\right]\right)^{-1}. \tag{4.24}$$

Denoting the number of observations in at age t by n, the sample analog of the aggregate loss function is given as

$$\min_{\theta} \sum_{t=1}^{40} \sum_{i=1}^{n} (m_{it} - m_t(\theta))(\pi - \mathbf{1}(m_{it} \leq m_t(\theta)))q_t. \tag{4.25}$$

In a first step, we set $q(t) = 1$ and obtain a consistent estimate $\hat{\theta}_1$ of θ_0. Then we choose the empirical density at $m_t(\hat{\theta}_0)$ of the distribution of wealth at the πth quantile of age t, $\hat{f}(m_t(\theta_0)|t)$, to be the weight q_t. The empirical density function $\hat{f}$ is estimated nonparametrically with a Gaussian kernel.

Appendix 4.D: Identification of the Model

In this section, we discuss how wealth data identify the parameters in the model. This is done for the purpose of exposition only. A rigorous proof is beyond the scope of this chapter. In fact, because there is not a closed-form analytical solution of models with labor income uncertainty, there has not been any formal proof of identification in the literature.[20]

In our model, the coefficient of relative risk aversion (ρ) and the discount factor (β) are estimated by matching simulated and empirical median wealth profiles over the life cycle. As argued below, the empirical profile of wealth accumulation identifies consumption growth over the life cycle, and the difference in consumption growth between young and old households then identifies the coefficient of relative risk aversion and the discount factor. Consumption growth can be rewritten using the budget constraint as

$$\frac{C_{t+1}}{C_t} = \frac{M_{t+1} - A_{t+1}}{M_t - A_t}. \tag{4.26}$$

Note that A_t determines M_{t+1} via (4.19). A sequence of market wealth $\{M_t\}_{t=t_0+1}^{t_0+T^{work}}$ is therefore determined by the empirical profile of $\{A_t\}_{t=t_0}^{t_0+T^{work}}$. As a result, consumption growth is identified by the empirical profile of wealth through (4.26). Recall that the Euler equation (4.19) implicitly determines expected consumption growth. Rewriting it in the context of CRRA utility function, we obtain

$$C_t = \left(R\beta\frac{S_{t+1}}{S_t}\right)^{-\frac{1}{\rho}} \Gamma_{t+1} E_t[(\psi_{t+1}C_{t+1})^{-\rho}]^{-\frac{1}{\rho}}. \tag{4.27}$$

If there was no labor income uncertainty, transitory and permanent shocks as well as the expectation operator would disappear in the Euler equation. Consequently,

$$\frac{C_{t+1}}{C_t} = \frac{\left(R\beta\frac{S_{t+1}}{S_t}\right)^{\frac{1}{\rho}}}{\Gamma_{t+1}}, \tag{4.28}$$

[20] A recent exception is Heathcote et al. (2014a), where wealth is a redundant state variable in their model. Tractability of the model and identification of parameters there are thus obtained.

in which case ρ and β are not identified because any combination of $(\rho,\, \beta)$ that satisfies $\beta^{\frac{1}{\rho}} = k$, where k is a constant, would suffice for the desired growth rate of consumption. However, this is not the case when there is labor income uncertainty. When households are old, their consumption is very close to what it would be when there was no uncertainty because they have accumulated a lot of assets to insure themselves against idiosyncratic shocks. Consumption growth for the old is primarily governed by the factor $\frac{\left(R\beta \frac{S_{t+1}}{S_t}\right)^{\frac{1}{\rho}}}{\Gamma_{t+1}}$. In contrast, when households are young, their wealth level is low and uncertainty plays a big role in determining households' consumption growth. As is indicated in equation (4.27), consumption growth does not only depend on the term $\frac{\left(R\beta \frac{S_{t+1}}{S_t}\right)^{\frac{1}{\rho}}}{\Gamma_{t+1}}$, but it also depends on the curvature of marginal utility, which is governed solely by ρ. Thus the difference in consumption growth between young and old will identify both the coefficient of relative risk aversion and the discount factor.

Appendix 4.E: Robustness of Parameter Choices

In this section, we investigate the robustness of our results to various preference parameter choices. As is mentioned in Appendix 4.D, identification of the preferences is achieved by using the slope and curvature of the wealth profile of the median household. In light of the noisiness in the data, however, our estimate of the risk aversion is subject to large standard errors in some occasions. For this reason, we choose various values of risk aversion and estimate the discount factor using the method of simulated moments. Table 4.E.2 displays the estimates.

Table 4.E.2

Robustness Check of Discount Factor Estimates.

	$\rho = 0.6529$ (preferred)	$\rho = 0.5$	$\rho = 1$	$\rho = 2$	$\rho = 3$
Total	0.9633	0.9622	0.9622	0.9627	0.9608
Employees	0.9630	0.9619	0.9635	0.9621	0.9545
Self-Employed	0.9767	0.9730	0.9839	1.0025	1.0132
College graduates	0.9705	0.9667	0.9722	0.9866	0.9893
Apprenticeship	0.9616	0.9611	0.9618	0.9565	0.9523
Low educated	0.9600	0.9599	0.9606	0.9600	0.9593
Blue collar	0.9600	0.9607	0.9594	0.9539	0.9443
White collar	0.9632	0.9624	0.9629	0.9604	0.9555
Civil servant	0.9650	0.9635	0.9675	0.9720	0.9744
Married with children	0.9676	0.9659	0.9720	0.9793	0.9826
Married without children	0.9565	0.9577	0.9542	0.9428	0.9281
Single	0.9658	0.9633	0.9700	0.9793	0.9865

Source: Own calculations.

Appendix 4.F: Data Description

Labor Income and Wealth

Our measure of labor income, available from 1984 to 2012, combines annual household pre-government labor income that this household received in the calendar year previous to the survey year. More specifically, labor income is the sum of income from primary job, secondary job, self-employment, service pay, 13th month pay, 14th month pay, Christmas bonus pay, holiday bonus pay, miscellaneous bonus pay, and profit-sharing income. Household heads with non-zero pension and private transfer income are excluded from the sample. Moreover, we exclude household heads that are retired, in education (including serving an apprenticeship, working as a trainee or intern) or in military service.

We use wealth data that are available in the 2002, 2007 and 2012 waves. The GSOEP questionnaire for these waves included a special module that collected information about private wealth. The surveys asked about the market value of personally owned real estate (owner-occupied housing, other property, mortgage debt), financial assets, tangible assets, private life and pension insurance, consumer credit, and private business equity (net market value; own share in case of a business partnership). The wealth balance sheets referred to the personal level, so in the case of jointly owned assets, the survey explicitly asked about each person's individually owned shares. The variables on labor income and wealth are aggregated to the household level and deflated to 2007 prices using the consumer price index provided by the Federal Statistical Office.

Initial Values

To initialize our model for simulation, we compute the wealth to income ratio distribution of households as follows. We take the wealth to income ratio data of households between ages 20 and 25 and trim the top 2% and the bottom 2%. Assuming that it follows a shifted log-normal distribution, we take the logarithm of the ratios and compute its mean and variance. With the shift, mean and variance, we discretize the distribution equiprobably. A discretization of the initial income distribution is obtained in a similar manner. We assume that these two distributions are independent.

Mortality Risk and Interest Rates

Households are assumed to live more than 65 and less than 91 years. For the probability to stay alive after retirement, we rely on the observations given in the life tables in the Human Mortality Database (HMD henceforth) for Germany, available at www.mortality.org. The life tables include survival probabilities and life expectancies that vary by age and are available for the years from 1991 to 2012. The HMD is provided by the University of California, Berkeley (USA) and Max Planck Institute for Demographic Research (Germany). Our data is affected by the relative size of the female and male populations at a given age and time. Therefore, we do not use the probabilities for women only (as done in Hubbard et al. (1995); Cagetti (2003)) but calculate first the age effects of the conditional probabilities of survival from 1991 to 2012 and then the probability to survive $t - t_0$ periods for each year from age 65 on.

We take annual averages of domestic mid- and long-term bonds yields as provided by the Deutsche Bundesbank to estimate the gross real interest rate. Over the sample period from 1984 to 2012 the yearly average real interest rate is 5.939 with a standard error of 2.735.

Estimation of Income Growth Rate

To remove the common trend of observed household pre-government labor income, we conduct a fixed-effects regression of the log of this variable on a third order polynomial of age, dummies indicating the highest level of education attained[21], dummies

[21] There are five level of educational attainment: (i) a degree from an university, (ii) having served as an apprentice, (iii) having attained a degree that allows to study at an university, (iv) a degrees from other secondary schools, (v) not having attained any qualification. The base category are individuals

indicating the occupational status[22] attained and two-way interactions between these categories and the age polynomial.

We apply different strategies to separate age, time and cohort effects. For instance, similarly to Deaton and Paxson (1994), we generate a set of $S-2$ year dummies defined as $d_s^* = d_s + [(s-2)d_1 - (s-1)d_2]$, from survey year $s = 3, \ldots, S$. Here d_s is a binary indicator for each year. This implies the restriction that the year dummies add to zero and are orthogonal to a linear trend. Recall, that we need to impose restrictions because of the identity $a = t - c$, where c denotes year of birth. We cluster standard errors at the cohort level in the main specification. If cohort effects are not affecting slopes, the elimination of the fixed effects removes also cohort shifters (French (2005)). The results remain similar if we drop the cohort dummies.

Moreover, we include household size indicators d_h for the number of persons $h = 1, .., 5$ in a household, where $d_{h=6}$ represents six or more persons. We also control for the total annual number of hours worked by all household members.

The average predicted income growth rates at each age is the deterministic growth rate of a household with the size of three persons (except for singles and married without children), and with average working hours. We restrict business cycle effects to be zero. We use these growth rates to calibrate our life cycle model. We then work with residuals from the regression as a measure of the idiosyncratic component of pre-government income (see the following section).

We separately estimate these growth rates for groups in our sample that differ with respect to education, occupation, employment, and marital status. Figure 4.F.1 shows the average predicted income levels calculated using the estimated growth rates for each subgroup. This figure shows how pre-government income would evolve over the

who hold a degree from an university. This set of binary variables is mutually exclusive: For example, if an individual has served as an apprentice and a degree from other secondary schools but holds no degree from university, a binary variable for apprenticeship is one and all other education dummies are zero.

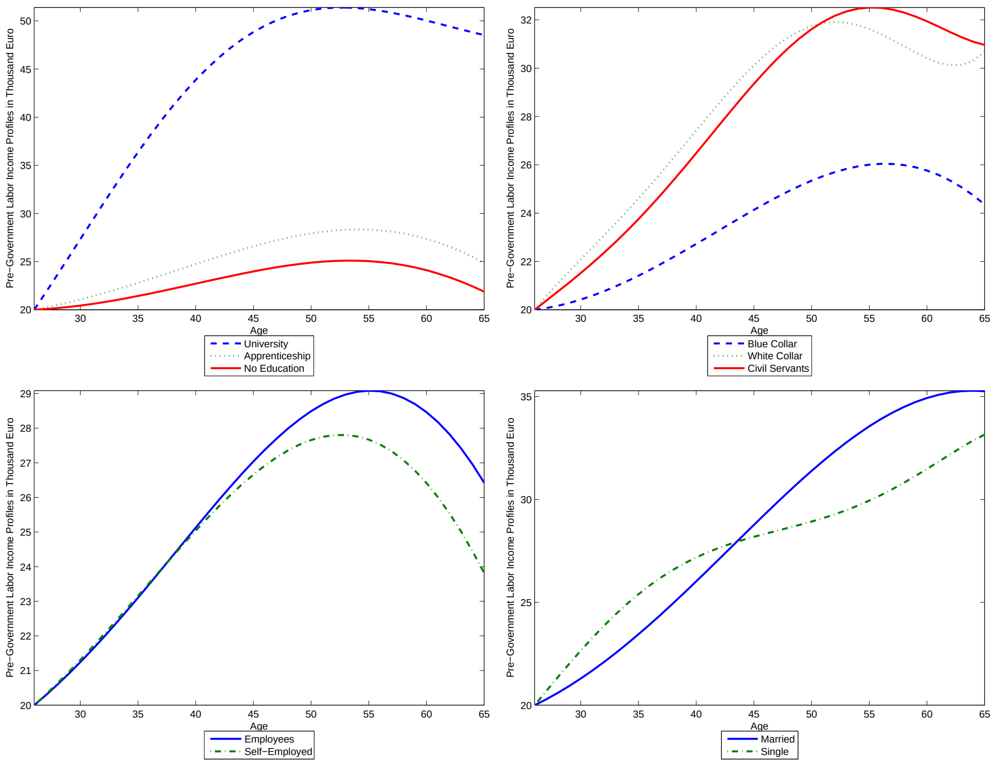
[22]There are two mutually exclusive occupational categories: (i) self-employment, (ii) employment. The base category are individuals in category (i).

life cycle for the same household head who receives 20,000[23] Euro of labor income at age 25 in different groups.

Figure 4.F.1

Predicted Income Growth by Education, Occupation, Type of Employment, and Marital Status.

Source: Authors' calculations based on the GSOEP (1984-2012).



The top left graph shows strong differences by educational attainment. University graduates have a much steeper income profile than all other groups. This is not surprising, still the reader should recall that we estimate growth rates based on household and not personal labor income. As is well known, university graduates constitute often

[23]This number is not entirely arbitrary. In fact, comparing the estimates to the evidence provided by the Federal Statistical Office (Fachserie 16) shows that the pre-government labor income profiles are estimated quite accurately using 20,000 to 25,000 Euro as initial income.

a household with other university graduates. This makes the household income profile even steeper compared to other groups. For example, apprentices' household income has only risen by about 10,000 Euro when household heads turn 55 with a modest decline thereafter. We offer two explanations for this decline: First, less educated household heads tend to work in more physically demanding occupations (see the income profile for blue collar workers below). For this reason they might work fewer hours (and accept lower real wages) towards retirement. Second, there have been financial incentives to do part-time work for older employees fixing nominal hourly wages.[24] The simulated pre-government labor income profile of household heads whose highest educational attainment is apprenticeship does not differ much from that of persons indicating no education. This is not surprising as we exclude household heads earning less than 9,600 Euro per year from the analysis.

The top right graph shows the simulated pre-government labor income profiles for different occupational groups. Civil servants profiles rise increasingly quickly, slowing down shortly before age 50. Their income peaks age 55 and declines somewhat towards retirement. This decline seems to be caused by the law incentivizing part-time work for civil servants older than 55. For white collar workers who receive the highest level of pre-government income up to age 50, there is a modest decline towards retirement. Blue collar workers, in contrast, have scaled down profiles with a slight decline towards the end of working life. Again, we argue that this is due to either early retirement schemes or reduction in hourly wages because of physically demanding work.

The bottom left graph shows profiles for employees, i.e. not self-employed household heads, in contrast to self-employed. Their profiles are very similar up to age 50 when incomes of self-employed decline substantially. One explanation of this pattern is that self-employed put more of their income in their business when older and receive more income from capital income towards the end of working life.

[24] See law for part-time work for older employees (Altersteilzeitgesetz, AltTZG).

The bottom right graph displays income profiles of persons who are living in single households and married couples. As with self-employed, household heads are unlikely to stay single during their entire life. However, in our exercise we concatenate observations of persons observed at each age to learn how their labor income profile would look like if marital status was not changed. Singles have more income before age 45, presumably, because they are able to provide more labor supply than families with children. Or conversely, the fact that low productive persons marry early can explain the pattern observed.

Estimation of the Income Risks

The following general stochastic process describes pre-government income.

$$Y_{it} = P_{it}\Xi_{it}, \tag{4.29}$$

$$P_{it} = P_{it-1}^{\alpha}\Gamma_{it}\Psi_{it}. \tag{4.30}$$

P_{it} is the persistent component of the income process where α is a parameter indicating the degree of persistence. Ψ_{it} and Ξ_{it} are persistent and transitory shocks to pre-government income, respectively. Γ_t is the deterministic component of pre-government income reflecting income growth due to experience. We are interested in the growth rate common for all households and thus restrict it accordingly. Lowercase variables indicate the log of the respective uppercase variables, i.e. $y_{it} = log(Y_{it})$, $p_{it} = log(P_{it})$, $\xi_{it} = log(\Xi_{it})$, $\gamma_t = log(\Gamma_t)$, $\psi_{it} = log(\Psi_{it})$.

Thus, log income follows

$$y_{it} = p_{it} + \xi_{it}. \tag{4.31}$$

The persistent component follows

$$p_{it} = \gamma_t + \alpha p_{it-1} + \psi_{it}.$$

In a general form, the transitory component is described by the following ARMA(1,1) process where L is the lag operator

$$\xi it = \frac{1+\theta L}{1-\varphi L}\varepsilon_t.$$

For the estimation, α is restricted to 1. According to Hryshko (2012), the restricted model cannot be rejected with data from the US. Shocks are assumed to be uncorrelated across calendar time, cohort, and age.[25] They are drawn from mean-zero normal distributions with age varying variance according to

$$\psi_{it} \sim N(0, \sigma^2_{\psi,it}),$$

$$\varepsilon_{it} \sim N(0, \sigma^2_{\varepsilon,it}).$$

Theoretical Moments in First Differences

To remove individual unobserved factors like ability, we take first differences after removing the deterministic component γ_t. Then, the idiosyncratic component of the income process is

$$\Delta y_{it} = p_{it} - p_{it-1} + \xi_{it} - \xi_{it-1}.$$

The first difference of the persistent component is

$$p_{it} - p_{it-1} = \alpha(p_{it-1} - p_{it-2}) + \psi_{it} - \psi_{it-1},$$

and recursive substitution yields

$$p_{it} - p_{it-1} = \alpha^2(\alpha p_{it-3} + \psi_{it-2} - p_{it-3}) + \alpha\psi_{it-1} - \alpha\psi_{it-2} + \psi_{it} - \psi_{it-1},$$

which is with $\alpha = 1$ simply

$$p_{it} - p_{it-1} = \psi_{it}.$$

The first difference of the transitory component is

$$\xi_t - \xi_{t-1} = \varphi(\xi_{t-1} - \xi_{t-2}) + \varepsilon_t + (\theta - 1)\varepsilon_{t-1} - \theta\varepsilon_{t-2},$$

and recursive substitution yields

$$\xi_t - \xi_{t-1} = \varphi^2(\varphi\xi_{t-3} + \varepsilon_{t-2} + \theta\varepsilon_{t-3} - \xi_{t-3}) + \varphi\varepsilon_{t-1}$$

[25] Age effects are separated from time and cohort effects following Deaton and Paxson (1994) and thus by definition orthogonal to the idiosyncratic shocks to income.

$$+\varphi(\theta-1)\varepsilon_{t-2}-\varphi\theta\varepsilon_{t-3}+\varepsilon_t+(\theta-1)\varepsilon_{t-1}-\theta\varepsilon_{t-2}.$$

The theoretical moments are

$$\gamma_0=\sigma^2_{\Delta p,t}+\sigma^2_{\Delta\xi,t}, \tag{4.32}$$

$$\gamma_1=\alpha\sigma^2_{\Delta p,t}-\sigma^2_{\psi,t}+\varphi\sigma^2_{\Delta\xi,t}+(\theta-1)\sigma^2_{\varepsilon,t}-\theta(\varphi+\theta-1)\sigma^2_{\varepsilon,t-1}, \tag{4.33}$$

$$\begin{aligned}\gamma_k &= \alpha^{(k-t)}\sigma^2_{\Delta p,t}-\alpha^{(k-t-1)}\sigma^2_{\psi,t}+ \\ &\quad \varphi^{(k-t)}\sigma^2_{\Delta\xi,t}+(\varphi^{(k-t-1)}(\theta-1)-\varphi^{(k-t-2)}\theta)\sigma^2_{\varepsilon,t}-\varphi^{(k-t-1)}\theta(\varphi+\theta-1)\sigma^2_{\varepsilon,t-1}\forall k\geq 2,\end{aligned} \tag{4.34}$$

where

$$\sigma^2_{\Delta\xi,25}=\varphi^2\sigma^2_{\Delta\xi,24}+\sigma^2_{\varepsilon,25}+\sigma^2_{\varepsilon,25}[(\theta-1)^2+\theta^2+2\varphi(\theta-1)-2\varphi\theta(\varphi+\theta-1)],$$

$$\sigma^2_{\Delta\xi,26}=\varphi^2\sigma^2_{\Delta\xi,25}+\sigma^2_{\varepsilon,26}+\sigma^2_{\varepsilon,25}(\theta-1)^2+\sigma^2_{\varepsilon,25}\theta^2+2\varphi(\theta-1)\sigma^2_{\varepsilon,25}-2\varphi\theta(\varphi+\theta-1)\sigma^2_{\varepsilon,25},$$

$$\sigma^2_{\Delta\xi,t}=\varphi^2\sigma^2_{\Delta\xi,t-1}+\sigma^2_{\varepsilon,t}+\sigma^2_{\varepsilon,t-1}(\theta-1)^2+\sigma^2_{\varepsilon,t-2}\theta^2+2\varphi(\theta-1)\sigma^2_{\varepsilon,t-1}-2\theta\varphi(\varphi+\theta-1)\sigma^2_{\varepsilon,t-2}.$$

Empirical Moments in First Differences

The empirical moments are calculated as

$$\hat{\Omega}=\frac{\Lambda}{N_{tt'}},$$

where Λ is the vectorized lower triangular part of the symmetric matrix $\sum_{i=1}^{N}\tilde{y}_i\tilde{y}_i'$ and $\tilde{y}_i=[\Delta y_{i2},\Delta y_{i3},\ldots,\Delta y_{iT}]$. N is the total number of heads in the sample. $N_{tt'}$ is a vector with row dimension $T(T+1)/2$. N_{11} is the number of heads contributing toward estimation of the variance in period 1 $(t=1,t=1)$, N_{12} is the number of heads contributing toward estimation of the first-order autocovariance between periods 1 and 2 $(t=1,t=2)$, etc. Since the sample is unbalanced, a household's income may be missing. Following Hryshko (2012), this household's contributions to the variance at age 1 and all the sample autocovariances involving this period are restricted to zero.

We estimate the vector of the 81 model parameters Θ by minimizing a squared distance function $[\Omega(\Theta)-\hat{\Omega}]'I[\Omega(\Theta)-\hat{\Omega}]$, where I is an identity matrix with the row dimension $T(T+1)/2=406$.[26] Standard errors of the parameters are calculated as the square roots of the diagonal of

$$(\tilde{\Omega}_{\Theta}'\tilde{\Omega}_{\Theta})^{-1}\tilde{\Omega}_{\Theta}'V\tilde{\Omega}_{\Theta}(\tilde{\Omega}_{\Theta}'\tilde{\Omega}_{\Theta})^{-1},$$

where $\tilde{\Omega}_{\theta}=\frac{\partial}{\partial\theta}[\Omega(\hat{\theta})-\hat{\Omega}]$, a vector with the row dimension $T(T+1)/2$, and the column dimension equal to the row dimension of the vector of estimated parameters; V is equal to $\sum_{i=1}^{N}(\hat{\Omega}_i-\hat{\Omega})(\hat{\Omega}_i-\hat{\Omega})/N_V$, where $\hat{\Omega}_i$ is the vectorized lower triangular part of the symmetric matrix $\tilde{y}_i\tilde{y}_i'$, and the klth element of N_V is calculated as $N_V^{kl}=N_{tt'}^{k}N_{tt'}^{l}$, where $N_{tt'}^{k}$ is the kth element of $N_{tt'}$.

Figure 4.F.2 shows the average empirical autocorrelation function and the theoretical autocorrelation function with the estimated parameters. It is obvious that the autocorrelation function is significant only from order 0 to order 2 and that the contribution of the transitory component toward the autocorrelation function tails off rather quickly. The estimated parameters along with their standard errors in parentheses are shown in Tables 4.F.3 to 4.F.6. Note that all negative point estimates in these tables are not statistically different from zero.

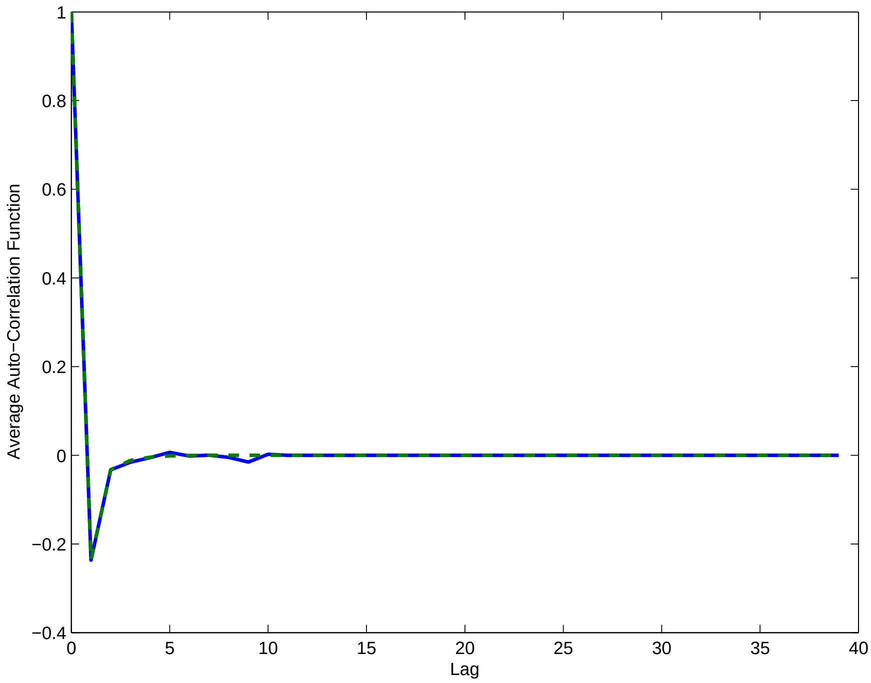
Table 4.F.3 shows our estimates for three levels of education: Both permanent and transitory variances are presented for household heads who are university graduates, those who have served an apprenticeship and no higher professional training, and those who do not have indicated having any education. A striking fact from this table is that university graduates face large permanent shocks which reduce rapidly up to their mid

[26] We use a Quasi-Newton method for the minimization procedure.

Figure 4.F.2

Simulated and Observed Auto-Correlation Function.

Source: Authors' calculations based on the GSOEP (1984-2012).



40s. They stay on a rather low level but increase towards retirement age modestly. In contrast, transitory shocks remain quite constant and relatively small over the life cycle.[27] Apprenticeship trained household heads face larger permanent than transitory variances both of which decline with age but rise again at a relatively slow pace after age 45. Not having attained education means facing quite large transitory shocks which are increasing towards retirement age. However, permanent shocks start from a comparatively low level and then decline steadily. These findings seem intuitive, permanent shocks, e.g. promotions, permanently higher productivity or health risks are more likely to affect labor income of higher educated persons, while transitory

[27] This are in line with the findings in Blundell et al. (2014) who find that after taking out calendar time effects, the variance of transitory shocks exhibits a smooth and decreasing profile over the life cycle.

shocks are relatively important for the less educated. Moreover, university graduates who might start a business in young years or move up within a firm are known to face large uncertainties. At young ages higher uncertainty is also documented for the other groups but at a much smaller level. Why does uncertainty rise at the end of working live? Shocks to health and thus productivity might increase at higher ages.

Table 4.F.4 displays the same estimates for two groups, namely self-employed and employees, as well as for the entire sample. As expected, self-employed face large risks. In fact, permanent variances are about twice as high as transitory variances. They follow the known u-shape over the life cycle. As the fraction of self-employed is quite small, the total sample and the employees have similar risks over the life cycle. For employees transitory risks remain quite stable throughout, while permanent uncertainty is high in young years declining towards retirement.

Table 4.F.5 shows that the three occupational groups face all constant transitory and u-shaped permanent risks over the life cycle. While transitory uncertainty is roughly on the same level for all three groups, permanent uncertainty is highest for white collar workers at early ages, second highest for civil servants, and lowest for blue collar workers. Towards retirement blue collar and white collar workers end up with almost the same uncertainty. Civil servants, however, faces almost no uncertainty at all at higher ages.

Finally, Table 4.F.6 shows that for married household heads transitory uncertainty is on average relatively more important than permanent, while this pattern is on average reverse for singles. Interestingly, singles face less uncertainty at young ages. However, towards the end of working life, in particular the permanent uncertainty is higher for singles compared to married.

Table 4.F.3

Permanent and Transitory Variances over Age by Education.

Sample	University Graduates				Apprentices				Lower Education			
Age	$\hat{\sigma}^2_\psi$	s.e.	$\hat{\sigma}^2_\varepsilon$	s.e.	$\hat{\sigma}^2_\psi$	s.e.	$\hat{\sigma}^2_\varepsilon$	s.e.	$\hat{\sigma}^2_\psi$	s.e.	$\hat{\sigma}^2_\varepsilon$	s.e.
26	-	-	0.0484	0.0255	-	-	0.0250	0.0062	-	-	0.0490	0.0053
27	0.1677	0.0409	0.0080	0.0100	0.0590	0.0104	0.0282	0.0051	0.0733	0.0168	0.0662	0.0213
28	0.1389	0.0239	0.0351	0.0148	0.0583	0.0083	0.0377	0.0085	0.0208	0.0212	0.0768	0.0236
29	0.1348	0.0245	0.0433	0.0125	0.0506	0.0061	0.0228	0.0042	0.0344	0.0151	0.0605	0.0160
30	0.1015	0.0184	0.0231	0.0083	0.0482	0.0061	0.0307	0.0071	0.0541	0.0210	0.0474	0.0171
31	0.0733	0.0127	0.0238	0.0120	0.0484	0.0054	0.0263	0.0036	0.0260	0.0190	0.0585	0.0160
32	0.0922	0.0155	0.0306	0.0088	0.0512	0.0060	0.0280	0.0041	0.0192	0.0155	0.0651	0.0174
33	0.0756	0.0136	0.0139	0.0057	0.0323	0.0045	0.0296	0.0036	0.0413	0.0177	0.0416	0.0124
34	0.0541	0.0088	0.0229	0.0062	0.0279	0.0046	0.0313	0.0051	0.0150	0.0146	0.0577	0.0145
35	0.0404	0.0083	0.0319	0.0087	0.0378	0.0064	0.0339	0.0051	0.0220	0.0139	0.0568	0.0140
36	0.0606	0.0107	0.0391	0.0094	0.0330	0.0053	0.0250	0.0035	0.0235	0.0240	0.0673	0.0180
37	0.0229	0.0073	0.0336	0.0087	0.0323	0.0046	0.0281	0.0036	0.0172	0.0129	0.0517	0.0130
38	0.0408	0.0114	0.0381	0.0080	0.0326	0.0047	0.0297	0.0050	0.0009	0.0167	0.0687	0.0187
39	0.0242	0.0083	0.0307	0.0079	0.0250	0.0043	0.0283	0.0037	0.0038	0.0168	0.0765	0.0187
40	0.0288	0.0089	0.0234	0.0062	0.0240	0.0047	0.0315	0.0041	0.0193	0.0120	0.0460	0.0134
41	0.0221	0.0068	0.0256	0.0066	0.0196	0.0039	0.0270	0.0032	0.0004	0.0140	0.0620	0.0150
42	0.0215	0.0055	0.0237	0.0050	0.0310	0.0052	0.0216	0.0031	-0.0031	0.0161	0.0711	0.0197
43	0.0132	0.0054	0.0261	0.0057	0.0284	0.0044	0.0262	0.0033	0.0283	0.0137	0.0394	0.0113
44	0.0198	0.0060	0.0275	0.0063	0.0248	0.0042	0.0260	0.0037	0.0090	0.0128	0.0523	0.0132
45	0.0304	0.0068	0.0314	0.0076	0.0225	0.0036	0.0274	0.0039	-0.0078	0.0255	0.0768	0.0360
46	0.0082	0.0064	0.0450	0.0108	0.0267	0.0039	0.0271	0.0044	-0.0093	0.0171	0.0822	0.0213
47	0.0116	0.0135	0.0464	0.0140	0.0303	0.0047	0.0258	0.0042	-0.0094	0.0156	0.0712	0.0179

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Sample	University Graduates				Apprentices				Lower Education			
Age	$\hat{\sigma}^2_\psi$	s.e.	$\hat{\sigma}^2_\varepsilon$	s.e.	$\hat{\sigma}^2_\psi$	s.e.	$\hat{\sigma}^2_\varepsilon$	s.e.	$\hat{\sigma}^2_\psi$	s.e.	$\hat{\sigma}^2_\varepsilon$	s.e.
48	0.0160	0.0111	0.0349	0.0108	0.0309	0.0048	0.0221	0.0032	0.0078	0.0178	0.0720	0.0192
49	0.0159	0.0067	0.0272	0.0069	0.0289	0.0046	0.0235	0.0033	0.0249	0.0135	0.0503	0.0138
50	0.0147	0.0074	0.0247	0.0056	0.0307	0.0056	0.0233	0.0044	-0.0024	0.0174	0.0740	0.0203
51	0.0211	0.0066	0.0292	0.0077	0.0341	0.0047	0.0253	0.0041	0.0109	0.0151	0.0704	0.0183
52	0.0142	0.0054	0.0203	0.0044	0.0236	0.0045	0.0307	0.0047	0.0123	0.0170	0.0646	0.0160
53	0.0151	0.0084	0.0204	0.0057	0.0222	0.0060	0.0354	0.0079	0.0037	0.0149	0.0548	0.0167
54	0.0204	0.0094	0.0435	0.0136	0.0312	0.0087	0.0325	0.0050	0.0007	0.0257	0.0892	0.0327
55	0.0176	0.0072	0.0297	0.0072	0.0347	0.0067	0.0269	0.0048	0.0116	0.0170	0.0654	0.0204
56	0.0043	0.0076	0.0377	0.0103	0.0466	0.0071	0.0236	0.0041	0.0071	0.0196	0.0730	0.0201
57	0.0141	0.0091	0.0352	0.0081	0.0334	0.0057	0.0264	0.0046	0.0291	0.0156	0.0392	0.0141
58	0.0279	0.0102	0.0447	0.0159	0.0417	0.0067	0.0337	0.0062	0.0255	0.0153	0.0417	0.0137
59	0.0193	0.0107	0.0199	0.0095	0.0365	0.0071	0.0325	0.0054	0.0465	0.0205	0.0390	0.0150
60	0.0360	0.0121	0.0175	0.0051	0.0323	0.0096	0.0402	0.0096	0.0380	0.0229	0.0524	0.0207
61	0.0251	0.0068	0.0264	0.0073	0.0390	0.0111	0.0310	0.0073	-0.0744	0.0590	0.1713	0.0688
62	0.0084	0.0143	0.0547	0.0205	0.0470	0.0103	0.0278	0.0091	-0.0204	0.0424	0.1011	0.0550
63	0.0514	0.0131	0.0074	0.0070	0.0221	0.0161	0.0562	0.0157	-0.0364	0.0651	0.1151	0.0691
64	0.0743	0.0353	0.0268	0.0123	0.0670	0.0227	0.0596	0.0158	-0.0350	0.1216	0.1648	0.1378
65	-	-	0.0950	0.0296	-	-	0.1215	0.0396	-	-	0.0943	0.0463
Mean	0.0415	0.0117	0.0317	0.0099	0.0354	0.0067	0.0322	0.0063	0.0113	0.0230	0.0694	0.0248
AR(1)	1	-	0.0174	0.0392	1	-	0.1879	0.046	1	-	0.8183	0.0662
MA(1)	-	-	0.067	0.0516	-	-	-0.026	0.0497	-	-	-0.1978	0.0398
N				5,013				15,677				16,511

Notes: Standard errors are given in columns entitled s.e.

Source: Authors' calculations based on the GSOEP (1984-2012).

Table 4.F.4

Permanent and Transitory Variances over Age by Work Status.

Sample	Total				Employees				Self-Employed			
Age	$\hat{\sigma}^2_\psi$	s.e.	$\hat{\sigma}^2_\varepsilon$	s.e.	$\hat{\sigma}^2_\psi$	s.e.	$\hat{\sigma}^2_\varepsilon$	s.e.	$\hat{\sigma}^2_\psi$	s.e.	$\hat{\sigma}^2_\varepsilon$	s.e.
26	-	-	0.0279	0.0069	-	-	0.0220	0.0049	-	-	-0.0511	0.0547
27	0.0806	0.0074	0.0221	0.0041	0.0797	0.0084	0.0198	0.0030	0.2001	0.0776	0.0580	0.0443
28	0.0683	0.0073	0.0357	0.0073	0.0723	0.0066	0.0202	0.0034	0.0347	0.0600	0.1872	0.0813
29	0.0655	0.0060	0.0249	0.0041	0.0668	0.0057	0.0217	0.0031	0.0847	0.0645	-0.0222	0.0381
30	0.0611	0.0059	0.0283	0.0057	0.0595	0.0053	0.0228	0.0044	0.1669	0.0578	0.0628	0.0566
31	0.0494	0.0051	0.0289	0.0044	0.0498	0.0047	0.0218	0.0031	0.0605	0.0367	0.0889	0.0469
32	0.0564	0.0049	0.0283	0.0040	0.0533	0.0047	0.0219	0.0029	0.0825	0.0443	0.0654	0.0373
33	0.0408	0.0046	0.0269	0.0033	0.0409	0.0044	0.0210	0.0024	0.0522	0.0455	0.0716	0.0204
34	0.0317	0.0039	0.0302	0.0041	0.0336	0.0036	0.0229	0.0024	0.0379	0.0317	0.0499	0.0157
35	0.0375	0.0048	0.0332	0.0046	0.0374	0.0042	0.0253	0.0025	0.0693	0.0325	0.0576	0.0267
36	0.0380	0.0048	0.0275	0.0035	0.0329	0.0044	0.0215	0.0027	0.1237	0.0330	0.0469	0.0229
37	0.0277	0.0036	0.0303	0.0037	0.0273	0.0030	0.0221	0.0023	0.0784	0.0308	0.0681	0.0249
38	0.0297	0.0039	0.0337	0.0044	0.0262	0.0031	0.0266	0.0036	0.0778	0.0285	0.0545	0.0166
39	0.0225	0.0034	0.0299	0.0035	0.0231	0.0030	0.0207	0.0023	0.0623	0.0210	0.0474	0.0136
40	0.0260	0.0038	0.0265	0.0031	0.0246	0.0034	0.0208	0.0021	0.0774	0.0220	0.0357	0.0147
41	0.0216	0.0033	0.0258	0.0028	0.0218	0.0031	0.0202	0.0020	0.0557	0.0151	0.0309	0.0086
42	0.0286	0.0037	0.0230	0.0028	0.0236	0.0031	0.0177	0.0021	0.1087	0.0250	0.0340	0.0121
43	0.0240	0.0034	0.0259	0.0029	0.0219	0.0029	0.0199	0.0021	0.0719	0.0186	0.0321	0.0111
44	0.0243	0.0033	0.0267	0.0032	0.0241	0.0027	0.0199	0.0024	0.0549	0.0157	0.0352	0.0104
45	0.0207	0.0031	0.0307	0.0043	0.0181	0.0024	0.0228	0.0035	0.0930	0.0187	0.0378	0.0164
46	0.0218	0.0033	0.0338	0.0044	0.0213	0.0026	0.0243	0.0034	0.0722	0.0271	0.0825	0.0275
47	0.0218	0.0043	0.0329	0.0047	0.0199	0.0032	0.0219	0.0025	0.0622	0.0398	0.0784	0.0338

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Sample	Total				Employees				Self-Employed			
Age	$\hat{\sigma}^2_\psi$	s.e.	$\hat{\sigma}^2_\varepsilon$	s.e.	$\hat{\sigma}^2_\psi$	s.e.	$\hat{\sigma}^2_\varepsilon$	s.e.	$\hat{\sigma}^2_\psi$	s.e.	$\hat{\sigma}^2_\varepsilon$	s.e.
48	0.0242	0.0037	0.0255	0.0032	0.0227	0.0031	0.0186	0.0020	0.0770	0.0267	0.0262	0.0154
49	0.0253	0.0036	0.0241	0.0030	0.0215	0.0028	0.0207	0.0023	0.1084	0.0264	0.0252	0.0117
50	0.0261	0.0041	0.0255	0.0036	0.0257	0.0038	0.0204	0.0024	0.0678	0.0208	0.0352	0.0211
51	0.0281	0.0036	0.0300	0.0039	0.0217	0.0029	0.0249	0.0031	0.1142	0.0244	0.0403	0.0184
52	0.0222	0.0037	0.0287	0.0037	0.0211	0.0029	0.0209	0.0026	0.0669	0.0291	0.0649	0.0208
53	0.0179	0.0040	0.0316	0.0057	0.0181	0.0034	0.0268	0.0054	0.0417	0.0297	0.0376	0.0148
54	0.0273	0.0060	0.0370	0.0054	0.0255	0.0059	0.0298	0.0047	0.0757	0.0287	0.0611	0.0209
55	0.0274	0.0042	0.0267	0.0036	0.0249	0.0035	0.0183	0.0023	0.0688	0.0319	0.0606	0.0238
56	0.0332	0.0054	0.0260	0.0038	0.0334	0.0048	0.0177	0.0030	0.0544	0.0368	0.0592	0.0176
57	0.0304	0.0047	0.0284	0.0041	0.0304	0.0036	0.0195	0.0026	0.0686	0.0375	0.0668	0.0236
58	0.0273	0.0050	0.0362	0.0065	0.0320	0.0042	0.0236	0.0038	0.0140	0.0314	0.0962	0.0408
59	0.0302	0.0054	0.0268	0.0050	0.0263	0.0040	0.0208	0.0033	0.0529	0.0396	0.0395	0.0296
60	0.0238	0.0068	0.0355	0.0071	0.0253	0.0045	0.0190	0.0027	0.0436	0.0430	0.0737	0.0291
61	0.0231	0.0068	0.0352	0.0060	0.0298	0.0061	0.0220	0.0042	0.0336	0.0238	0.0574	0.0183
62	0.0234	0.0079	0.0406	0.0094	0.0304	0.0066	0.0226	0.0051	0.0570	0.0272	0.0603	0.0327
63	0.0267	0.0098	0.0358	0.0096	0.0206	0.0052	0.0144	0.0037	0.1252	0.0365	0.0393	0.0291
64	0.0552	0.0185	0.0483	0.0123	0.0165	0.0094	0.0271	0.0088	0.1908	0.0613	0.0534	0.0244
65	-	-	0.1053	0.0225	-	-	0.0394	0.0148	-	-	0.1930	0.0743
Mean	0.0334	0.0052	0.0320	0.0053	0.0317	0.0042	0.0221	0.0035	0.0786	0.0342	0.0560	0.0275
AR(1)	1	-	0.3629	0.1391	1	-	0.0968	0.0987	1	-	-0.4351	0.0753
MA(1)	-	-	-0.1495	0.0963	-	-	0.0821	0.074	-	-	0.3261	0.0891
N				23,241				21,425				3,258

Notes: Standard errors are given in columns entitled s.e.

Source: Authors' calculations based on the GSOEP (1984-2012).

Table 4.F.5

Permanent and Transitory Variances over Age by Occupation.

Sample	Blue Collar				White Collar				Civil Servant			
Age	$\hat{\sigma}^2_\psi$	s.e.	$\hat{\sigma}^2_\varepsilon$	s.e.	$\hat{\sigma}^2_\psi$	s.e.	$\hat{\sigma}^2_\varepsilon$	s.e.	$\hat{\sigma}^2_\psi$	s.e.	$\hat{\sigma}^2_\varepsilon$	s.e.
26	-	-	0.0159	0.0048	-	-	0.0188	0.0075	-	-	-0.0053	0.0252
27	0.0526	0.0068	0.0205	0.0037	0.1007	0.0124	0.0170	0.0048	0.0860	0.0443	0.0245	0.0184
28	0.0533	0.0097	0.0191	0.0048	0.1020	0.0106	0.0212	0.0056	0.0261	0.0136	0.0193	0.0112
29	0.0528	0.0061	0.0208	0.0039	0.0769	0.0100	0.0204	0.0044	0.0506	0.0171	0.0201	0.0112
30	0.0409	0.0060	0.0214	0.0036	0.0762	0.0092	0.0233	0.0082	0.0488	0.0134	0.0219	0.0181
31	0.0325	0.0058	0.0255	0.0053	0.0595	0.0080	0.0213	0.0040	0.0673	0.0190	0.0023	0.0129
32	0.0372	0.0049	0.0161	0.0027	0.0601	0.0071	0.0222	0.0038	0.0758	0.0326	0.0218	0.0254
33	0.0336	0.0050	0.0211	0.0034	0.0528	0.0074	0.0152	0.0031	0.0350	0.0165	0.0168	0.0118
34	0.0250	0.0044	0.0237	0.0032	0.0441	0.0058	0.0216	0.0032	0.0236	0.0125	0.0250	0.0123
35	0.0317	0.0049	0.0241	0.0035	0.0418	0.0071	0.0232	0.0034	0.0251	0.0098	0.0235	0.0092
36	0.0318	0.0063	0.0186	0.0031	0.0382	0.0072	0.0197	0.0039	0.0131	0.0099	0.0266	0.0135
37	0.0244	0.0039	0.0185	0.0024	0.0276	0.0043	0.0244	0.0036	0.0370	0.0147	0.0213	0.0106
38	0.0308	0.0046	0.0201	0.0028	0.0280	0.0045	0.0298	0.0064	-0.0036	0.0114	0.0340	0.0136
39	0.0201	0.0033	0.0217	0.0031	0.0238	0.0047	0.0189	0.0033	0.0277	0.0140	0.0140	0.0062
40	0.0286	0.0068	0.0212	0.0032	0.0233	0.0038	0.0217	0.0028	0.0245	0.0084	0.0088	0.0052
41	0.0272	0.0043	0.0202	0.0025	0.0182	0.0047	0.0205	0.0027	0.0194	0.0092	0.0113	0.0065
42	0.0220	0.0036	0.0149	0.0022	0.0250	0.0051	0.0162	0.0027	0.0201	0.0078	0.0165	0.0066
43	0.0277	0.0056	0.0236	0.0038	0.0228	0.0040	0.0176	0.0026	0.0027	0.0041	0.0129	0.0049
44	0.0270	0.0044	0.0160	0.0036	0.0258	0.0039	0.0209	0.0033	0.0107	0.0073	0.0168	0.0096
45	0.0311	0.0060	0.0182	0.0029	0.0159	0.0033	0.0221	0.0033	0.0068	0.0081	0.0202	0.0116
46	0.0214	0.0042	0.0204	0.0031	0.0227	0.0034	0.0278	0.0059	0.0109	0.0063	0.0151	0.0068
47	0.0271	0.0040	0.0188	0.0028	0.0178	0.0055	0.0244	0.0038	0.0052	0.0054	0.0166	0.0064

Continued on next page

Sample	Blue Collar				White Collar				Civil Servant			
Age	$\hat{\sigma}^2_\psi$	s.e.	$\hat{\sigma}^2_\varepsilon$	s.e.	$\hat{\sigma}^2_\psi$	s.e.	$\hat{\sigma}^2_\varepsilon$	s.e.	$\hat{\sigma}^2_\psi$	s.e.	$\hat{\sigma}^2_\varepsilon$	s.e.
48	0.0305	0.0053	0.0169	0.0023	0.0203	0.0047	0.0196	0.0029	0.0098	0.0056	0.0151	0.0066
49	0.0274	0.0045	0.0170	0.0031	0.0191	0.0040	0.0246	0.0036	0.0085	0.0063	0.0139	0.0058
50	0.0317	0.0071	0.0174	0.0030	0.0276	0.0055	0.0192	0.0027	0.0002	0.0103	0.0325	0.0158
51	0.0262	0.0041	0.0207	0.0033	0.0213	0.0043	0.0267	0.0048	0.0125	0.0083	0.0222	0.0125
52	0.0250	0.0042	0.0194	0.0028	0.0231	0.0047	0.0215	0.0041	0.0047	0.0070	0.0208	0.0108
53	0.0195	0.0043	0.0214	0.0041	0.0198	0.0056	0.0337	0.0102	0.0011	0.0053	0.0172	0.0066
54	0.0211	0.0054	0.0338	0.0087	0.0287	0.0109	0.0304	0.0067	0.0074	0.0059	0.0153	0.0071
55	0.0206	0.0055	0.0218	0.0041	0.0274	0.0055	0.0190	0.0030	0.0131	0.0040	0.0068	0.0038
56	0.0359	0.0092	0.0164	0.0033	0.0355	0.0068	0.0214	0.0051	0.0137	0.0057	0.0077	0.0047
57	0.0396	0.0059	0.0201	0.0041	0.0261	0.0052	0.0187	0.0035	0.0091	0.0086	0.0210	0.0097
58	0.0305	0.0077	0.0284	0.0070	0.0398	0.0066	0.0214	0.0058	0.0108	0.0045	0.0156	0.0060
59	0.0348	0.0071	0.0130	0.0035	0.0311	0.0065	0.0239	0.0053	0.0047	0.0046	0.0127	0.0051
60	0.0237	0.0082	0.0253	0.0052	0.0270	0.0066	0.0177	0.0038	0.0180	0.0078	0.0104	0.0054
61	0.0117	0.0072	0.0342	0.0119	0.0384	0.0101	0.0177	0.0052	0.0173	0.0100	0.0186	0.0082
62	0.0312	0.0127	0.0173	0.0063	0.0355	0.0107	0.0253	0.0083	0.0252	0.0080	0.0064	0.0036
63	0.0264	0.0111	0.0069	0.0051	0.0170	0.0069	0.0155	0.0054	0.0205	0.0121	0.0134	0.0091
64	0.0528	0.0259	0.0034	0.0039	0.0172	0.0132	0.0267	0.0121	-0.0022	0.0183	0.0317	0.0233
65	-	-	0.0012	0.0109	-	-	0.0628	0.0280	-	-	0.0238	0.0128
Mean	0.0307	0.0065	0.0194	0.0042	0.0357	0.0066	0.0229	0.0053	0.0207	0.0110	0.0172	0.0103
AR(1)	1	-	-4.17E-04	3.00E-04	1	-	-9.07E-04	0.0032	1	-	0.4707	0.3721
MA(1)	-	-	0.1583	0.0194	-	-	0.1507	0.0202	-	-	-0.1437	0.1843
N				9,580				12,772				1,975

Notes: Standard errors are given in columns entitled s.e.

Source: Authors' calculations based on the GSOEP (1984-2012).

Table 4.F.6

Permanent and Transitory Variances over Age by Marital Status.

Sample	Married with Children				Single			
Age	$\hat{\sigma}^2_\psi$	s.e.	$\hat{\sigma}^2_\varepsilon$	s.e.	$\hat{\sigma}^2_\psi$	s.e.	$\hat{\sigma}^2_\varepsilon$	s.e.
26	-	-	0.0317	0.0112	-	-	0.0412	0.0137
27	0.0524	0.0109	0.0539	0.0132	0.0329	0.0130	0.0186	0.0067
28	0.0414	0.0167	0.0518	0.0139	0.0350	0.0095	0.0178	0.0045
29	0.0423	0.0081	0.0276	0.0058	0.0422	0.0092	0.0217	0.0060
30	0.0389	0.0092	0.0377	0.0107	0.0503	0.0125	0.0163	0.0063
31	0.0336	0.0069	0.0335	0.0067	0.0389	0.0079	0.0172	0.0045
32	0.0447	0.0067	0.0283	0.0054	0.0283	0.0067	0.0218	0.0050
33	0.0311	0.0056	0.0301	0.0048	0.0187	0.0080	0.0137	0.0046
34	0.0230	0.0041	0.0254	0.0042	0.0298	0.0096	0.0228	0.0058
35	0.0388	0.0076	0.0324	0.0054	0.0181	0.0074	0.0173	0.0043
36	0.0349	0.0064	0.0327	0.0056	0.0538	0.0176	0.0142	0.0046
37	0.0178	0.0044	0.0331	0.0050	0.0200	0.0082	0.0172	0.0042
38	0.0246	0.0052	0.0328	0.0063	0.0158	0.0080	0.0246	0.0105
39	0.0174	0.0044	0.0309	0.0051	0.0158	0.0085	0.0346	0.0121
40	0.0192	0.0050	0.0312	0.0052	0.0174	0.0100	0.0241	0.0076
41	0.0137	0.0039	0.0291	0.0045	0.0090	0.0081	0.0145	0.0041
42	0.0206	0.0047	0.0250	0.0042	0.0081	0.0074	0.0140	0.0045
43	0.0162	0.0044	0.0311	0.0047	0.0272	0.0090	0.0187	0.0064
44	0.0147	0.0035	0.0262	0.0042	0.0511	0.0280	0.0274	0.0100
45	0.0144	0.0053	0.0364	0.0068	0.0221	0.0137	0.0324	0.0119
46	0.0148	0.0042	0.0340	0.0067	0.0132	0.0115	0.0334	0.0122
47	0.0153	0.0062	0.0308	0.0070	0.0195	0.0129	0.0347	0.0097

Continued on next page

Sample	Married with Children				Single			
Age	$\hat{\sigma}^2_{\psi}$	s.e.	$\hat{\sigma}^2_{\varepsilon}$	s.e.	$\hat{\sigma}^2_{\psi}$	s.e.	$\hat{\sigma}^2_{\varepsilon}$	s.e.
48	0.0165	0.0057	0.0335	0.0059	0.0190	0.0095	0.0121	0.0066
49	0.0228	0.0051	0.0247	0.0044	0.0127	0.0092	0.0154	0.0062
50	0.0256	0.0064	0.0247	0.0047	0.0033	0.0059	0.0211	0.0095
51	0.0241	0.0046	0.0280	0.0047	0.0122	0.0072	0.0169	0.0048
52	0.0212	0.0049	0.0269	0.0051	0.0087	0.0084	0.0223	0.0075
53	0.0198	0.0051	0.0243	0.0045	0.0079	0.0101	0.0176	0.0128
54	0.0173	0.0047	0.0302	0.0054	0.0760	0.0346	0.0218	0.0199
55	0.0260	0.0072	0.0324	0.0063	0.0121	0.0142	0.0529	0.0290
56	0.0207	0.0080	0.0345	0.0068	0.0376	0.0156	0.0013	0.0073
57	0.0296	0.0109	0.0397	0.0101	0.0414	0.0130	0.0024	0.0039
58	0.0212	0.0104	0.0510	0.0119	0.0418	0.0127	0.0058	0.0073
59	0.0304	0.0098	0.0235	0.0080	0.0347	0.0134	0.0057	0.0040
60	0.0390	0.0152	0.0474	0.0146	0.0247	0.0135	0.0085	0.0049
61	0.0270	0.0124	0.0306	0.0086	0.0241	0.0158	-0.0015	0.0068
62	-0.0014	0.0201	0.0662	0.0313	0.0061	0.0268	0.0502	0.0418
63	0.0158	0.0259	0.0566	0.0285	0.0545	0.0292	-0.0001	0.0056
64	0.0495	0.0244	0.0278	0.0098	0.1236	0.1222	0.0395	0.0317
65	-	-	0.0215	0.0132	-	-	0.1387	0.1430
Mean	0.0257	0.0083	0.0337	0.0083	0.0291	0.0155	0.0232	0.0128
AR(1)	1	-	0.4117	0.1822	1	-	-0.5237	0.0614
MA(1)	-	-	-0.1631	0.1249	-	-	0.5514	0.0484
N				12,663				3,012

Notes: Standard errors are given in columns entitled s.e.

Source: Authors' calculations based on the GSOEP (1984-2012).

5 Means-Tested Benefits and Precautionary Saving

5.1. Introduction

"80 grams of cereals for 40 Cents,
1 banana for 25 Cents,
a quarter liter of milk or one container of yogurt for 35 Cents,
20 grams of honey for 8 Cents,
and 2 cups of coffee for 5 Cent each."[1]

This was the recommended breakfast for a single person receiving unemployment assistance (UA) in Germany in 2008 according to Sarrazin (2010). While this recommendation was not legally binding, to become eligible to UA, an asset-based, means-test had to be passed. In this environment, households receiving UA may only adjust their consumption/saving choices within a limited range. Therefore, some precautionary saving models that describe behavior of households with median wealth holdings reasonably well, but do not take into account saving constraints due to asset-based, means-tested transfers, dramatically underpredict the proportion of households who hold virtually no wealth (Hubbard et al. (1995)).

This study attempts to improve the predictive power for low-wealth households by explicitly incorporating the details of two important kinds of transfers in Germany into the budget constraint: not asset-based means-tested unemployment benefits (UB) designed for short-term unemployed, and after its expiration the UA designed for long-term unemployed illustrated above. Both institutions have been amended by a reform known as "Hartz IV"[2]: the maximum unemployment benefit entitlement periods of UB

[1] Author's translation.

[2] The name derives from the fourth law for modern services on the job market "Viertes Gesetz für

were cut and the level of UA which was depending on previous earnings was replaced by a lump sum benefit. Moreover, the asset-based means-test for UA was tightened.

Another objective of this study is to evaluate the effects of this reform on precautionary saving. Direct effects on households who are unemployed before and after the reform (about 1/3 of all unemployed are unemployed for one year or longer according to the Federal Employment Agency) are virtually non-existent, because the asset-based means-test was an implicit tax of 100 percent on precautionary saving both before and after the reform. Thus, low wealth holdings are likely to be an "absorbing state" for low-lifetime-income households (Hubbard et al. (1995)) due to asset-based means testing in Germany. Allowances and the amendments to these allowances explicitly conceded saving for other motives than precautionary saving, in particular old-age saving.

Very wealthy households who have accumulated such an amount of assets that the probability to become eligible to UA is little, even if they get unemployed, are not influenced much by the reform either. However, the reform might have influenced saving behavior of households who are not eligible to UA before the reform but have had a high probability of becoming eligible.

There are three channels through which the reform might have influenced consumption/saving choices.[3] First, unemployed were monitored more strictly after the reform, making benefits cuts more likely. Therefore, the variance of shocks to income might have increased after the reform. This increase in uncertainty of household labor income leads to an increase in precautionary savings compared to the situation before the reform because prudent households will self-insure against states of the world with low consumption. A countervailing effect is that prior to the reform, UA benefits were dependent on *uncertain* net income, whereas after the reform, UA was granted as a *certain* lump sum transfer.

A second channel is that the UB was granted only for a shorter period for older households after the reform implying a cut of the consumption floor. Moreover, the

moderne Dienstleistungen am Arbeitsmarkt" of Dec, 24 2003 based on proposals of a commission whose head was Peter Hartz.

[3] Households are assumed to perceive all reforms as arriving unexpectedly.

level of consumption guaranteed by UA which was strictly lower than UB before the reform was changed. This did not always imply a cut of the consumption floor. The reason is that the new lump sum transfer could exceed benefits under the system before the reform when previous income was low or it could fall below when previous income was high. Therefore, for households who would have received a higher transfer in case of unemployment than after the reform precautionary saving increased due to the reform. In turn, households who would have received a lower transfer in case of unemployment would reduce precautionary saving.

The third channel is the tightening of the asset-based means-test. Households who are not eligible to UA anymore due to the tightening, will accumulate wealth for precautionary reasons.

Few studies provide evidence on the effect of means-tested benefits on precautionary saving. A closely related paper is Hubbard et al. (1995) who study the general effects of a welfare program of unlimited duration but do not evaluate a specific reform. Engen and Gruber (2001) provide an excellent overview of the literature and focus in their analysis on a program similar to UB that was limited in duration and means-tested. They find that reducing the means-tested benefit replacement rate by 50 percent would increase gross financial asset holdings by 14 percent for the average worker in the United States. For Germany, Heer (2006) and a series of dissertations (Biewald (2009); Ahrens (2011); Whang (2014)) study how the "Hartz IV" reform affected precautionary saving. Most of these studies find that the amendment hardly affected savings (and average labor supply, see also Schmitz and Steiner (2007)).

To evaluate the effect of the reform on precautionary saving is a challenging task since the precautionary part of saving not easy to identify (Engen and Gruber (2001); Fossen and Rostam-Afschar (2013)). Moreover, consumption/saving data is collected rarely (usually 5 year-interval) and often of dubious quality (Runkle (1991); Shapiro (1984); Alan and Browning (2010)). Another problem is that complete life cycles are usually not observed in panel data. Therefore, this study follows the literature (e.g. Hubbard et al. (1995); Engen and Gruber (2001)) and uses micro data on income and assets and simulates consumption choices with a structural life cycle model. Despite the mentioned challenges, the model performs reasonably well in predicting both the fraction of transfer recipients and of low-wealth households. Moreover, the model's predictions are often better than other "naive" forecasts.

The results show that precautionary saving decreased mainly for young households after the reform, though both short- and long-term effects are small. Welfare effects of the reform show that the median household would be ready to pay 1.4 percent of a certain lifetime income for an implementation of the reform because better insurance outweighs higher risk.

This chapter is structured as follows. In Section 5.2 the key elements of the reform and their implementation in the model are presented. Section 5.3 provides descriptive statistics. Section 4.5 discusses how well the model describes the data, presents the estimated short- and long-term effects on precautionary saving, and welfare effects of the reform. Section 5.5 concludes.

5.2. Modeling Key Elements of the "Hartz IV" Reform

Prior to the "Hartz IV" reform, unemployed younger than 65 years were covered by two kinds of institutions, Unemployment Benefit (UB, "Arbeitslosengeld") and Unemployment Assistance (UA, "Arbeitslosenhilfe"). The former was funded by contributions of employers and jobholders, subject to an individual income-based means-test and limited in duration, depending on age and contributions. The latter was tax-financed and could be received indefinitely, provided an income-based means-test and an asset-based means-test were passed.

A series of changes affected both institutions regarding duration of benefit entitlement (UB), determination of replacement, tightness of income-based means-test and asset-based means-test (UA). The duration of UB entitlement in effect from 1997 was amended in the context of the "Hartz IV" reform. From 2006 on, the duration was reduced for older workers from a maximum of 32 months to a maximum of 18 months and the entitlement criteria regarding an individual's previous employment record were tightened. In 2008, this part of the "Hartz IV" reform was slightly reverted because the duration of unemployment benefits for older workers was increased to a maximum of 24 months.

Another key element of the "Hartz IV" reform was the integration of social assistance (SA), a lump sum transfer, and unemployment assistance benefits for employable persons under a new label (Arbeitslosenhilfe [UA] and Sozialhilfe [SA] before, Arbeitslosengeld II (ALG II) [UA] after 2005). Before 2005, persons who were not eligible for UB (anymore) could receive UA if they passed a household-income-based, and an asset-based means-test. Benefit duration was in principle indefinite but subject to annually means-tests. Analogous to UB, the replacement depended on previous net income before the reform such that UA was always below UB. This system was replaced by a lump sum transfer (analogous to SA) which depended on the number and age of household members, covering as well adequate lodging and heating expenditures subject to typically semiannual means-tests.

The asset-based means-test for UA was changed several times, e.g. in 1999 (monetary specification of adequate old-age saving allowance), 2002 (integration of basic and old-age allowance, new allowance for car), 2003 (tightening of allowance), 2005 (new allowance for children, necessities, reintroduction of old-age allowance) and 2007 (tightening of basic allowance, allowance for children, relaxing old-age allowance).

Tables 5.A.1 to 5.A.3 in the appendix present the institutional details in effect in 2001, 2006, and 2011 because the cross-sections in which wealth data are observed (2002, 2007, 2012) in the dataset include retrospective information (see Section 5.3).

The reform could have increased income risk. The effect of this increase is (more than) offset by the change from UA benefits that were *uncertain* because they depended on previous net income to the *certain* lump sum UA transfer after the reform. Whether higher income risk or lower benefit risk is more important is an empirical question that is addressed in Section 5.4.

Besides this, there are two generic changes of the reform that affect precautionary saving. First, a benefit cut increases precautionary saving. The shortening of the duration of UB eligibility was equivalent to a reduction of the consumption floor because a household was covered by UA which was typically lower than UB if still unemployed. This effect was reinforced if a household has relatively high previous income which implied a substantial drop in benefits due to the replacement of income-based UA by lump sum UA. If a household had low previous income such that lump sum UA exceeded UA provided by the previous system, incentives for precautionary saving could have shrunken. This effect seems important because 44 percent of UA recipients have had higher income after the reform according to Bruckmeier and Schnitzlein (2007). Therefore precautionary saving is expected to be lower after the reform.

Second, the tightening of the asset-based means-test could have influenced precautionary saving. For households who drop out of UA due to the tightening, the direct effect of the reform was an increase in precautionary savings. According to Bruckmeier and Schnitzlein (2007) about 10 percent of those who received UA before did not pass the wealth test after the reform.

These effects depend on lifetime income of households. The benefit cut and tightening of the means-test changed the level of wealth at which households engaged in precautionary saving. To quantify these effects, I simulate life cycles using the methodology from Chapter 4.

In the model used in this chapter, households enter work life at age $t_0 = 25$, work $T^{work} = 40$ years, enter retirement at $T = 65$ with certainty, then account for longevity risk with the unconditional probability of survival until time t, $S_t < 1$. Preferences are assumed to be time-separable constant relative risk aversion (CRRA) utility $u(C_t) = \frac{C_t^{1-\rho}}{1-\rho}$, where ρ is the coefficient of relative risk aversion. Households consume C_t according to the solution of the following optimization problem.

$$\max_{C_t} E_{t_0}\left[\sum_{t=t_0}^{T+t_0} S_t\beta^{t-t_0}u(C_t) + \alpha\frac{A_{iT+t_0+1}^{1-\rho}}{1-\rho}\right]. \tag{5.1}$$

E_{t_0} is the expectation operator conditional on information available at period t_0, $T+t_0$ is the date at which the probability to survive is 0, β is a discount factor, $u(.)$ is the instantaneous utility function, α is a constant, and A_{iT+t_0+1} are asset holdings at death. To keep the model tractable, labor supply, fertility and retirement decisions are assumed to be exogenous.

Assets are determined by the transition equation

$$A_{it} = A_{it-1}(1+r(1-\tau_A)) + TX(Y_{it}, Y_{it-1}, E_{t-e}, X_{it}) - (1+\tau_C)C_{it}. \qquad (5.2)$$

A_{t_0} denotes risk-free asset holdings, r the real interest rate, τ_A is the tax on capital income, and τ_C the tax on consumption. Y_{it} represents pre-government income from labor during work life and pension income after retirement. $TX(.)$ is after-government income which is a function according to the income tax schedule as in Jessen et al. (2015) if after-government income is high enough to exceed income when receiving benefits. Otherwise, it is a function of age t, current pre-government income from labor Y_{it}, last period labor income Y_{it-1}, number of month worked in the last $e=\{3,5,7\}$ years E_{t-e}[4], a vector X_{it} including household size and the number of children.[5]

UB is incorporated in the budget constraint for each adult household member as $TX = \max[UA, \min(\overline{B}, \varpi \times \overline{Y}_{it-1}E_{t-e}/2)]$ if $Y_{it} < \overline{\Upsilon}_{it}$, where ϖ is 0.67 if children are living in the household, 0.60 otherwise. $\overline{Y}_{it-1} = 30[Y_{it-1}/(n \times 365) - \tau_{prt,ssc,ss}]$ is the monthly income per effective labor unit (n is the number of adults) in a given year from which UB is determined.[6] $\overline{\Upsilon}_{it}$ is the income allowance as in Table 5.A.2. Using information on age t and E_{t-e} the benefit is calculated according to the rules before and after the reform. $\overline{B}$ is a legally defined cap.

Prior to the reform, UA is similarly incorporated in the budget constraint for each adult household member as $UA = \max[SA \times \max(0, \overline{A}_{SA} - A_t)/(\overline{A}_{SA} - A_t), \min(\overline{B}, \varkappa \times$

[4]The period between the last and the new unemployment spell determines the entitlement length for unemployed who received UB in the last seven years (the last three years since 2006, the last five years since 2008).

[5]Note that borrowing against expected benefits is not allowed.

[6]Payroll-tax, social security contributions and solidarity surcharge are represented by $\tau_{prt,ssc,ss}$. Note that before 2005 this calculation was based on calendar weeks instead of days.

$12 \times \overline{Y}_{it-1}) \times \max(0, \overline{A}_{UA} - A_t)/(\overline{A}_{UA} - A_t)]$, where $\varkappa$ is 0.57 if children are living in the household, 0.53 otherwise. SA is social assistance, $\overline{A}_{UA}$ is the sum of all (sometimes age-depended) asset allowances according to Table 5.A.3 and $\overline{A}_{SA}$ are the (lesser) asset allowances for social assistance.

After the reform, I take the standard rates and approximate costs of lodging and heating, number of household members, of children and their age to calculate UA similarly to Jessen et al. (2015). UA is withdrawn according to Table 5.A.2.

Pre-government income of households whose head is not retired is $Y_{it} = w_{it} g_{it} h$, where w_{it} is the wage rate per effective labor unit, g_{it} is an exogenous age and education specific human capital adjustment factor, and h is exogenous hours of work. Households are assumed to take up UB or UA if their market income is below their transfer income. Log income $y_{it} = ln(Y_{it})$ is assumed to follow a random walk with drift and a transitory stochastic component ξ representing illness, a bad guess about when to buy or sell, bad weather, lottery prizes, bequests, measurement error etc.

$$y_{it} = p_{it} + \xi_{it}, \tag{5.3}$$

where $\xi_{it} = \frac{1+\theta L}{1-\varphi L} \varepsilon_{it}$ is specified as an ARMA(1,1) process and $\varepsilon_t \overset{iid}{\sim} N(0, \sigma^2_{\varepsilon,t})$.

The permanent component is specified to represent promotions, severe health shocks, etc. as $p_{it} = p_{it-1} + \psi_{it}$, where $\psi_t \overset{iid}{\sim} N(0, \sigma^2_{\psi,t})$. This specification is standard in the literature (Lillard and Willis (1978); Lillard and Weiss (1979); MaCurdy (1982); Abowd and Card (1989)).

5.3. Data and Empirical Strategy

5.3.1. The Distribution of Wealth by Age in Germany

As in Chapters 2 and 4, this analysis is based on data from the GSOEP. The annual measure of household post-government income includes incomes from labor, pensions, transfers after taxes but not asset income (interest, dividends, rent).[7] All variables are aggregated to the household level, and characteristics from the household head are assumed to be relevant for a household's consumption/saving decisions. A measure of post-government income per effective labor unit is obtained by dividing household post-government income by the number of persons minus children under 18.[8]

Information on asset holdings with consistent definition are only observed in 2002, 2007, and 2012 in the GSOEP. Using this data, a measure of household net worth is the sum of owner occupied and not owner occupied housing minus mortgage, savings balance, savings bonds, bonds, shares or investments, life insurance policy or private retirement insurance policy, current value of your enterprise, gold, jewelery, coins or valuable collections, outstanding debts.

In contrast to Engen and Gruber (2001), I focus on total household net worth and not only on financial wealth, for three reasons. First, Table 2.2.1 in Chapter 2 shows that the average stock of financial wealth could replace only two to three month of average permanent income. This seems just enough for short run smoothing, but not to build up a steady-state stock of accumulated precautionary savings. At the same time, the largest part of total wealth is owner-occupied housing and other property. Börsch-Supan et al. (2001) report a share of 80 to 90 percent for the group aged 30 to 59. If households perceive non-financial wealth to be part of precautionary savings, excluding this part would lead to mismeasurement of precautionary savings. Second, as Engen and Gruber (2001) point out, non-financial assets may serve both consumption as well as savings. Thus, in response to an income drop, households may cut down consumption, for instance, by renting out single rooms of the house they live in or deferring renovation or refurbishment works for precautionary reasons. Similarly, tangible assets such as paintings may be rented out for some period, reducing

7 The descriptive exploration of the wealth distribution in this section includes incomes from self-employment in post-government income. Self-employed are dropped from the sample for reasons described in Chapter 2 in the results section.

8 The results change little when other measures are applied.

own consumption and increasing saving returns.[9] Third, considering total net worth is appropriate since the model abstracts from portfolio decisions as pointed out in Chapter 2. Results using financial wealth only are available on request.

The top part of Figure 5.1 shows the ratio of household net worth to household post-government annual income as observed in the survey year 2002 for each age of household heads from 20 to 90. Average income is about 37,000 Euro. Light gray circles represent households who do not receive neither UB nor UA. Horizontal, dashed, black lines indicate households who do not hold any wealth, where the ratio is zero, and households who hold exactly the same amount of wealth as income earned at a given age, where the ratio is equal to one. Households whose wealth to income ratio exceeds 11 are not shown.

Following the definition of high-wealth households in Hubbard et al. (1995), i.e. classifying households as high-wealth when net worth equals or exceeds income in a given age, a pattern over age is clearly visible: most households are between the two horizontal lines early in the life cycle and many stay low-wealth households over age, while others expand their wealth holdings with age. While most of wealth inequality is due to accumulation of positive wealth holdings over age, some, in particular young households, spread the wealth distribution by borrowing. The bold dashed line shows the predicted median of the wealth to income ratio, expressed as cubic polynomials in age, of those who do not receive neither UB nor UA. This figure departs from the line of no wealth where net worth is somewhat below five times of income at retirement which is indicated by a vertical, dashed line. After retirement, dissaving seems stronger compared to data from the survey year 2007 or 2012 (see below). The concentration within the bands confining low but positive wealth is striking.

To examine the effect of an asset-based means-test, it is instructive to compare this trajectory to that of households who passed the means-test.[10] Dark, gray triangles

[9]Although assets do not enter the utility function directly, I argue that using total net worth as approximation produces a smaller error than using financial wealth.

[10]There might be households who would have passed the income and wealth tests but who did not take-up transfers because of transactions costs and the perceived stigma attached to transfer dependence.

in the top part of Figure 5.1 mark the wealth to income ratio of UA recipients as observed in the data. The solid black line is the median of those who did receive UA in 2002, predicted as above. The 25th and 75th percentiles of wealth to income ratios of unemployment assistance recipients are overlaid as thin dashed lines. Average income for recipients of transfers is about 16,000 Euro, for those who do not receive UA or UB 38,000 Euro.

Clearly, prior to the reform, wealth holdings of UA recipients were less than transfer incomes over almost the entire life span to age 65 for the median. Households in the 25th percentile do not hold wealth at all, while only the 75th percentile had a wealth to income ratio comparable to the median of those who did not receive transfers. Note that most of the transfer recipients are not indebted but if they are, their debts are rarely higher than their transfer income.

This is only slightly different in the analogous graphs for 2007 (bottom graph of Figure 5.1) and 2012 (Figure 5.2). In both graphs median wealth to transfer ratios follow a similar pattern over age as in 2002. The only striking difference to 2002 is that the 75th percentile is below the median of households who did not hold transfers. This difference could reflect the tightening of the wealth test. Note that the number of observations of UA recipients is quite low (see also Table 5.A.5 in the appendix).

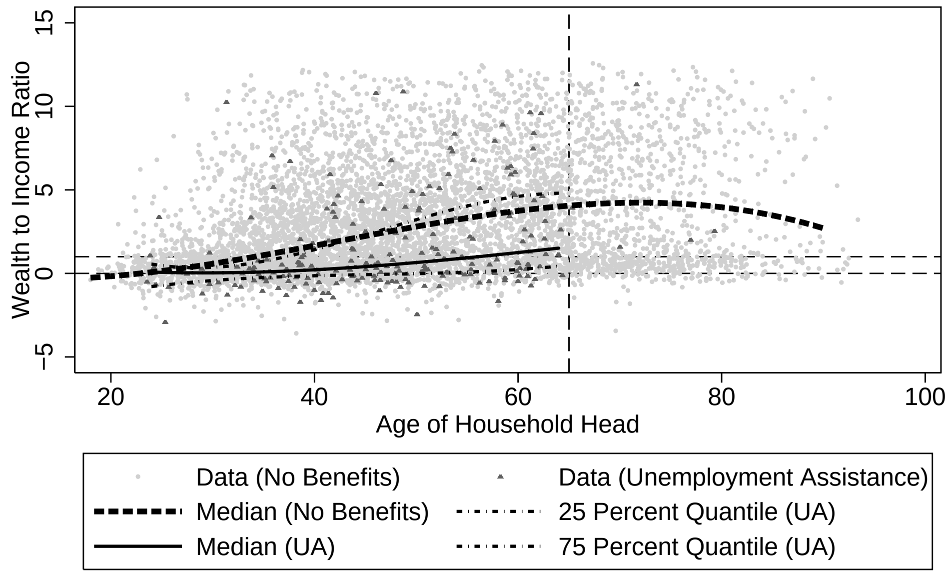
Figure 5.A.2 in the appendix shows the corresponding graphs of the wealth to income ratio of recipients of unemployment insurance and those who do not receive unemployment insurance. Predicted median of the wealth to income distribution, expressed as cubic polynomials in age, of those who do not receive UI, median, 25th and 75th percentiles of unemployment insurance recipients are overlaid.

Table 5.3.1 presents an overview of the changes in levels of wealth and income before and after the reform and in shares of high-wealth and low-wealth households for those who did not receive UA or UI. For each of the three survey years, the table shows wealth and income at the median and at the 75th percentile for five agegroups (25–34, 35–44, 45–54, 55–64, 65–74). Below, three shares are reported by agegroup: the share of households with a wealth to income ratio greater than one, between zero

Figure 5.1

Wealth to Income of Median Household, Recipients of Unemployment Assistance, and Inequality (2002, 2007).

Source: Own calculations based on the GSOEP (2002, 2007).



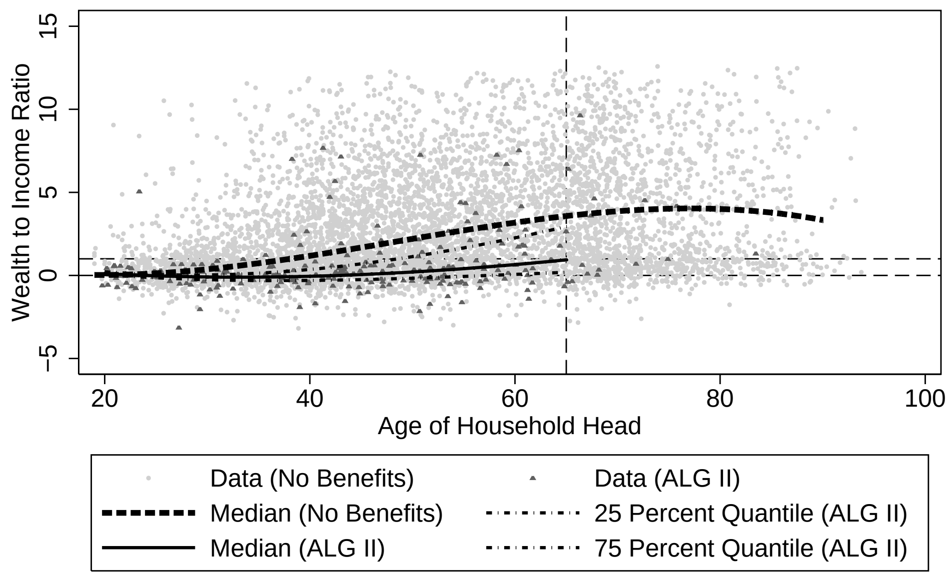
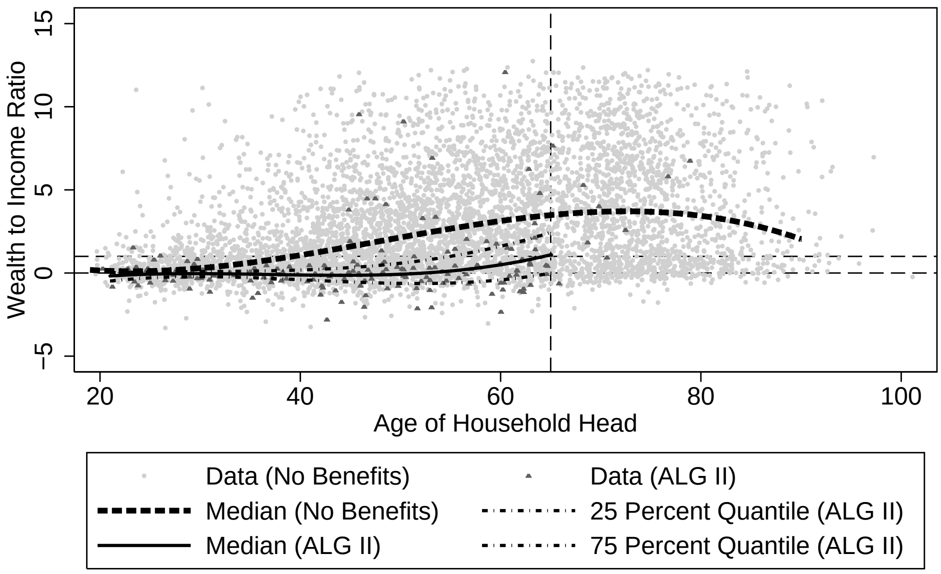


Figure 5.2

Wealth to Income of Median Household, Recipients of Unemployment Assistance, and Inequality (2012).

Source: Own calculations based on the GSOEP (2012).



and one, and smaller than zero but greater than minus one. These shares add up to 100 percent; however, note that the shares of households whose absolute value of debts exceeded their income are not reported.

This table is instructive for several reasons. First, a good test how well the model predicts the data is to compare predicted and actual *shares* of high-wealth and low-wealth households. Second, a more ambitious test is to compare predicted median wealth to income *ratios* to actual. I will return to both exercises in Section 5.4. Third, this table presents the data in a fashion that makes it straightforward to take double differences.

This is a simple exercise that suggests how the “Hartz IV” reform affected precautionary saving if among other assumptions the median was influenced by the reform, while a percentile of a control group was not, no other changes affected saving, and both the median and the control group percentile would have followed the same time trend in the absence of the reform. A natural candidate for a control group would be households who received asset-based, means-tested benefits. Table 5.A.5 in the appendix provides similar descriptive statistics for households who received UA (Table 5.A.4 in the appendix for those who received UI). However, while the number of recipients of UI and UA are very close to those reported by the Federal Employment Agency, only few of the latter group report wealth resulting in a low number of observations. Moreover, median wealth of these households, in particular of UA recipients, is very low.

Table 5.3.1

Wealth and Income (2002, 2007, and 2012).

	Age				
	25–34	35–44	45–54	55–64	65–74
	Before "Hartz IV" (2002): Recipients neither UI nor UA				
Median wealth (Euro)	11,524	38,173	51,858	72,025	71,065
Median income (Euro)	22,056	22,826	19,398	20,496	16,610
75th quantile wealth (Euro)	40,881	100,835	107,749	141,227	86,430
75th quantile income (Euro)	28,452	28,687	26,572	28,440	33,922
Wealth > income (%)	34.3	60.1	68.6	75.5	78.7
Wealth < income (%)	49.4	28.4	23.8	19.2	21.3
Debt < income (%)	14.1	9.9	6.8	4.8	0.0
Number of households	3,116,252	4,546,882	3,246,636	1,531,311	109,128
Number of observations	1,042	1,838	1,524	709	49
	After "Hartz IV" (2007): Recipients neither UI nor UA				
Median wealth (Euro)	6,375	20,720	35,773	59,503	59,769
Median income (Euro)	19,103	20,184	18,699	19,396	17,549
75th quantile wealth (Euro)	24,673	73,848	90,318	129,455	100,943

Continued on next page

	Age				
	25–34	35–44	45–54	55–64	65–74
75th quantile income (Euro)	23,381	26,519	25,372	27,221	30,002
Wealth > income (%)	30.5	49.3	63.6	70.4	67.0
Wealth < income (%)	45.9	31.3	26.1	23.6	26.1
Debt < income (%)	22.6	17.0	8.5	5.7	6.5
Number of households	2,451,276	4,628,406	3,800,872	1,729,371	187,189
Number of observations	827	1,562	1,431	695	79
	After "Hartz IV" (2012): Recipients neither UI nor UA				
Median wealth (Euro)	4,907	21,099	29,833	60,597	55,936
Median income (Euro)	17,067	19,144	18,969	19,886	15,808
75th quantile wealth (Euro)	23,061	60,597	80,960	112,853	143,929
75th quantile income (Euro)	21,350	25,010	25,281	26,824	21,651
Wealth > income (%)	27.5	51.1	59.6	73.0	70.8
Wealth < income (%)	50.3	31.5	25.0	20.9	25.9
Debt < income (%)	18.1	14.5	12.5	5.8	0.0
Number of households	2,138,040	3,332,251	4,991,655	2,481,404	207,880
Number of observations	734	1,085	1,591	916	93

Notes: "Wealth > income", "Wealth < income" reports the weighted percentage of the sample with positive net worth greater or less than after-government income net of asset income. Similarly, "Debt < income" reports the same figure with the absolute value of negative net worth (debt) less than after-government income as defined above. All figures are in 2011 Euros.

Source: Authors' calculations based on the GSOEP (2002, 2007, 2012).

Therefore, for a rough calculation it suffices to focus on Table 5.3.1 and to assume that wealth holdings of the comparison group are zero before and after the reform. Then, median wealth of households who did not receive transfers declined by roughly the same amount in all agegroups. For instance, in agegroup 25–34, median wealth dropped from 11,524 Euro in 2002 to 6,375 Euro in 2007, and 4,907 Euro in 2012. Suggesting that the effect of the reform was 6,375-11,524 = -5,149 Euro as measured in 2007 (short-term effect) and similarly -6,617 Euro as measured in 2012 (long-term effect). These differences are larger for older ages, short and long-term effects differ most for agegroup 45–54 and are virtually the same for other groups.

A problem with these calculations might be that wealth levels might vary with factors that affect all households whose wealth holdings are above zero. Therefore, a better comparison might be the development of wealth holdings of the 75th percentile. These households are very unlikely to take up transfers and to be influenced by the "Hartz-IV" reform. Using this control group, the effects have two important differences. First, taking double differences suggests that the "Hartz IV" reform increased wealth. Second, the effects of the reform are higher for young and smaller for older households.

Again, this interpretation could be problematic since the reform might not only have influenced wealth holdings but also incomes. Therefore, the preferred descriptive statistic is obtained by comparing wealth to income ratios. For example, dividing wealth holdings by income for the 75th percentile of the agegroup 25–34 before the reform gives 40,881/28,452 = 1.43 and 1.06 in 2007. For the median, this figure is 0.52 before and 0.33 in 2007. Taking double differences gives 0.19 which may be interpreted as short-term effect for this age-group. Using 2012 instead of 2007, this effect is similar, namely 0.12. For the agegroup 35–44 the effects are also positive but smaller using 2007 and larger using 2012. The relative effects, calculated e.g. for 2012 as $0.12/(0.29-0.12)$, are with one exception roughly above 70 percent for young households. For all other groups of working age the effects are negative and roughly around 10 percent with the exception of the long-run effect for agegroup 55–64. Thus, again the "Hartz IV" reform seems to have increased (or decreased using households with zero wealth as comparison) precautionary savings for young households.

Of course these calculation are very rough and do not take into account effects like the "hurricane of the financial crisis" (Bach et al. (2014)) and other confounding factors that preclude strong conclusions.[11] Therefore, the above exercises are very

[11]First, in the period between 2002 and 2012, many institutional factors were changed, for instance the public pension system was reformed (Boersch-Supan and Wilke (2004)). Moreover, the health

likely to be far from the true effect and I caution not to interpret them in a causal sense.

Table 5.3.1 shows how the above defined shares changed over the life cycle. In 2002, the share of high wealth households increases from agegroup 25–34 to agegroup 35–44 by roughly 25 percentage points. Then, with transition to agegroup 45–54, this share increased by more than 8 percentage points and by additional 7 points for the agegroup before retirement. In 2002, the share of the retired agegroup is slightly larger than before retirement.

The share of low-wealth households is about 50 percent in the youngest agegroup in 2002. This share drops dramatically, namely by about 20 percentage points, when households transited to agegroup 35–44. During working age, this share drops further at a much smaller rate and increases somewhat in retirement.

Most of these changes reflect increasing wealth inequality due to capital accumulation, not borrowing. This is evident from the evolution of the share of indebted households who may repay their debts with annual income. This share is highest for the youngest agegroup and declines over life.

Over the five-year periods reported, the shares in each agegroup do not change much. Comparing 2002 to 2007, the share of households with wealth exceeding income differs most for agegroup 35–44 and the retirement agegroup. Interestingly, between 2007 and 2012, the largest difference in the shares is only 4 percentage points. Thus, if an effect of the "Hartz IV" reform on saving is identifiable, this effect is expected to be relevant for younger households.

For low-wealth households, the shares change at most 4.8 percentage points between 2002 and 2007, and 4.4 percentage points between 2007 and 2012. For indebted households 8.5 and 6.5 percentage points, respectively.

care system was changed frequently in many respects. One example is a lump sum payment for visits to a physician's office, the socalled "Praxisgebühr", introduced in 2004 and in effect until 2012. For young households who assumed that this reform was permanent, anticipation of future medical expenses might have raised saving. Second, the uncertainty about the growth rate of income increased (see below). Third, as discussed above, the asset limits for unemployment benefits were changed significantly. Finally, effects of the German reunification might still be present. According to Beznoska and Steiner (2012) saving behavior changed dramatically leading to strong cohort effects.

5.3.2. Parametrization of the Model

Many details of the parametrization of the model are described in Chapter 4. Here, I only briefly summarize some of these, point out the differences, and refer to Appendix 4.B in Chapter 4 for the model solution. Figure 5.A.3 shows how well simulated wealth profiles match actual for 2002, 2007, and 2012 using the method of simulated moments.

Given the data on income from several survey years and an identifying assumption, it is possible to decompose age effects from time and cohort effects using linear regression. I assume a quadratic cohort trend or alternatively time effects orthogonal to a linear trend if more than one survey year is used and extract the component determined by age, education and occupation and the idiosyncratic component from the data.[12] The empirical parameters characterizing labor income uncertainty, refer to uninsured risk, i.e. the risk faced by households conditional on existing insurance, in particular the unemployment benefits introduced above. Since the reform might have changed the level of risk, I estimate a measure of uncertainty for the period after the reform (2007-2012) and before the reform (1999-2004) separately[13] using the methodology described in Appendix 4.F of Chapter 4.

Table 5.3.2 shows the results excluding households with income from self-employment.[14] After the reform, permanent variance increased on average by $(0.0479-0.0457)/0.0457=4.8\%$. The transitory variance increased as well, on average by $(0.0657-0.0636)/0.0636=3.3\%$. The differences are statistically significant at some ages. Note that permanent uncertainty resembles the typical decreasing shape over age and that this pattern becomes much smoother when the sample size is extended.

[12]This components are net of observable variables including the number of children, labor hours, marital status etc. Another approach is to specify an exogenous process for marriage and fertility (see Blundell et al. (2013)).

[13]In 2006 a retrospective question on unemployment benefit II was asked the first time instead of unemployment assistance. Since the reform of the entitlement length of UB became effective early in 2006, including retrospective data asked in 2007 in the post policy period seems appropriate. To avoid measuring pre-policy adjustment effects, data asked in 2005 are dropped. Results using other definitions of pre- and post-policy periods are available on request.

[14]For models explicitly accounting for entrepreneurship, see e.g. Cagetti and Nardi (2006, 2009).

Table 5.3.2

Labor Income Risk (1999-2004 and 2007-2012).

	Permanent Var		*Transitory Var*			*Permanent Var*		*Transitory Var*	
Age	Before	After	Before	After	Age	Before	After	Before	After
26	0.0800	0.1078	0.0676	0.0429	46	-0.0082	0.1126	0.0751	0.0454
	–	–	(0.0249)	(0.0327)		(0.0139)	(0.0518)	(0.0194)	(0.0148)
27	0.0800	0.1078	0.0425	0.0829	47	0.0434	0.0521	0.0477	0.0460
	(0.0210)	(0.0312)	(0.0115)	(0.0201)		(0.0208)	(0.0191)	(0.0093)	(0.0096)
28	0.0338	0.0550	0.0714	0.0838	48	0.0287	0.0231	0.0381	0.0744
	(0.0147)	(0.0256)	(0.0172)	(0.0168)		(0.0126)	(0.0135)	(0.0057)	(0.0213)
29	0.0673	0.0195	0.0675	0.1014	49	0.0148	0.0420	0.0770	0.0734
	(0.0293)	(0.0206)	(0.0200)	(0.0231)		(0.0096)	(0.0228)	(0.0133)	(0.0172)
30	0.0296	0.0703	0.0652	0.0677	50	0.0333	0.0150	0.0379	0.0643
	(0.0150)	(0.0226)	(0.0225)	(0.0143)		(0.0152)	(0.0178)	(0.0072)	(0.0282)
31	0.0641	0.0010	0.0399	0.0963	51	0.0157	0.0453	0.0548	0.0440
	(0.0178)	(0.0181)	(0.0099)	(0.0242)		(0.0110)	(0.0191)	(0.0101)	(0.0094)
32	0.0619	0.0129	0.0375	0.0595	52	0.0359	0.0371	0.0571	0.0498
	(0.0146)	(0.0161)	(0.0072)	(0.0120)		(0.0137)	(0.0171)	(0.0138)	(0.0158)
33	0.0515	0.0290	0.0829	0.0402	53	0.0324	0.0389	0.0599	0.0493
	(0.0158)	(0.0179)	(0.0249)	(0.0085)		(0.0161)	(0.0153)	(0.0173)	(0.0108)
34	0.0384	0.0570	0.0469	0.0479	54	0.0153	0.0327	0.0422	0.0652
	(0.0149)	(0.0180)	(0.0083)	(0.0114)		(0.0158)	(0.0197)	(0.0125)	(0.0159)
35	0.0278	0.0645	0.0424	0.0454	55	0.0183	0.0210	0.0626	0.0637
	(0.0113)	(0.0213)	(0.0067)	(0.0116)		(0.0125)	(0.0114)	(0.0155)	(0.0127)
36	0.0321	0.0614	0.0427	0.0334	56	0.0162	0.0219	0.0650	0.0597
	(0.0105)	(0.0159)	(0.0093)	(0.0120)		(0.0143)	(0.0155)	(0.0122)	(0.0126)
37	0.0478	0.0439	0.0437	0.0354	57	0.0131	0.0150	0.0626	0.0684
	(0.0130)	(0.0143)	(0.0094)	(0.0074)		(0.0130)	(0.0208)	(0.0136)	(0.0231)
38	0.0267	0.0203	0.0506	0.0611	58	0.0426	0.0653	0.0498	0.0555
	(0.0118)	(0.0116)	(0.0086)	(0.0132)		(0.0164)	(0.0312)	(0.0176)	(0.0173)
39	0.0431	0.0269	0.0449	0.0510	59	0.0377	0.0255	0.0674	0.0484
	(0.0157)	(0.0156)	(0.0073)	(0.0174)		(0.0239)	(0.0197)	(0.0199)	(0.0126)
40	0.0193	0.0363	0.0483	0.0493	60	0.0902	0.0823	0.0650	0.0546
	(0.0110)	(0.0141)	(0.0112)	(0.0134)		(0.0225)	(0.0221)	(0.0194)	(0.0150)
41	0.0488	0.0163	0.0406	0.0550	61	0.1157	0.0797	0.0819	0.0960
	(0.0128)	(0.0109)	(0.0100)	(0.0112)		(0.0274)	(0.0399)	(0.0238)	(0.0304)
42	0.0204	0.0092	0.0637	0.0395	62	0.0990	0.0720	0.0803	0.1682
	(0.0140)	(0.0135)	(0.0129)	(0.0091)		(0.0309)	(0.0645)	(0.0208)	(0.0834)
43	0.0412	0.0284	0.0416	0.0586	63	0.0598	0.0516	0.1061	0.0945
	(0.0121)	(0.0116)	(0.0072)	(0.0165)		(0.0321)	(0.0465)	(0.0204)	(0.0279)

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	Permanent Var		*Transitory Var*			*Permanent Var*		*Transitory Var*	
Age	Before	After	Before	After	Age	Before	After	Before	After
44	0.0512	0.0180	0.0575	0.0460	64	0.1152	0.1303	0.1433	0.1243
	(0.0183)	(0.0140)	(0.0113)	(0.0089)		(0.0511)	(0.0498)	(0.0536)	(0.0464)
45	0.0268	0.0368	0.0957	0.0492	65	0.1152	0.1303	0.1773	0.1378
	(0.0161)	(0.0117)	(0.0300)	(0.0095)		–	–	(0.0586)	(0.0469)

Notes: "Before" refers to 1999-2004 and "After" to 2007-2012. Estimates and standard errors of the income process $y_{it} = p_{it} + \xi_{it}$ are reported, where $\xi_{it} = \frac{1+\theta L}{1-\varphi L}\varepsilon_{it}$, $\varepsilon_t \overset{iid}{\sim} N(0, \sigma^2_{\varepsilon,t})$ and $p_{it} = p_{it-1} + \psi_{it}$, where $\psi_t \overset{iid}{\sim} N(0, \sigma^2_{\psi,t})$. The results are obtained using a Quasi-Newton minimization procedure of a distance function with identity weighting matrix (see Altonji and Segal (1996)).

Source: Authors' calculations based on the GSOEP (1999-2004, 2007-2012).

5.4. Results and Discussion

5.4.1. How Well Does the Model Perform?

Following Hubbard et al. (1995), this section provides evidence on the validity of the consumption/saving model. From a pragmatic epistemological view, a model's predictive accuracy may be viewed as a criterion to asses its usefulness. Impressive research like Keane and Wolpin (2007) demonstrated that it is possible to predict welfare take-up, school attendance, work, and pregnancy for four age groups (15-17.5, 18-21.5, 22-25.5, 26-29.5) very well using a dynamic programming model with 202 parameters for up to 36 *discrete* choices or a multinomial logit model with 240 parameters for 13 *discrete* choices. Also the model used in this chapter violates the law of parsimony—another possible criterion for the usefulness of models—since it employs in simple versions 120 parameters to predict *continuous* saving choices with reasonable accuracy.

However, an exclusive focus on prediction accuracy would come with a cost: the underlying reasons why, say, including another dummy variable increases the fit, cannot be traced back to the axioms of choice. Thus, usefulness of a model must not only be assessed by its predictive power but as well by its consistency with economic theory. Otherwise policy recommendations may be misleading or not possible at all. One extreme example would be to use a purely stochastic process that may provide an excellent fit to the data to analyze a policy intervention that influences saving behavior. Functions flexible enough disguise the channels through which the policy change works and therefore it is hardly possible to derive conclusions with policy implications. Also the model used in this chapter uses some extra theoretical functional form assumptions but aims to limit these to the minimum.

In general, a two-pronged approach is necessary in economic research: one that aims to bring the data to the theory and one that brings theory to the data in the hope that both theoretical and empirical advances will make these two approaches indistinguishable. Until this day, the best theoretical models available should not be rejected if they cannot forecast with the best precision but rather be compared with competing models with the same theoretical stringency. Keane and Wolpin (2007) conclude their paper with the words “Economics is indeed valuable in econometrics”. I argue similarly but conversely: econometrics is valuable for economics.

The main difference of the model in this chapter to work like Keane and Wolpin (2007) is that not discrete but continuous choices (consumption) are predicted by the model. Therefore the model’s performance cannot be compared directly to Keane and Wolpin (2007).[15] A better comparison is Imai and Keane (2004) or Hubbard et al. (1995). The latter presents shares of both transfer recipients and low-wealth households by agegroups as observed in the data and as simulated by the model to assess the model (within-sample) fit.

Table 5.4.3 reports this statistic for transfer recipients for each age. This share was not targeted by the estimation procedure. The leftmost column entitled “GSOEP” and “Model” show the shares observed in survey year 2007 and simulated shares based on parametrization using survey year 2007. The shares at each age are close and the

[15] See Imai and Keane (2004) for a discussion of central differences between discrete and continuous choice dynamic models.

pattern over the life cycle is similar in the data and the simulation. This indicates that model predicts welfare take up quite well.

The next two columns entitled "GSOEP 2002" and "Model" show the shares observed in the survey year 2002 only and simulated shares based on estimation with data from 2012.[16] The model fits the magnitude of the shares based on out-of-sample data reasonably well. Moreover, the model is able to match the pattern over the life cycle. Similarly, the last two columns show the shares calculated from the 2012 survey and model predictions using 2002. Here, the model does not perform well regarding the pattern over the life cycle and likewise regarding the magnitude of the shares.

Table 5.4.3

Actual and Predicted Share of Transfer Recipients.

	Within-Sample		*Out-of-Sample*			
Age	GSOEP	Model	GSOEP 2002	Model	GSOEP 2012	Model
26	14.5	3.6	5.3	4.4	4.7	2.1
27	11.2	4.7	7.1	4.6	14.5	3.6
28	7.0	5.6	8.4	5.9	8.2	4.3
29	10.9	6.3	4.8	5.2	14.2	4.3
30	9.0	5.9	7.0	6.5	12.5	4.6
31	10.7	5.1	8.5	5.4	4.3	5.5
32	3.6	5.3	4.8	4.7	6.7	6.7
33	11.4	5.8	7.2	5.4	5.9	5.4
34	1.4	6.2	6.7	6.6	6.2	4.3
35	6.5	6.8	6.9	6.5	10.7	4.8
36	8.5	7.6	5.1	6.6	11.2	5.2
37	8.1	8.3	6.0	7.7	3.7	5.5
38	13.6	8.2	8.6	7.5	5.8	5.4
39	8.8	7.1	12.3	7.6	6.0	5.0
40	10.8	7.0	6.8	8.4	6.2	4.0
41	5.3	7.1	8.0	7.2	5.6	4.9
42	7.0	7.8	10.8	7.7	7.3	4.2
43	4.4	7.4	6.0	7.4	5.1	4.4
44	11.9	7.9	8.1	8.0	7.8	4.5
45	12.8	9.6	7.9	7.3	7.5	4.6

Continued on next page

[16]Estimation results using both the cross sections 2007 and 2012 do not change much and are available on request.

	Within-Sample		*Out-of-Sample*			
Age	GSOEP	Model	GSOEP 2002	Model	GSOEP 2012	Model
46	9.0	8.9	13.6	8.3	5.1	3.3
47	9.3	9.5	12.6	10.1	7.1	3.1
48	16.1	10.1	15.6	10.0	6.8	2.9
49	7.8	9.1	11.5	9.9	11.6	3.1
50	17.3	9.3	11.9	10.1	9.5	3.1
51	13.0	9.9	13.2	11.0	10.4	2.8
52	9.3	9.8	12.9	10.8	10.5	3.3
53	12.8	10.6	12.4	11.6	11.5	2.5
54	10.0	11.8	8.8	11.2	9.6	2.7
55	16.1	10.4	11.8	12.1	7.5	2.8
56	16.6	10.7	16.5	12.1	13.4	2.5
57	16.1	11.4	7.7	12.9	10.8	2.3
58	10.4	11.6	18.3	12.5	9.3	2.0
59	13.1	13.1	18.8	12.9	7.1	2.7
60	14.6	13.9	26.2	14.0	13.0	2.8
61	20.4	15.2	17.8	15.4	13.6	2.8
62	13.0	14.5	11.5	13.5	17.7	3.1
63	11.5	15.2	11.5	15.5	11.2	4.0
64	9.4	16.5	5.7	17.1	11.5	3.5

Notes: Households are marked as receiving transfers if the sum of the product of the number of months that either UB or UA was received in the previous year and the average amount per month over all household members was positive. The column header "GSOEP" refers to shares from the survey year 2007, "GSOEP 2002" from 2002, and "GSOEP 2012" from 2012. The columns entitled "Model" show shares simulated based on wealth and income data from 2007 in the "Within-Sample" columns, on 2002 and 2012, respectively, in the "Out-of-Sample" columns. Simulations were done for 1,000 households at each age.

Source: Authors' calculations based on the GSOEP (2002, 2007, 2012).

Table 5.4.4 presents the same statistic for low-wealth households by age. Note that the shares are slightly above those reported in Table 5.3.1 because transfer recipients are included. Compared to data from the United States (Hubbard et al. (1995)), the share of low-wealth households seem quite high. Presumably, this difference is caused by the differences between the pension systems in both countries.[17] The shares obtained from survey year 2007 and the simulated shares based on parametrization using

[17]Moreover, item non-response could be non-random.

this year are quite similar, though this share was not targeted in the estimation. The simulated shares are at most ages larger than the observed which might be due to the fact that the model abstracts from variation in the rate of return.

The next two columns demonstrate how well the out-of-sample fit is for low-wealth households. The match between the shares observed in the survey year 2002 and simulated shares based on data from 2012 is not satisfactory. The magnitude of the shares are overpredicted throughout, though the simulated pattern is quite similar to the pattern over age in the data. This could be due to effects of the financial crisis[18] or the burst of the "dot-com" bubble[19]. The last two columns show that the shares from the 2012 survey and model predictions using 2002 and 2007 are reasonably close until age about 40 but then the predictions deviate from the data.

Table 5.4.4

Actual and Predicted Share of Low-Wealth Households.

	Within-Sample		*Out-of-Sample*			
Age	GSOEP	Model	GSOEP 2002	Model	GSOEP 2012	Model
26	75.6	91.5	81.2	93.8	96.0	84.3
27	92.9	93.2	71.4	94.3	87.7	77.7
28	75.7	92.8	76.6	94.3	77.3	75.5
29	77.8	92.5	82.4	93.9	79.9	75.3
30	77.3	90.5	72.2	93.1	82.1	74.9
31	82.5	90.1	63.9	92.5	70.1	74.5
32	70.8	86.7	68.0	91.5	58.3	69.9
33	53.9	85.2	65.6	88.1	69.0	70.2
34	63.5	81.7	53.9	87.8	79.3	68.9
35	60.9	80.1	56.1	85.2	76.9	69.8
36	66.8	78.6	46.7	82.0	69.1	67.5
37	65.9	75.2	57.0	80.3	63.6	66.6
38	58.5	73.3	52.4	76.5	41.6	64.4

Continued on next page

[18] According to the German Federal Statistical office a recession of real annual GDP was observed in Germany in 2008/9.

[19] According to the German Federal Statistical office a recession of real annual GDP was observed in Germany in 2003. Note that effects on wealth could be present before 2003 since, e.g., the Business Cycle Dating Committee of the National Bureau of Economic Research determines March 2001 as beginning of the recession for the US.

	Within-Sample		*Out-of-Sample*			
Age	GSOEP	Model	GSOEP 2002	Model	GSOEP 2012	Model
39	60.2	70.4	48.0	73.5	61.9	66.0
40	50.4	68.8	38.6	68.8	55.1	66.1
41	48.0	65.1	38.3	67.7	49.8	65.7
42	61.0	65.7	49.6	65.9	50.9	64.5
43	58.1	61.2	32.9	62.8	49.1	64.6
44	48.4	59.8	37.2	61.4	52.2	62.1
45	44.8	59.9	36.9	62.4	49.8	61.6
46	43.9	58.3	33.8	59.3	38.2	62.5
47	52.3	57.0	42.2	59.1	45.4	62.8
48	43.0	55.9	35.8	56.6	47.7	63.3
49	48.6	55.2	44.3	55.4	54.6	63.9
50	38.1	54.3	41.1	54.7	44.6	64.2
51	42.2	55.2	46.7	52.2	38.7	65.0
52	51.9	52.5	33.1	51.6	43.5	64.1
53	35.5	52.6	29.4	51.0	33.8	63.5
54	39.6	51.3	39.1	50.1	46.6	63.8
55	32.1	50.4	27.9	49.7	32.6	63.1
56	31.5	49.0	40.5	48.4	31.4	64.1
57	39.3	49.0	17.6	47.8	36.5	63.7
58	28.4	48.1	30.9	47.9	21.4	61.9
59	37.6	47.7	29.8	48.1	35.3	64.3
60	32.1	48.3	31.6	48.2	30.8	64.2
61	31.9	48.2	33.3	47.7	40.9	64.8
62	23.6	49.5	25.1	47.1	30.7	64.8
63	37.2	49.6	29.6	48.7	32.0	65.1
64	30.4	50.4	24.6	48.3	23.8	64.1

Notes: Households are marked as low-wealth households if the wealth to post-government labor income ratio was below one. The column header "GSOEP" refers to shares from the survey year 2007, "GSOEP 2002" from 2002, and "GSOEP 2012" from 2012. The columns entitled "Model" show shares simulated based on wealth and income data from 2007 in the "Within-Sample" columns, on 2002 and 2012, respectively, in the "Out-of-Sample" columns. Simulations were done for 1,000 households at each age.

Source: Authors' calculations based on the GSOEP (2002, 2007, 2012).

A further ambitious validation exercise measures how well the model predicts future wealth to income *ratios* using only information from past survey years. Table 5.4.5 reports the Root Mean Squared Error (RMSE), calculated as $RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(\hat{w}_i - w_i)^2}$

where N is the number of predictions, w_i the variable to be predicted, and $\hat{w}_i$ the prediction. Scale free alternative measures are the Theil U statistics $U = \sqrt{\frac{1/N \sum_i (\hat{w}_i - w_i)^2}{1/N \sum_i w_i^2}}$. Large values indicate a poor forecasting performance (Greene (2008)).

In this table, a "naive" forecast based on implied wealth to income ratios from the model estimates from one wave only is compared to two other "naive" forecasts: to an autoregressive process[20] (using information from two survey years) and to a prediction based on quantile regressions with a cubic age polynomial (using information from only one cross section).

The first three columns show that the model outperforms the polynomial and predicts similarly well within sample as the autoregressive process that uses more information. From the columns entitled "Predict 2002" it is apparent that the RMSEs are as expected on average higher than for the within-sample prediction. Again, the model's RMSEs are smaller than the polynomial's, while the RMSEs of the autoregressive process are smallest. The last three columns report RMSEs that show the same result.[21]

The forecasts are not very accurate which is not surprising since the forecast horizon is 10 years (or 5 years for the autoregressive process).[22] For example, considering Theil's U[23], a value of 1 implies that the average squared forecast error is as large as the average squared wealth to income ratio at a given age. Still, the model's Us are on average below 1 in the within sample column and the columns showing the out-of-sample predictions. This is true as well for the two competing models, however, according to this measure, the model performs best in all three cases.

The same ranking of models emerges using a modified Theil statistic defined as $U_\Delta = \sqrt{\frac{1/N \sum_i (\Delta\hat{w}_i - \Delta w_i)^2}{1/N \sum_i \Delta w_i^2}}$, where $\Delta w_i = w_i - w_{i-1}$ and $\Delta\hat{w}_i = \hat{w}_i - w_{i-1}$. Results are available on request.

[20] Since wealth data is only observed in five-year intervals, first lag refers to the realization 5 years ago. Stationarity is assumed.

[21] Note that for all models the RMSEs are on average smaller than those reported in the first three columns because of fewer outliers.

[22] Note that predicting 5 instead of 10 years ahead does not result in better predictive performance.

[23] Note that this measure gets smaller with age because the dispersion of the wealth to income ratio increases. This means that the forecast error is independent from age.

Table 5.4.5

Root Mean Squared Error and Theil's U for Wealth to Income Ratio.

	Within-Sample			*Predict 2002*			*Predict 2012*		
Age	AR	Poly	Model	AR	Poly	Model	AR	Poly	Model
					RMSE				
30	1.71	1.53	1.07	1.83	1.97	1.49	2.78	1.97	1.42
31	1.64	0.83	0.39	2.14	2.00	1.63	1.25	2.20	1.47
32	1.93	2.34	1.76	2.55	2.90	2.45	1.80	1.92	1.38
33	1.62	2.52	2.02	1.57	2.08	1.76	1.79	1.66	1.03
34	1.51	2.71	2.15	1.68	3.06	2.66	1.92	1.93	1.25
35	1.92	2.77	2.16	2.72	3.21	2.73	2.32	2.04	1.42
36	2.39	2.69	2.11	1.87	3.07	2.58	2.35	2.12	1.28
37	2.08	2.74	2.16	2.06	3.50	2.99	1.96	2.47	1.87
38	1.92	2.28	1.78	2.31	3.06	2.57	1.90	1.55	1.19
39	2.30	2.55	1.92	2.35	3.04	2.43	1.39	1.89	1.23
40	2.67	3.57	3.04	2.06	3.05	2.56	2.52	2.37	1.84
41	1.76	2.88	2.46	2.66	3.37	2.99	3.08	2.90	2.38
42	1.62	2.66	2.07	2.33	3.35	2.73	2.78	2.85	2.37
43	2.22	2.93	2.26	2.53	3.38	3.03	2.29	2.52	2.10
44	1.76	2.61	2.03	3.21	3.64	3.09	2.55	2.92	2.35
45	2.18	2.54	1.82	2.08	3.44	3.22	2.37	2.85	2.65
46	2.60	3.20	2.33	1.85	2.58	2.35	1.83	2.66	2.28
47	2.26	3.48	2.23	2.14	2.87	2.51	2.02	2.97	2.92
48	2.47	2.80	2.02	2.15	3.01	2.68	1.97	2.35	1.73
49	2.58	3.35	2.62	2.23	3.22	2.94	1.93	2.55	2.21
50	2.14	3.22	2.42	2.85	3.40	2.94	2.62	2.77	2.71
51	2.05	2.59	2.23	2.95	3.11	2.56	2.85	3.01	2.93
52	2.12	2.88	2.33	2.23	2.96	3.10	2.40	3.04	2.73
53	2.08	2.78	2.19	3.10	3.22	3.07	2.86	3.27	3.31
54	2.45	2.92	2.32	2.15	3.37	3.10	2.64	3.12	3.27
55	2.78	3.11	2.54	2.81	3.39	3.16	2.15	3.02	3.37
56	2.97	3.95	3.50	2.93	3.39	3.17	2.11	2.97	3.26
57	2.01	2.76	2.49	3.06	3.48	4.04	2.22	3.16	3.77
58	2.23	3.15	3.07	2.93	3.30	3.28	2.00	2.70	3.54
59	2.41	3.18	2.86	2.55	3.61	3.07	2.42	3.13	3.87
60	2.10	2.85	3.58	2.84	2.94	3.28	2.77	3.10	3.80

Continued on next page

	Within-Sample			*Predict 2002*			*Predict 2012*		
Age	AR	Poly	Model	AR	Poly	Model	AR	Poly	Model
				Theil U					
30	1.02	0.92	0.55	0.88	0.95	0.76	1.25	0.92	0.73
31	1.58	0.80	0.19	1.00	0.94	0.80	0.50	0.89	0.72
32	0.76	0.93	0.65	0.82	0.94	0.91	0.84	0.91	0.51
33	0.57	0.89	0.85	0.68	0.90	0.74	0.91	0.85	0.43
34	0.50	0.90	0.71	0.50	0.92	0.88	0.84	0.85	0.41
35	0.61	0.89	0.69	0.77	0.92	0.87	1.00	0.88	0.45
36	0.78	0.87	0.67	0.53	0.88	0.82	0.96	0.87	0.40
37	0.65	0.86	0.61	0.52	0.89	0.85	0.65	0.82	0.53
38	0.69	0.82	0.58	0.64	0.85	0.83	0.89	0.73	0.38
39	0.75	0.83	0.61	0.66	0.86	0.77	0.58	0.80	0.39
40	0.62	0.84	0.82	0.57	0.84	0.69	0.86	0.81	0.50
41	0.49	0.81	0.66	0.66	0.84	0.80	0.85	0.80	0.64
42	0.49	0.81	0.56	0.56	0.81	0.74	0.77	0.79	0.64
43	0.62	0.82	0.60	0.59	0.79	0.81	0.69	0.76	0.56
44	0.53	0.78	0.51	0.70	0.79	0.78	0.66	0.76	0.59
45	0.64	0.75	0.45	0.47	0.78	0.81	0.60	0.72	0.66
46	0.62	0.77	0.62	0.51	0.71	0.62	0.53	0.77	0.61
47	0.50	0.78	0.53	0.54	0.72	0.60	0.49	0.72	0.70
48	0.64	0.73	0.54	0.51	0.72	0.72	0.66	0.78	0.47
49	0.58	0.76	0.64	0.50	0.72	0.72	0.60	0.79	0.54
50	0.50	0.75	0.57	0.62	0.74	0.69	0.68	0.72	0.64
51	0.56	0.70	0.55	0.69	0.73	0.63	0.67	0.71	0.72
52	0.53	0.72	0.55	0.51	0.69	0.74	0.55	0.70	0.65
53	0.49	0.66	0.48	0.67	0.70	0.68	0.60	0.68	0.73
54	0.57	0.68	0.51	0.43	0.68	0.68	0.59	0.70	0.71
55	0.58	0.66	0.54	0.56	0.68	0.67	0.47	0.67	0.71
56	0.54	0.72	0.70	0.58	0.68	0.63	0.48	0.67	0.65
57	0.47	0.65	0.51	0.55	0.63	0.83	0.47	0.67	0.78
58	0.47	0.66	0.63	0.55	0.63	0.67	0.43	0.58	0.72
59	0.50	0.67	0.56	0.47	0.67	0.60	0.47	0.61	0.76
60	0.51	0.70	0.75	0.57	0.59	0.69	0.55	0.62	0.80

Notes: The column header "Within-Sample" refers measures from the survey year 2007, "Predict 2002" and "Predict 2012" show measures based on wealth and income data from 2012, and from 2002, respectively. The statistics are based on simulations for the number of households observed in the data at a given age where the distance between the simulated and the actual distribution is smallest.

Source: Authors' calculations based on the GSOEP (2002, 2007, 2012).

Three conclusions follow from this exercise. First, the model's performance is not precise enough to rely on its predictions over a 10 (or 5) year horizon.[24]

Second, the model performs often better than atheoretical processes. This implies that economic thought may improve predictive power and including more detailed specifications to model the effects of relevant variables like labor hours, number of children, etc. is a challenging but promising avenue of ongoing research.

Finally, the model has the advantage that moments that were not targeted by the estimation procedure like the share of transfer recipients are predicted reasonably well. This is hardly possible for statistical processes without further assumptions. Therefore, the model is much better suited for policy experiments.

5.4.2. Short- and Long-Term Effects of the Reform and Welfare Impact

In this section, I simulate the short and longer-run effects of the "Hartz IV" reform described in Section 5.2 on precautionary savings. Recall the definition of precautionary savings $\Delta\overline{C}_t = \overline{C}_t - C_t$, where $\overline{C}_t$ is optimal when shocks $\xi_t = \varepsilon_t = 0$. This means that precautionary savings is the behavioral difference between a consumer who faces uninsurable labor income risk and will therefore consume less, and a consumer with the same path for expected income but who does not perceive any uncertainty as being attached to that future income.

Table 5.4.6 presents the simulated impact of the reform for the households of different ages at the time of the reform. The first two columns show the median amount of precautionary savings simulated under the situation before and after "Hartz IV", respectively. At all ages, this part of savings was reduced due to the reform. The next three columns present the median change of the fraction of savings that are held out

[24]However, given that the forecast horizon spans several years, arguably only (usually unfalsifiable) methods used by fortunetellers are known to perform better. Essentially, the conducted exercise is a test of the efficient market hypothesis which implies that the study of past asset prices in an attempt to predict future prices does not enable an econometrician to achieve better predictions than those that could be obtained by guessing (Malkiel (2003)). Though the model is not designed for such a test and the finance literature provides many cases which are arguably better suited to study this hypothesis, the results suggest that markets are not efficient.

of precaution for 1, 5 and 10 years after the reform. Suppose that the share of precautionary savings was 90 percent of total savings at the reform for a household who was 26 years old. Then this share was reduced by the reform by 7.6 percentage points in the first year after the reform. At higher ages (with more savings), the effects were smaller. In the longer run the share of precautionary savings was reduced less than in the short run. The main reason for the reduction of precautionary savings is that the reform replaced unemployment assistance, which was uncertain by certain lump sum transfers, and that it raised the consumption floor for many households.[25]

Table 5.4.6

Simulated Effects of "Hartz IV" Reform on Precautionary Savings.

Reform	*Median Prec. Savings (Euro)*		*Change in Share of Prec. Savings (pp.)*		
at Age	Before "Hartz IV"	After "Hartz IV"	1 Year	5 Years	10 Years
26	6,961	5,442	−7.6	−6.1	−6.4
27	7,157	5,325	−8.8	−7.0	−6.7
28	6,990	5,414	−7.6	−7.5	−5.4
29	6,986	5,689	−6.1	−7.4	−4.9
30	6,965	5,652	−5.6	−7.0	−4.2
31	7,171	5,714	−6.0	−6.4	−3.1
32	7,419	5,598	−7.0	−6.6	−2.7
33	7,596	5,523	−7.5	−5.5	−5.3
34	7,671	5,540	−7.4	−4.9	−5.2
35	7,888	5,774	−7.0	−4.2	−4.9
36	7,931	5,902	−6.4	−3.1	−5.0
37	8,245	5,970	−6.6	−2.7	−4.4
38	8,585	6,555	−5.4	−5.2	−4.9
39	8,618	6,837	−4.8	−5.2	−4.7
40	8,626	7,034	−4.1	−4.8	−4.5
41	8,372	7,204	−2.9	−4.9	−4.8
42	8,563	7,305	−2.6	−4.4	−4.6
43	8,992	6,671	−5.1	−4.8	−4.6
44	9,039	6,544	−5.1	−4.6	−4.5
45	9,330	6,815	−4.7	−4.4	−4.8
46	9,221	6,552	−4.8	−4.7	−4.3
47	9,627	7,109	−4.2	−4.4	−4.2

Continued on next page

[25]Note that these effects are much smaller if preferences are kept constant.

Reform	*Median Prec. Savings (Euro)*		*Change in Share of Prec. Savings (pp.)*		
at Age	Before “Hartz IV”	After “Hartz IV”	1 Year	5 Years	10 Years
48	10,039	7,139	−4.7	−4.4	−3.3
49	9,961	7,080	−4.4	−4.4	−2.9
50	10,287	7,277	−4.2	−4.6	−2.7
51	10,507	7,149	−4.6	−4.2	−2.9
52	10,692	7,337	−4.2	−4.0	−2.9
53	11,038	7,778	−4.3	−3.2	−6.4
54	11,743	8,385	−4.1	−2.8	−6.5
55	11,826	8,120	−4.4	−2.5	−6.6

Note: Medians and medians of differences based on 1,000 households of each age at the time of the reform. Information on income of the pre reform period is kept constant, labor income risk is increased by one percent.

Source: Author’s calculations based on the GSOEP (2002, 2007, 2012).

Finally, the impact on life cycle welfare is considered. The measure of lifetime welfare is calculated as

$$\tilde{H}_{t_0}^{T+t_0} = \sum_{t=t_0}^{T+t_0} \frac{Y_t}{(1+r)^{t-t_0}} = \text{such that} \sum_{t=t_0}^{T+t_0} \beta^{t-t_0} u_t(\tilde{C}_{it}) = E_{t_0}\left[\sum_{t=t_0}^{T+t_0} \beta^{t-t_0} u_t(C_{it})\right].$$

It represents the present discounted value of *certain* income that generates the same expected utility as when income is uncertainty.

To understand the effects shown in Table 5.4.7, it is informative to consider the importance of social insurance through the tax and benefit system for different households. High lifetime income households are unlikely to become eligible for unemployment transfers, even if a negative shock occurred; as a result these households find the increase in uncertainty after the reform costly. Also low lifetime income households dislike higher uncertainty which they faced before the reform because the transfer payments depend on uncertain, previous income. In contrast, under “Hartz IV” low lifetime income households benefit from higher uncertainty, since unemployment assistance protects them against negative shocks, while they gain from positive shocks. This is similar for households at higher percentiles of the lifetime income distribution, like the median, who are more likely to take up transfers than the high wealth households but earn too much to be entirely protected against negative shocks by the tax and transfer system.

Table 5.4.7

Impact of "Hartz IV" Reform on Welfare.

	Certainty Equivalent Life Cycle Income		Compensation for
	Before "Hartz IV" (Euro)	After"Hartz IV" (Euro)	reform (%)
40 % of median	361,930	371,958	−2.8
60 % of median	488,190	502,478	−2.9
Median	496,610	503,342	−1.4
90th percentile	1,375,000	1,369,663	0.4

Note: Percentiles refer to the distribution of (undiscounted, realized) lifetime income. Preferences and information on income of the pre reform period are kept constant, labor income risk is increased by one percent. The reported figures are averages of the respective figures calculated for 1,000 households of each age at the time of the reform. All figures are in 2011 Euros.
Source: Author's calculations based on the GSOEP (2002, 2007, 2012).

In Table 5.4.7, certainty equivalent life cycle incomes are reported before the reform and after for four households of the lifetime income distribution. The last column presents the effect on welfare for these households which is calculated as

$$\left(\tilde{H}^{T+t_0}_{t_0,\text{Before}} - \tilde{H}^{T+t_0}_{t_0,\text{After}}\right)/\tilde{H}^{T+t_0}_{t_0,\text{Before}}.$$

The welfare effects are negative for most households which implies that these households were ready to give up part of their income to replace the system before the reform with "Hartz IV". These effects are decreasing with the position in the lifetime income distribution, since a smaller part of negative shocks is covered by the tax and transfer system, and because the consumption floor was raised for poorer households by the reform. High wealth household who are not much affected by the actual reform, would prefer to live in an environment with less uncertainty as before the reform.

Since higher transactions costs, increased perceived stigma attached to transfer dependence, and more rigorous threat of benefit cuts are not included in the model, the welfare effects do not measure disutility due to these factors which were arguably important in practice.

5.5. Conclusion

This chapter evaluates the effect of a recent reform of means-tested unemployment benefits in Germany ("Hartz IV") on precautionary saving. The reform had two main components. First, the maximum unemployment benefit entitlement periods were cut (in effect in 2005). Second, unemployment assistance that depended on previous earnings was replaced by a lump sum transfer with a tighter asset-based means-test from 2006 on.

Three channels through which the reform may have influenced precautionary saving behavior are identified: first, the reform increased the general level of income uncertainty leading to more precautionary saving. On the other hand precautionary saving was reduced by the reform because unemployment assistance, which was *uncertain* due to its determination by uncertain previous income, was replaced by *certain* lump sum transfers. Overall, the change in uncertainty faced by households reduced precautionary saving since the latter effect outweighs the former. Second, higher (lower) transfer before the reform leads to more (less) precautionary saving after. Third, a tighter means-test causes less/more precautionary saving (depending on lifetime income).

Short-term effects on the change in the share of precautionary saving are negative but small and decreasing with age. After 5 and 10 years, the share of precautionary saving is smaller at most ages both 5 and 10 years after the reform.

The welfare analysis shows that household at 40 percent of median life-time income would pay 2.8 percent of this income to live under "Hartz IV". This is similar for the household at 60 percent of the median life-time income and the median life-time income household who would give up 2.9, and 1.4 percent, respectively. This is due to the fact that consumption can be smoothed better when unemployment assistance is certain and that the consumption floor was raised for many households by the reform. The 90th percentile life-time income household needs to be compensated with 0.4 percent of life-time income to be indifferent to “Hartz IV”.

The fact that the reform in practice caused emotional debates and much disappreaciation may be due to the emphasis on efforts to reduce the level of unemployment when the details of the reform were communicated to the public. Further, higher transactions costs, increased perceived stigma attached to transfer dependence, and more rigorous threat of benefit cuts which are not part of the model may explain why this reform was not perceived as the welfare analysis suggests.

Finally, this chapter examines how well the model captures important features of the data by comparing two statistics not targeted by the estimation procedure that are interesting in the context of the reform: the share of transfer recipients, and the share of low wealth households. The model simulations reasonably predict these statistics but implementation of other factors not considered in the model like fertility or labor supply decisions may improve the model’s predictive power.

Appendix 5.A: Tables and Figures

Table 5.A.1

Duration and Replacement Before and After the "Hartz IV" Reform.

	Duration								
	Before "Hartz IV" (2001)			*After "Hartz IV" (2006)*			*After "Hartz IV" (2011)*		
	month of entitlement[c]	*age*[c]	*months worked last seven years*[c]	*month of entitlement*[d]	*age*[d]	*months worked last three years*[d]	*month of entitlement*[e]	*age*[e]	*months worked last five years*[e]
UB[a]	6		12	6		12	6		12
	8		16	8		16	8		16
	10		20	10		20	10		20
	12		24	12		24	12		24
	14	45	28	15	55	30	15	50	30
	16	45	32	18	55	36	18	55	36
	18	45	36				24	58	48
	20	47	40						
	22	47	44						
	24	52	48						
	26	52	52						
	28	57	56						
	30	57	60						
	32	57	64						
UA[b]	No limit but cuts possible			No limit but cuts possible and more likely			No limit but cuts possible and more likely		

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	Replacement		
	Before "Hartz IV" (2001)	*After "Hartz IV" (2006)*	*After "Hartz IV" (2011)*
UB	67[f] percent of last year's net income max 4,500 Euro	67[f] percent of last year's net income max 5,250 Euro	67[f] percent of last year's net income max 5,500 Euro
UA	57[f] percent of last year's net income max 4,500 Euro, yearly adjustment	monthly lump sum of 627[g] Euro	monthly lump sum of 666[g] Euro

[a] Unemployment Benefits (Arbeitslosengeld).

[b] Unemployment Assistance (Arbeitslosenhilfe and Sozialhilfe before, Arbeitslosengeld II (ALG II) after 2005).

[c] SGB III §127 (2) from Jan 01, 1998 to Dec 12, 2003 in effect until Jan 31, 2006.

[d] SGB III §127 (2) from Jan 01, 2004 to Dec 12, 2007, in effect from Feb 1, 2006.

[e] SGB III §127 (2) in effect from Jan 01, 2008 to Mar 31, 2012, from Apr 1, 2012 SGB III §147 (2). §434r Abs. 1 SGB III those who are eligible for UB on Dec, 31 2007 are subject to the longer duration as of Jan, 1 2008 provided requirements are met.

[f] UB 7 percent less (SGB III §129, from from Apr 1, 2012 §149), UA in 2002 4 percent without children SGB III §195. Caps from Appendix 2 SGB VI.

[g] Average amount per needs unit including lodging and heating observed in 2006/2011, Federal Employment Agency.

Table 5.A.2

Income-Based Means Test Before and After the "Hartz IV" Reform.

	Before "Hartz IV" (2001)	*After "Hartz IV" (2006)*	*After "Hartz IV" (2011)*
UB[a]	allowance of about 165 Euro or less then 20 % of replacement	allowance of 165 Euro	allowance of 165 Euro
	max less than 15 h per week	max less than 15 h per week	max less than 15 h per week
UA[b]	allowance of 165 Euro or less than 20 % of replacement	allowance of 100 Euro	allowance of 100 Euro
	marginal withdrawal rate (MWR) of 1 afterwards	MWR of 0.8 up to income of 1,000 Euro	MWR of 0.8 up to income of 1,000 Euro
		MWR of 0.9 up to income of 1,200 Euro (1,500 Euro with children)	MWR of 0.9 up to income of 1,200 Euro (1,500 Euro with children)
		MWR of 1 afterwards	MWR of 1 afterwards
	max 15 h per week	no hour restriction, max 3,000	no hour restriction, max 3,000
	partner hypothetical UA		

[a] Unemployment Benefits (Arbeitslosengeld), see SGB III §§119, 141.

[b] Unemployment Assistance (Arbeitslosenhilfe [see SGB III §195] and Sozialhilfe before, Arbeitslosengeld II (ALG II) after 2005 [see SGB II §30 (2006), §11 (2011)]).

Table 5.A.3

Asset-Based Means Test Before and After the "Hartz IV" Reform.

	Before "Hartz IV" (2001)	*After "Hartz IV" (2006)*	*After "Hartz IV" (2011)*
UB[a]	—	—	—
	Before "Hartz IV" (2001)	*After "Hartz IV" (2006)*	*After "Hartz IV" (2011)*
UA[b]		*Basic Allowance*	
	about 4,000 Euro, respectively (520 per age in 2002) (max 33,800 in 2002)	200 Euro per age of each adult and partner min 4,100 Euro 4,100 for each child max 13,000 Euro	150 Euro per age of each adult and partner min 3,100 Euro 3,100 for each child max 9,750 Euro if born before 1958 max 9,900 Euro if born after 1958, before 1964 max 10,050 Euro if born after 1963
UA[b]		*Old Age Saving*	
	about 500 Euro per age	200 Euro per age, respectively max 13,000 Euro, respectively	750 Euro per age, respectively max 48,750 Euro if born before 1958 max 49,500 Euro if born after 1958, before 1964 max 50,250 Euro if born after 1963
UA[b]		*"Riester"-Saving*	
	deductible (since 2002)	deductible	deductible
UA[b]		*Appropriate Car*	
	(assumed 7,500[c] Euro in 2011 prices, since 2002)	(assumed 7,500[c] Euro in 2011 prices)	(assumed 7,500[c] Euro in 2011 prices)

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	Before "Hartz IV" (2001)	*After "Hartz IV" (2006)*	*After "Hartz IV" (2011)*
UA[b]		*Necessities*	
		max 750 Euro for necessities per beneficiary	max 750 Euro for necessities per beneficiary
UA[b]		*Appropriate owner-occupied housing*	
	(assumed 90,000 Euro in 2011 prices)	(90,000[d] Euro in 2011 prices)	(90,000[d] Euro in 2011 prices)

[a] Unemployment Benefits (Arbeitslosengeld).

[b] Unemployment Assistance (Arbeitslosenhilfe [see AlhiV, AlhiV 2002] and Sozialhilfe before, Arbeitslosengeld II (ALG II) after 2005 [see SGB II §12]).

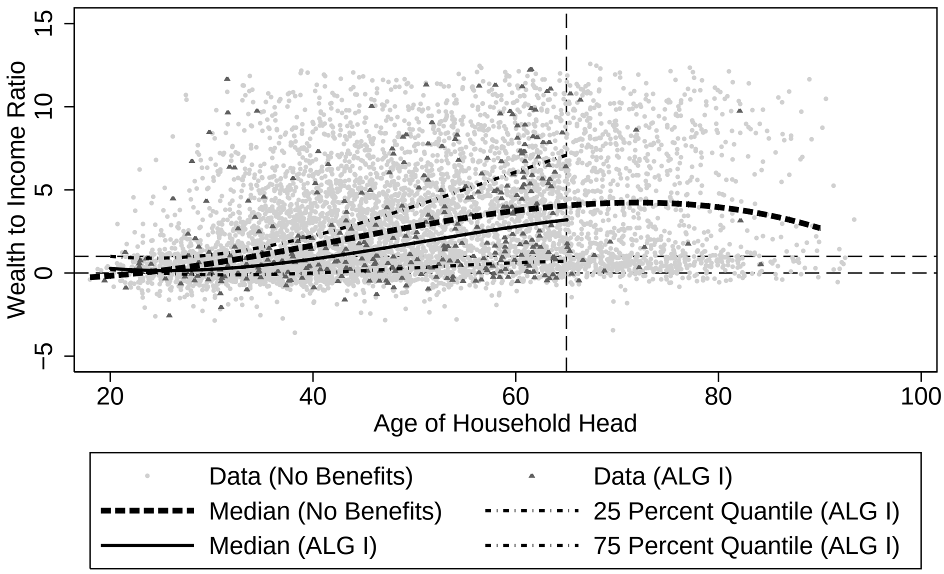
[c] (see Bundessozialgericht Sept 07, 2007, AZ: B 14/7b AS 66/06 R).

[d] Average net worth of owner-occupied housing of UA recipients observed in 2007, 2011, (see Bundessozialgericht Nov 07, 2006, AZ: B 7b AS 2/05 R).

Figure 5.A.1

Wealth to Income of Median Household, Recipients of Unemployment Benefits, and Inequality (2002, 2007).

Source: Own calculations based on the GSOEP (2002, 2007).



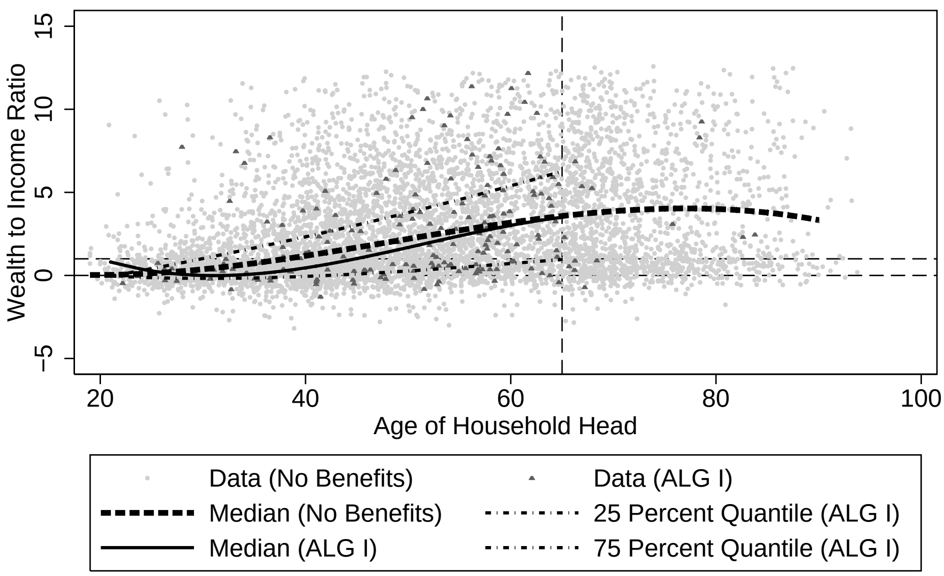


Figure 5.A.2

Wealth to Income of Median Household, Recipients of Unemployment Benefits, and Inequality (2012).

Source: Own calculations based on the GSOEP (2012).

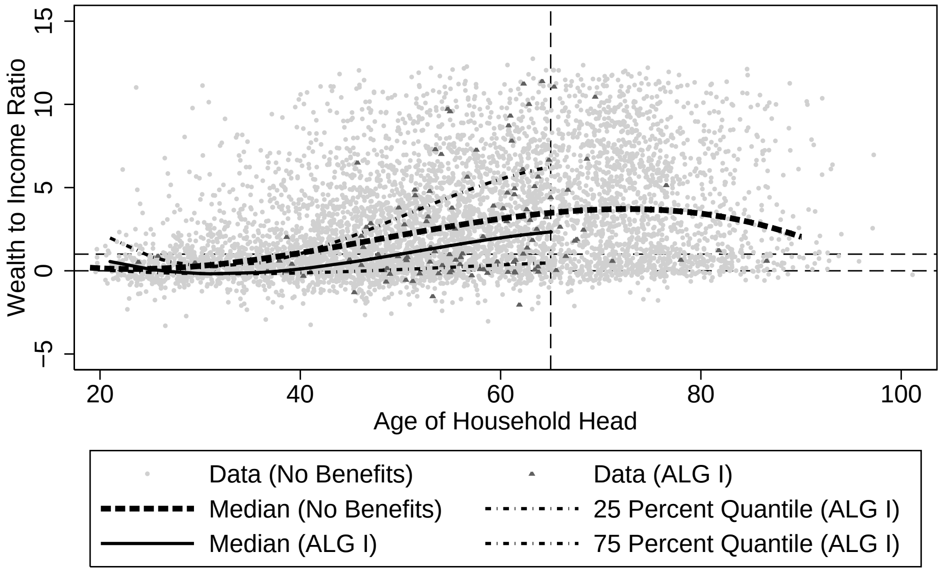


Table 5.A.4

Wealth and Income of Unemployment Benefits Recipients (2002, 2007, and 2012).

	Age			
	25–34	35–44	45–54	55–64
	Before "Hartz IV" (2002): Recipients of UB			
Median wealth (Euro)	10,372	12,676	12,100	35,340
Median income (Euro)	15,191	15,485	12,549	15,219
Wealth > income (%)	41.6	46.4	46.2	68.9
Wealth < income (%)	32.9	25.3	36.0	24.2
Debt < income (%)	15.5	21.9	12.2	6.9
Number of households	224,425	351,264	395,243	531,287
Number of observations	84	129	144	202
	After "Hartz IV" (2007): Recipients of UB			
Median wealth (Euro)	930	-159	17,532	56,847
Median income (Euro)	12,995	15,519	13,498	15,640
Wealth > income (%)	10.3	31.4	48.6	69.2
Wealth < income (%)	45.8	18.4	39.5	21.0
Debt < income (%)	43.9	49.2	11.9	9.8
Number of households	98,324	238,156	229,780	356,422
Number of observations	47	46	83	120
	After "Hartz IV" (2012): Recipients of UB			
Median wealth (Euro)	-1,717	1,963	7,851	36,800
Median income (Euro)	10,267	14,139	12,074	15,014
Wealth > income (%)	0.0	31.1	37.4	61.0
Wealth < income (%)	39.8	25.3	50.5	25.9
Debt < income (%)	60.2	39.8	12.0	11.0
Number of households	49,272	61,235	209,542	286,855
Number of observations	17	28	66	91

Note: "Wealth > income", "Wealth < income" reports the weighted percentage of the sample with positive net worth greater or less than after-government income net of asset income. Similarly, "Debt < income" reports the same figure with the absolute value of negative net worth (debt) less than after-government income as defined above. All figures are in 2011 Euros.
Source: Authors' calculations based on the GSOEP (2002, 2007, 2012).

Table 5.A.5

Wealth and Income of Unemployment Assistance Recipients (2002, 2007, and 2012).

	Age			
	25–34	35–44	45–54	55–64
	Before "Hartz IV" (2002): Recipients of UA			
Median wealth (Euro)	576	1,729	6,530	23,048
Median income (Euro)	14,095	12,585	10,037	11,551
Wealth > income (%)	8.7	25.8	37.5	63.6
Wealth < income (%)	47.8	37.0	36.9	29.7
Debt < income (%)	38.5	28.3	23.1	6.2
Number of households	195,844	310,358	384,539	329,390
Number of observations	60	119	138	111
	After "Hartz IV" (2007): Recipients of UA			
Median wealth (Euro)	-638	-1,275	-2,524	10,626
Median income (Euro)	12,217	11,938	10,549	11,244
Wealth > income (%)	1.8	24.6	10.3	45.9
Wealth < income (%)	29.6	12.7	34.3	35.8
Debt < income (%)	44.1	54.5	36.9	16.9
Number of households	307,301	484,445	612,686	492,188
Number of observations	98	119	153	115
	After "Hartz IV" (2012): Recipients of UA			
Median wealth (Euro)	-98	-1,472	451	1,963
Median income (Euro)	8,742	9,350	9,681	9,357
Wealth > income (%)	0.0	7.4	33.0	30.2
Wealth < income (%)	42.6	16.9	18.4	31.7
Debt < income (%)	54.4	55.5	27.5	31.3
Number of households	316,403	340,122	566,251	563,824
Number of observations	96	108	157	158

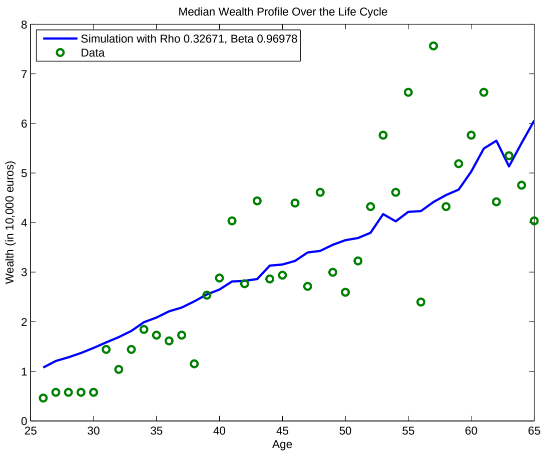
Note: "Wealth > income", "Wealth < income" reports the weighted percentage of the sample with positive net worth greater or less than after-government income net of asset income. Similarly, "Debt < income" reports the same figure with the absolute value of negative net worth (debt) less than after-government income as defined above. All figures are in 2011 Euros.
Source: Authors' calculations based on the GSOEP (2002, 2007, 2012).

Figure 5.A.3

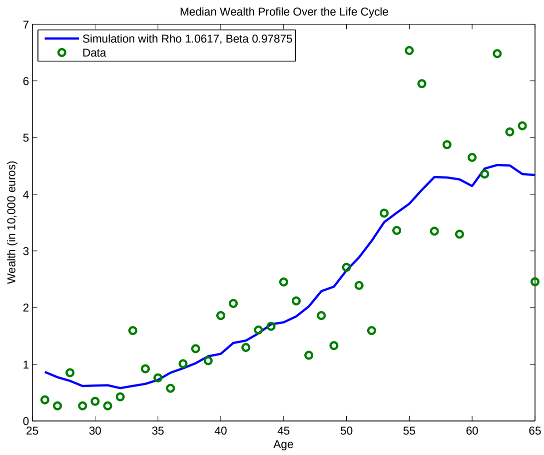
Simulated and Observed Wealth Profile.

Source: Own calculations based on the GSOEP (2002, 2007, 2012).

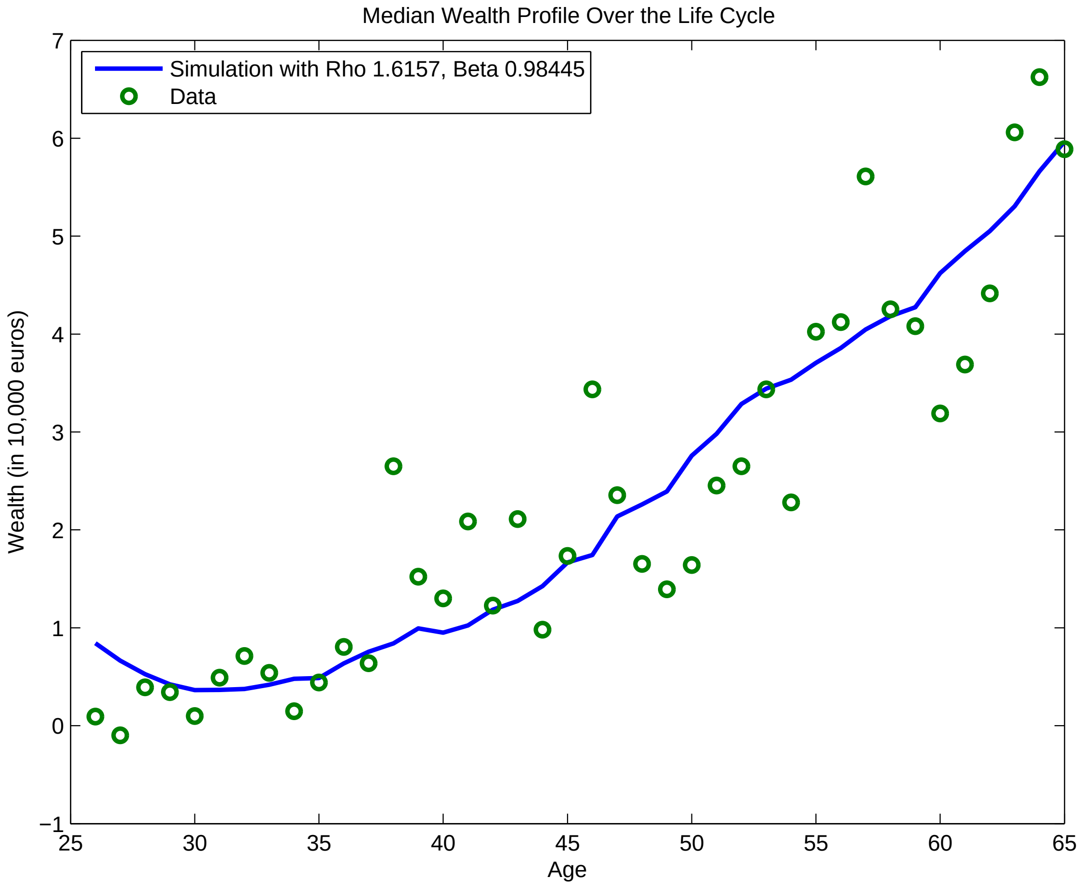
(a) *2002*



(b) *2007*



(c) *2012*



6 Postface

6.1. Main Findings and Conclusion

The four main chapters of this thesis are concerned with the investigation of consumption/saving behavior under labor income uncertainty that is analyzed with micro data. The common theme of all chapters is that households may save out of precaution to self-insure against labor income risks. Increasing with the chapter number, more complex tax and transfer systems, some of which provide additional insurance, are investigated.

After a general introduction in Chapter 1, Chapter 2[1] addresses questions of the empirical measurement of precautionary saving in the presence of other saving motives and does not focus on the tax and transfer system. The results show that empirical estimates of significant precautionary savings disappear once the heterogeneity between entrepreneurial and non-entrepreneurial households is accounted for, similar to the findings of Hurst et al. (2010) using data from the United States. The preferred specification cannot find significant estimates of precautionary savings for Germany after controlling for entrepreneurship.

One explanation for this finding might be that the difference in the saving behavior of entrepreneurial versus non-entrepreneurial households may be particularly pronounced in countries with an extensive social security system, such as Germany, where employees receive statutory pension insurance, but entrepreneurs have to save individually for their old age consumption. Extra savings by entrepreneurs likely reflect their exclusion from the social security system. Pooling household types without controlling for entrepreneurship, therefore, misleadingly connects the higher savings of entrepreneurs to their higher income risk and leads to an upward bias in estimates of precautionary savings.

[1]This chapter is the result of a collaboration with Frank Fossen.

Prior studies that estimated precautionary savings in Germany, particularly Fuchs-Schündeln and Schündeln (2005) and Bartzsch (2008), have analyzed the effect of income risk on certain components of wealth, such as net financial wealth. They interpreted their results as evidence of precautionary savings, but even though their results can be replicated, we demonstrate the lack of significant effects of income risk on total net worth. We acknowledge that higher income risk is associated with a portfolio shift from less liquid toward more liquid assets, but argue that this is not necessarily evidence for precautionary saving but rather reflects portfolio adjustments due to other reasons.

Methodologically, the main innovation of our study involves our recognition of entrepreneurship as being endogenous with wealth, in line with substantive literature on the credit constraints faced by nascent entrepreneurs. This study employs IV estimators and an endogenous switching regression model, which acknowledges that entrepreneurial and non-entrepreneurial households face different regimes, to deal with this endogeneity. Moreover, we account for self-selection of less risk-averse persons into occupations with higher income risk by controlling for new and experimentally validated measures of individual risk attitudes, separately for each partner in couple households.

Estimates of precautionary savings are important for policy design, especially for labor market, social insurance, and taxation policies, which directly affect the variance in households' net income.

Chapter 3[2] presents a test of Ricardian Equivalence in an environment where taxes and transfers are lump sum.

Our first main finding is that Ricardian Equivalence does not hold generally. A non-parametric analysis shows that deviations from optimal consumption as well as utility loss appear to be larger with the tax scheme that increases the difficulty to smooth consumption compared to the one that decreases difficulty to smooth consumption. Overall, deviations from optimal behavior are lowest in the treatment with constant

[2]This chapter is joint work with Thomas Meissner.

taxation. This implies that both difficulty and Ricardian taxation affect consumption behavior.

Our second main result from panel data estimations is that Ricardian taxation has a significant and strong effect on consumption in our sample. A tax benefit in early periods increases consumption by about 17 percent of the tax benefit on average, while a tax increase causes a reduction by 22 percent of the tax increase.

Our third main result is that the behavior of a significant portion of our subjects can be classified as inconsistent with the Ricardian Equivalence proposition. A conservative estimation suggests that this portion is about 62 percent.

The forth main result is that subject react to tax cuts even after 8 rounds of repetition of the experiment, suggesting that the learning behavior observed is not sufficient to accept Ricardian Equivalence.

Chapter 4[3] introduces a stylized progressive tax and transfer system to focus on the effects of progressivity on precautionary saving. We estimate idiosyncratic labor income risk profiles over the life cycle for heterogeneous household groups. Using an incomplete-markets life cycle model calibrated with the preference estimates, we show that progressive taxation reduces average savings by about 24.6 percent for a household with median wealth, compared to a hypothetical revenue-neutral flat tax that is directly comparable to previous literature that abstracted from social insurance.

In our simulated economy 60 percent of permanent shocks and 30 percent of transitory shocks to pre-government labor income are insured against under progressive taxation; in contrast, only 30 percent of permanent shocks and 70 percent of transitory shocks are insured against in an economy with a revenue-neutral flat tax. This underlines the importance to allow for social insurance when studying consumption/saving behavior for countries with progressive tax and transfer systems.

Though the hypothetical reform is intended to bridge the gap to the previous literature, there are some actual reform proposals advocating less progressive tax and transfer systems like Kirchhof's "flat tax" proposal for Germany. Our welfare analysis

[3] Jiaxiong Yao is coauthor of this chapter.

shows sizable welfare gains on average with progressive taxation with considerable heterogeneity among different subgroups. Therefore, we urge reform proposals that reduce social insurance to explicitly evaluate the consequences on saving behavior.

Finally, Chapter 5[4] implements important parts of the German tax and transfer law in the budget constraint explicitly to evaluate the effect of a reform of means-tested benefits on precautionary saving.

Three changes influenced precautonary saving due to the reform. A higher level of income uncertainty increased the precautionary motive. The replacement of *uncertain* unemployment assistance by *certain* lump sum transfers reduced precautionary saving. Moreover, higher transfer before the reform caused precautionary savings to decrease after the reform. Finally, a tighter means-test causes has ambiguous effects on precautionary saving depending on lifetime income.

The main finding of the chapter is that the short-term effects of the reform on median precautionary savings were small but negative. Short-term effects on the share of precautionary saving were negative as well and decreasing with age. After 5 and 10 years, the reduction of the share of precautionary saving was smaller at most ages both 5 and 10 years after the reform.

A welfare analysis shows that most households embraced the reform. Only the household at the 90th percentile of life-time income required a compensation of 0.4 percent of life-time income to be indifferent. This is mainly due to the replacement of uncertain unemployment assistance by a certain lump sum and to the fact that the consumption floor was raised for many households by the reform. Since higher transactions costs, increased perceived stigma attached to transfer dependence, and more rigorous threat of benefit cuts are not included in the model, the welfare effects do not measure disutility due to these factors which were arguably important in practice.

Finally, the model predictive power is assessed by comparing not targeted statistics, namely the share of transfer recipients, and the share of low wealth households. The model simulations perform well in predicting these statistics. Implementation of

[4] This chapter is single-authored.

important factors for household decision making in future research may improve predictive power.

6.2. Outlook

This thesis extends previous studies that focus on saving as the only way to self-insure against risks from labor income by studying precautionary behavior and its interaction with the risk sharing effects of tax and transfer systems. Still, there are other potentially important insurance mechanisms left to study in future research.

One particularly interesting extension is to model labor supply choices explicitly (Blundell et al. (2008); Flodén (2006)). Then, households may be insured against labor income risks in four ways: by building a buffer stock of wealth by cutting consumption, i.e. by precautionary saving. By the presence of a progressive tax and transfer system. By increasing labor supply at the extensive margin, i.e. a currently unemployed household member takes up a job, and at the intensive margin, i.e. precautionary labor supply.

Precautionary labor supply is a natural extension based on an analogy of precautionary saving when workers are prudent with respect to leisure. This literature is an explanation for the puzzle why some part of the population facing higher uncertainty from labor income tends to provide more hours of work, even if wages are lower compared to similar households facing less uncertainty. Parker et al. (2005) provides evidence of precisely this pattern by comparing self-employed to non-self-employed and Flodén (2006) shows how this may be explained by a precautionary labor supply motive. Still, further research is necessary to understand how important this insurance mechanism is compared to other mechanisms. One step in this direction is to investigate empirically how prudent workers are (with respect to leisure). This question is addressed in companion papers to this dissertation (Rostam-Afschar and Yao (2015); Jessen and Rostam-Afschar (2015)).

Beyond labor supply, fertility decisions are neglected in many models of life cycle decision making. Though children might not primarily serve as a insurance device against risks from labor income in developed economies, they might act as help for old age care. Furthermore, expenditures on children might be postponed to facilitate the choice of precautionary savings, while labor income risks are high (Sommer (2012)). Therefore, an interesting further extension would be to study how labor income uncertainty relates to fertility decisions. Some efforts in this direction are addressed in a companion paper to this dissertation (Rostam-Afschar and Schmitz (2015)).

Moreover, a promising research agenda is to study other sources of uncertainty and interactions between different sources of uncertainty. First, to separately measure wage uncertainty of spouses and its correlation is difficult but promising. The results from such a research program could sharpen the understanding of how insurance against risks works in the household context and provide important insights for the design of tax and transfer systems. Second, other sources of uncertainty like rate of return risk and shocks to wealth might interact with labor income risks, for example during or after a financial crisis. Extensions taking this into account could be helpful for the design of stabilization policies like short-time working.

Current models are relying on rationally optimizing households who form expectations according to expected utility theory. Introducing heuristic decision making like behavior that follows from a rule of thumb might improve the accuracy of model predictions. With the methods used in this thesis it is straightforward to estimate the share of households who choose consumption expenditures to be a constant fraction of their net income in survey data. This estimate could be used to quantify reactions to tax cuts.

In addition, the assumption of time separable instantaneous utility is subject to a very active literature. Non-separability between leisure and consumption choice as well as habit formation have turned out to be important. The dual nature of owner-occupied housing that is a consumption good and a vehicle to shift wealth between periods requires special treatment.

Finally, exercises in optimal taxation may result in important insights on how to improve the status quo of tax and transfer systems. The mechanics studied in this thesis, show how the level of inequality of consumption, income and wealth is changed by the tax and transfer system and may thus prove valuable to evaluate future reforms.

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ABSTRACT

Each of the four chapters of this dissertation are devoted to a specific question of consumption/saving behavior under labor income risk using evidence from micro data. In particular, I study questions regarding the measurement of precautionary saving from survey data, and analyze effects of tax and transfer systems—increasing in complexity with each chapter—on saving behavior.

Following a general introduction in Chapter 1, Chapter 2 (co-authored with Frank Fossen) shows that precautionary savings were overestimated because the previous literature failed to separate the precautionary motive from the entrepreneurial motive to save. Therefore, once entrepreneurs are excluded from the estimation sample and the estimation is repeated for employees, the large estimates of precautionary savings reported in prior studies disappear.

We argue that entrepreneurial status is endogenous with respect to wealth. Wealthy households are more likely to engage in entrepreneurship than low wealth households because of tighter borrowing constraints. At the same time entrepreneurs hold more wealth due to the business saving motive.

In light of these results, we discuss and compare three ways to avoid biased estimates: to use a dummy variable for entrepreneurs; to exclude entrepreneurial households from the sample; to use a measure of wealth that does not include business equity. Moreover, we apply instrumental variable estimators and an endogenous switching regression model.

Further, we find that while total wealth remains unchanged, higher uncertainty is related to shifts to more liquid wealth. It is not obvious that this is due to the precautionary saving motive. This relation might simply reflect portfolio shifts resulting for example from higher rates of return that households with higher income uncertainty enjoy.

Chapter 3 (joint work with Thomas Meissner) presents a test of Ricardian Equivalence in an environment where taxes and transfers are lump sum in a laboratory experiment.

We extend a dynamic stochastic optimization model of consumption/saving behavior by lump sum taxation and induce CARA preferences to solve for the linear optimal consumption function.

The design of our experiment is novel in that we take into account that the perceived difficulty to smooth consumption over the life cycle may confound a test of Ricardian Equivalence. Therefore, we introduce two different taxing schemes, one that increases the difficulty to smooth consumption and one that decreases it relative to a control treatment where taxes are constant. A comparison of the treatment groups allows us to distinguish the effects of difficulty and Ricardian taxation separately.

In this setting, we find that Ricardian taxation does influence consumption decisions. Using nonparametric and panel data methods, we show that both difficulty and taxation affect consumption behavior. In our experiment, these effects are economically and statistically relevant. For instance, about 17% of a tax cut translate into consumption changes, suggesting that reforms involving tax cuts would affect consumption outside the laboratory as well. This finding does not mean that Ricardian Equivalence is rejected for the entire sample. We cannot reject behavior in accordance to Ricardian Equivalence for more than one third of our subjects.

Finally, we show that subjects do not learn to behave according to Ricardian Equivalence. Even after eight repetitions of the experiment, effect of tax cuts are still substantial.

Chapter 4 (collaboration with Jiaxiong Yao) is devoted to measure precautionary savings using its theoretical definition and to study how saving behavior changes in response to changes of the progressivity of the tax and transfer system.

We find that progressive taxation resembling the German tax and transfer system crowds out 24.6% of wealth for a median household on average over the life cycle. Other studies that abstracted from social insurance thus overemphasize the role of precautionary saving. Importantly, the effect of progressive taxation on savings varies across households of different subgroups because it depends on the growth and the risk profiles of pre-government income. For instance, the share of savings crowded out by progressive taxation is only 19.1% for college graduates whereas it is 60.0% for blue collars.

Proposals advocating a reduction of progressivity or in the extreme case a flat tax, usually do not discuss social insurance. We show that this is an important omission, since under progressive taxation more insurance is provided than under a revenue-neutral flat tax for all the subgroups we consider. For the total sample, our simulated economy shows that approximately 60% of permanent shocks and 90% of transitory shocks to pre-government labor income are insured against under progressive taxation. In comparison, only 30% of permanent shocks and 70% of transitory shocks are insured against in an economy with a revenue-neutral flat tax. We underline the importance to recognize the tension between social insurance provided by progressive taxation and self-insurance in the form of wealth accumulation. Our results suggest that despite the reduced incentive to do self-insurance in an economy with progressive taxation, households are still better insured against pre-government income shocks.

Further, we find considerable heterogeneity in welfare gains for different subgroups when comparing the equivalent income under progressive taxation to that under revenue-neutral flat tax. For instance, whereas blue collars need to be compensated with 16.5% of equivalent income under progressive taxation to be indifferent under revenue-neutral flat taxation, college graduates would ask for 0.1% more equivalent income under progressive taxation to be indifferent. The results highlight the importance to discuss policy implications of progressive taxation for different subgroups separately.

Chapter 5 (single-authored) implements important parts of the German tax and transfer law in the budget constraint explicitly to evaluate the effect of a reform of means-tested benefits in Germany on precautionary saving.

Three channels through which the reform, known as "Hartz IV", may have influenced precautionary saving behavior: first, the reform increased the general level of income uncertainty leading to more precautionary saving. On the other hand precautionary saving was reduced by the reform because unemployment assistance which was *uncertain* due to its determination by uncertain previous income was replaced by *certain* lump sum transfers. Overall, the change in uncertainty faced by households reduced precautionary saving if the latter effect outweighs the former. Second, higher (lower) transfer before the reform leads to more (less) precautionary saving after. Third, a tighter means-test causes less/more precautionary saving (depending on lifetime income).

Short-term effects of the reform on median precautionary savings were small and negative. Short-term effects on the share of precautionary saving were negative as well and decreasing with age. After 5 and 10 years, the reduction of the share of precautionary saving was smaller at most ages both 5 and 10 years after the reform.

A welfare analysis shows that most households embraced the reform. Only the household at the 90th percentile of life-time income required a compensation of 0.4 percent of life-time income to be indifferent. This is mainly due to the replacement of uncertain unemployment assistance by a certain lump sum and to the fact that the consumption floor was raised for many households by the reform. Since higher transactions costs, increased perceived stigma attached to transfer dependence, and more rigorous threat of benefit cuts are not included in the model, the welfare effects do not measure disutility due to these factors which were arguably important in practice.

Beyond this evaluation, this chapter tests how well the model captures important features of the data by comparing two statistics not targeted by the estimation procedure that are interesting in the context of the reform: the share of transfer recipients, and the share of low wealth households. The model simulations predict these statistics reasonably well.

Chapter 6 summarizes the main findings and conclusions, followed by a short outlook.

Zusammenfassung

Die vorliegende, kumulative Dissertation behandelt vier verschiedene Fragestellungen, die das Konsum- und Sparverhalten privater Haushalte, deren Arbeitseinkommen zufälligen Schwankungen unterliegt, betreffen. Im Einzelnen wurde die Messung von Vorsichtssparen in Befragungsdaten untersucht und Effekte von Steuer- und Transfersystemen — in mit der Kapitelnummer ansteigender Komplexität — auf das Konsum- und Sparverhalten analysiert.

Nach einer allgemeinen Einführung in Kapitel 1, wird im Kapitel 2 gezeigt, dass die Vorsichtsersparnis, der Teil der Ersparnis, den Haushalte zum Ausgleich von unvorhergesehenen Schwankungen im Einkommen zurücklegen, in Gleichungen zur Bestimmung von Vermögen überschätzt wurde. Dies ist darauf zurückzuführen, dass in der früheren Literatur das Vorsichtsmotiv nicht vom unternehmerischen Sparmotiv getrennt wurde. Die früheren Schätzungen hoher Vorsichtsersparnis verschwinden daher, sobald Unternehmer aus der Stichprobe entfernt werden und die Schätzung nur für abhängig Beschäftigte wiederholt wird.

Für die Verzerrung ist umgekehrte Kausalität in der Beziehung zwischen Vermögen und Unternehmertum ursächlich. Dieses Problem besteht darin, dass zum einen vermögendere Haushalte eine höhere Neigung zu unternehmerischer Tätigkeit haben als Haushalte mit geringerem Vermögen, da diese höheren Kreditbeschränkungen unterliegen. Zum anderen ist der Vermögensbestand von vermögenderen Haushalten durchschnittlich größer, da die Zahl der Unternehmer, die ein höheres Vermögen zur Durchführung unternehmerischer Tätigkeiten benötigen, in dieser Gruppe höher ist.

Im Licht dieser Ergebnisse, werden drei Ansätze verglichen, um Verzerrung von Schätzergebnissen zu vermeiden: Spezifikation einer Schätzgleichung, die einen binären Indikator unternehmerischer Tätigkeit beinhaltet, Ausschluss von Unternehmern von der Stichprobe und Ausschluss von Betriebsvermögen in der zu erklärenden Variablen.

Außerdem werden die Ergebnisse einer Instrumentvariablenschätzung und eines Regressionsmodells mit endogenem Regimewechsel diskutiert.

Des Weiteren, wird gezeigt, dass höhere Unsicherheit mit Verschiebungen zu liquideren Vermögensklassen verbunden ist, während das Gesamtvermögen bei höherer Unsicherheit unverändert bleibt. Hierbei wird herausgestellt, dass dieser Zusammenhang nicht notwendigerweise durch das Vorsichtsmotiv verursacht wird, sondern Portfolioverschiebungen aufgrund höherer Renditen, die mit höherer Einkommensunsicherheit einhergehen können, ursächlich sein könnten.

Dieses Kapitel entstand in Mitautorenschaft von Frank Fossen, dessen Anteil bei Konzeption, Durchführung und Berichtsabfassung jeweils bei 50% lag, und wurde in der Fachzeitschrift *Oxford Bulletin of Economics and Statistics* veröffentlicht.

Kapitel 3 beschreibt einen experimentellen Test Ricardianischer Äquivalenz, einer zentralen Verhaltensannahme intertemporaler Entscheidungsmodelle, die besagt, dass unter bestimmten Voraussetzungen kurzfristige Steuererleichterungen keine Auswirkungen auf Konsumentscheidungen haben sollten.

Dazu wird ein dynamisches, stochastisches, Optimierungsmodell zur Beschreibung von Konsum- und Sparentscheidungen unter Arbeitseinkommensunsicherheit um Pauschalbesteuerung erweitert. Präferenzen mit konstanter relativer Risikoaversion werden durch monetäre Anreize induziert und die optimale, lineare Konsumfunktion des erweiterten Modells analytisch ermittelt.

Das experimentelle Design ist insofern neuartig, als dass die von den Untersuchungsteilnehmern wahrgenommene Schwierigkeit, ihr Konsumniveau über einen experimentellen Lebenszyklus zu glätten, berücksichtigt wird. Der Versuchsaufbau besteht aus drei Besteuerungssystemen, von denen eines die Schwierigkeit, Konsum zu glätten, erhöht, und das andere diese Schwierigkeit reduziert im Vergleich zum dritten System, in dem der pauschale Steuerbetrag über den experimentellen Lebenszyklus konstant bleibt. Ein Vergleich des Verhaltens der Teilnehmer unter diesen drei Besteuerungssystemen ermöglicht es, die Effekte unterschiedlicher Konsumglättungsschwierigkeit von denen kurzfristiger Steuersenkungen zu unterscheiden.

Die Ergebnisse zeigen, dass sowohl kurzfristige Steuersenkungen als auch Unterschiede im Schwierigkeitsgrad Konsumentscheidungen beeinflussen. Mittels nichtparametrischer Methoden und Schätzverfahren für Längsschnittdaten wird gezeigt, dass diese Effekte im Experiment ökonomisch und statistisch relevant sind. Es lässt sich vermuten, dass eine Steuerreform, die Steuererleichterungen beinhaltet, das Konsumniveau auch außerhalb des Labors beeinflussen würde, da im Experiment etwa 17% einer Steuererleichterung konsumiert werden. Für etwa ein Drittel der Teilnehmer kann die Gültigkeit Ricardianischer Äquivalenz jedoch nicht abgelehnt werden.

Schließlich zeigen die Ergebnisse, dass Verhalten gemäß Ricardianischer Äquivalenz nicht erlernt wird. Nach acht Wiederholungen des Experiments, sind im Durchschnitt noch immer starke Reaktionen auf Steuererleichterungen zu beobachten.

Dieses Kapitel ist das Resultat einer Zusammenarbeit mit Thomas Meißner, dessen Anteil bei Konzeption, Durchführung und Berichtsabfassung jeweils bei 50% lag.

In Kapitel 4 wird ein im Vergleich zum vorigen Kapitel realistischeres Modell mit konstanter relativer Risikoaversion und konkaver Konsumfunktion spezifiziert, um zu untersuchen, wie das Sparverhalten durch Variationen der Progressivität eines stilisierten Steuer- und Transfersystems beeinflusst wird. Ein progressives Steuer- und Transfersystem unterscheidet sich von einer Pauschalbesteuerung und einer Proportionalbesteuerung durch den sozialen Versicherungseffekt. Dies bedeutet, dass ein Teil unerwarteter Einkommensschwankungen durch das Steuer- und Transfersystem absorbiert wird.

Im Vergleich mit einem hypothetischen Szenario einer aufkommensneutralen Proportionalbesteuerung, verdrängt ein an das deutsche, progressive Steuer- und Transfersystem angelehntes Steuersystem im Durchschnitt 24,6% des Vermögens eines mittleren Haushalts über den Lebenszyklus. In Abhängigkeit von Bruttoarbeitseinkommenswachstum und Risikopräferenzen, ergeben sich unterschiedlich starke Effekte für verschiedene Teilstichproben. Beispielsweise, beträgt der Anteil der Vermögensverdrängung nur 19,1% bei Universitätsabsolventen und 60,0% bei Arbeitern, die körperlich beanspruchende Tätigkeiten ausüben.

Ferner weist die soziale Versicherung durch progressive Besteuerung in allen Teilstichproben einen höheren Grad an Versicherung auf als bei einer aufkommensneutralen Proportionalbesteuerung, die mit früherer Forschung, die soziale Versicherung nicht berücksichtigt, direkt vergleichbar ist. Daraus lässt sich schließen, dass diese Studien die Relevanz des Vorsichtssparens übergewichteten. Simulationsergebnisse zeigen, dass näherungsweise 60% permanenter Schocks wie unerwartete Beförderungen oder chronische Krankheiten und 90% transitorischer Schocks, z. B. vorübergehende Krankheit oder Wetterunbeständigkeit, die auf das Jahresbruttohaushaltseinkommen wirken, bei progressiver Besteuerung versichert sind. Im Vergleich dazu sind bei Proportionalbesteuerung nur etwa 30% permanenter Schocks und 70% transitorischer Schocks versichert. Dabei ist es wichtig, das Spannungsverhältnis zu beachten, das bei Progressivbesteuerung zwischen der Verminderung von Anreizen, sich durch Vorsichtssparen selbst zu versichern, und der Versicherung durch das Steuer- und Transfersystem besteht. Insgesamt gleichen sich diese Effekte nicht aus, sondern führen zu einer Erhöhung des Versicherungsschutzes unter progressiver Besteuerung. Daher müssen Reformvorschläge, die die soziale Versicherung reduzieren, wie beispielsweise Kirchhofs "Flat Tax"-Vorschlag, die Wirkung auf das Sparverhalten explizit zur Diskussion stellen.

Wohlfahrtsgewinne von Progressivbesteuerung weisen im Vergleich zu einer aufkommensneutralen Proportionalbesteuerung starke Unterschiede auf. Beispielsweise müssten Arbeiter, die körperlich beanspruchende Tätigkeiten ausüben, mit 16,5% ihres äquivalenten Lebenseinkommens unter Sicherheit kompensiert werden, um nach einer Reform, die die bestehende Progressivbesteuerung durch eine aufkommensneutrale Proportionalbesteuerung ersetzt, keinen Nutzenverlust zu erleiden. Universitätsabsolventen müssten dagegen nur mit 0,1% kompensiert werden. Die Ergebnisse zeigen die Wichtigkeit, Reformvorhaben für verschiedene Teilstichproben im Hinblick auf Alter, Risikopräferenz und erwartetes Lebenseinkommen einzeln zu analysieren.

Dieses Kapitel wurde zu gleichen Teilen von Jiaxiong Yao und dem Autor dieser Dissertation konzipiert. Methoden zur Ermittlung der Ergebnisse und die Berichtsabfassung wurden ebenfalls zu gleichen Teilen durchgeführt.

In Kapitel 5, das in Alleinautorenschaft konzipiert, durchgeführt und abgefasst wurde, werden die zentralen Bestandteile der Steuer- und Transfergesetzgebung explizit in die Budgetbeschränkung implementiert, um die Effekte einer Reform bedarfsgeprüfter Transfers ("Hartz IV") in Deutschland auf das Vorsichtssparverhalten zu evaluieren.

Drei Kanäle, über die diese Reform das Vorsichtssparen beeinflusst haben könnte, werden identifiziert. Zum einen war die Unsicherheit des Arbeitseinkommens im Zeitraum nach der Reform höher als vor der Reform, was das Vorsichtsmotiv verstärkte. Zum anderen wurde die Arbeitslosenhilfe, deren Höhe wegen der Bestimmung aus früherem, unsicherem Einkommen ebenfalls unsicher war, durch das pauschale Arbeitslosengeld II ersetzt, das nicht von Arbeitseinkommensfluktuationen abhängig und somit sicher war. Insgesamt führte die veränderte Unsicherheit im Nettoeinkommen zu einer Reduktion der Vorsichtsersparnis, falls letztgenannter Effekt überwiegt. Zweitens, bewirkt eine höhere (geringere) Transferleistung vor der Reform eine Erhöhung (Reduktion) der Vorsichtsersparnis nach der Reform. Drittens, kann eine restriktivere Vermögensanrechnung in Abhängigkeit vom erwarteten Lebenseinkommen zu einer Reduktion oder einer Erhöhung der Vorsichtsersparnis führen.

Die Ergebnisse zeigen, dass die kurzfristigen Effekte der Reform geringe, negative Wirkung auf die Höhe der Vorsichtsersparnis eines mittleren Haushaltes hatten. Die kurzfristigen Reformeffekte auf den Anteil der Vorsichtsersparnis an der

Gesamtersparnis waren ebenfalls gering, nahmen jedoch mit steigendem Alter zum Reformzeitpunkt ab. Nach fünf und zehn Jahren, fiel die Abnahme des Anteils der Vorsichtsersparnis geringer aus.

Die meisten Haushalte konnten durch die Reform Wohlfahrtsgewinne verzeichnen. Nur sehr wohlhabende Haushalte — etwa der Haushalt mit einem Lebenseinkommen, das dem 90 Prozentquantil entspricht — müssten kompensiert werden, um unter "Hartz IV" indifferent zur Arbeitslosenhilfe zu sein. Der Grund hierfür ist vor allem, dass die meisten Haushalte zum einen durch die Reform einen Nutzengewinn durch Sicherheit über die Höhe der Transferleistung erzielten und zum anderen von einem höheren Leistungsniveau profitierten. Im zugrundeliegenden Modell sind allerdings möglicherweise gestiegene Transaktionskosten und ein stärker empfundenes Stigma durch Transferbezug sowie eine strengere Androhung von Leistungskürzungen nicht berücksichtigt. Daher widersprechen die Ergebnisse der Rezeption dieser Reform, die in hitzigen Debatten eher auf Ablehnung gestoßen war.

Schließlich wird die Fähigkeit des Modells, zentrale Eckdaten zu prognostizieren, deren Abweichung vom Prognosewert nicht durch die Schätzprozedur minimiert wird, geprüft. Im Kontext dieser Studie sind zum einen der Anteil der Transferempfänger und zum anderen der Anteil der Haushalte einer Altersgruppe, deren Vermögen kleiner als ihr Jahresnettoeinkommen ist, interessante Eckwerte. Die Simulation prognostiziert diese Werte relativ gut.

Kapitel 6 fasst die zentralen Ergebnisse und Schlussfolgerungen zusammen und bietet einen kurzen Ausblick.

Davud Rostam-Afschar – Vita

For reasons of data protection, the curriculum vitae is not included in the online version.

Publications

Fossen, F. M., and D. Rostam-Afschar (2013): "Precautionary and Entrepreneurial Savings: New Evidence from German Households," *Oxford Bulletin of Economics and Statistics*, 75(4), 528–555.

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