Intertemporal and Intratemporal Household Consumption Allocation

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Empirical Analysis and Policy Reform Simulation based on German Microdata

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Thesis

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Contents

Preface

Motivation

Since 2000, an increasing inequality of incomes and wealth, as well as frequently appearing global macroeconomic turbulences have put no longer considered research questions back on the agenda.[1] In times of volatile financial markets and income and a growing inequality, questions about the welfare of people and of the economy gain importance. Volatility and a trend of increasing concentrations at the tails of the welfare distribution yielded a rethinking in economic research and fiscal policy. The theory of Keynes (1936) got a comeback as a guideline for stabilization policy in terms of the crisis. In micro analysis, welfare economists are searching for new ways to define true economic wealth and to measure the wealth of people and distributional analyses as well as economically efficient and sophisticated methods of redistribution are of interest among economists. Furthermore, increased public debt and deficits due to the financial crisis in 2008 and the lasting Euro crisis force governments in Europe and the United States to increase the public revenue.

The thesis at hand focuses on several issues regarding the consumption behavior of private households. The contributions of this dissertation have micro- and macroeconomic perspectives and implications relating to intertemporal consumption and the taxation of consumption goods.

Due to increased public debt and deficits, the value-added tax (VAT) is seen as a cost-efficient instrument to raise the public revenue (see e.g. Alt, 1983) and there is a shift in the relevance for the public budget from income taxation toward this tax over the last decades in Germany. Though, recent studies on the tax incidence of the VAT find a regressive distributional effect, which means that the poorest individuals face the highest relative tax burden compared to their net income (see e.g. Ochmann, Bach, and Beznoska, 2012). Besides the value-added tax, there are other commodity taxes that became popular in the last years, for instance taxes on polluting goods in the course of a rising environmental awareness in the

[1] See for the evolution of income concentration Bach, Corneo, and Steiner (2009), and for an estimated wealth distribution Bach, Beznoska, and Steiner (2013), which both studies consider the case of Germany.

population. However, there is little empirical evidence so far, especially for Germany, on the allocational and distributional effects of these taxes.

Since 2008, the macro policy was given more priority in the public discussion and among governments in the U.S. and Europe. The global recession caused by the subprime mortgage crisis called for instruments that stabilize the economy. Keynesian economists proposed to increase public spending in the form of investments and income transfers to households that suffered in the course of the crisis by losing their jobs or their houses. The issuing banks all around the world lowered their interest rates dramatically to push consumption, credits and investments. In Germany, the Grand Coalition introduced the "Growth Package", which was a bundle of policies that should keep up consumption and investments and lower the labor costs. Policy instruments were e.g. a temporary subsidy on new car buys and a temporary subsidy on short-time work. Besides these instruments, the automatic stabilizers, like the unemployment insurance, worked against the crisis by lowering the drops in income of private households.

Economists have been arguing for a long time about how individuals allocate their resources over the lifetime or which causalities determine intertemporal consumption. After the "Great Depression", Keynes (1936) argued that the current income is the best predictor of consumption. Individuals react sensitively in the short-run to changes in their current economic position and adjust their consumption. This conclusion and Keynes' implications for fiscal and monetary policy are widely accepted and implemented by governments especially in times of economic crisis. In 1950s, criticism on the "naive" view of the Keynesian economists arose. An alternative draft of the consumption model was developed, called the *Life Cycle-Permanent Income Hypothesis* (PIH), which refers to the work of Modigliani and Brumberg (1954) and Friedman (1957). This approach is based on the neoclassical micro-theory framework and assumes that agents have rational expectations on their lifetime income and wealth. Lifetime resources are allocated among all periods of the lifecycle according to the marginal utility of period consumption. Thereby, *permanent income* results as a long-term resource flow, which subsequently determines consumption in each period, following the theory. The major implication is that the current income is no longer important for consumption because it is just a fraction of the lifetime resources. Therefore, it also cannot hold as a proxy for welfare any more. Short-time fiscal spending in recessions should have no effect on consumption demand of private households, whereas tax cuts in the income taxation should have effects.

The thesis at hand wants to empirically test the validity of the PIH and parameterize a consumption function referring to the PIH. Additionally, the presence of liquidity constraints, which is suggested to be a reason for a possible failure of the PIH in reality, is investigated. The necessary condition for liquidity constraints is that agents do not hold enough liquid assets to keep up *permanent* consumption, which is determined by lifetime income. The sufficient condition is usually assumed fulfilled if agents are not able to borrow as desired at an interest rate that is in an acceptable range around the market lending rate or cannot allocate the amortization payments in the preferred periods.

Compared to the PIH model, the effects of short-term fiscal and monetary policy on private consumption are evaluated in a Keynesian consumption function. The research question is here, to which extent do private households adjust their consumption in response to shocks to current income, inflation and the interest rate. The latter gets high macro- and microeconomic explosiveness with respect to the economic consequences in times of low or negative real interest rates at the macro level, on the one hand, and, on the other hand, with respect to the policy fostered savings for retirement provision and home purchase savings from the micro perspective.

Another question, which is connected to the described dispute among macroeconomists about the relevance of current and lifetime income, is whether consumption or income is a good measure for true economic welfare. Since, most distributional studies use only cross-sectional data, which is a snap-shot at one point of time of the world they try to describe, it is important to define a welfare reference to measure e.g. the inequality of an economy (see e.g. Poterba, 1991; Caspersen and Metcalf, 1994, for a discussion). The distributional analysis has gained a lot of attention in the last years. Reforms of the taxes on income and consumption, as well as of the social transfer system are evaluated with regard to their distributional characteristics. Policies that may foster the inequality, which is already driven by the spread of the gross incomes, are likely to be politically controversial. So, this thesis also wants to focus on intratemporal issues of consumption, especially on the distributional characteristics of certain commodity taxes.

The taxation of consumption was intensified in Germany by the Grand Coalition, which increased the value-added tax rate from 16% to 19% in 2007. Earlier, the governing coalition of the Social Democratic Party and the Green Party forced a more intense taxation of polluting goods between the years 1998 and 2005. In the course of the green tax reform from 1998 to 2003 (*Ökosteuerreform*), a tax on electricity was introduced and the existing taxes on fossil fuels were increased. The taxes on gasoline and diesel were increased from 50 cents to 65 cents per liter for gasoline and for diesel from 32 cents to 47 cents. It is likely that the indirect taxation of energy and fuel will be extended in the next year due to the transition from fossil fuels and nuclear energy to renewable energy (*Energiewende*), which is already burdening the electricity price with a yearly adjusted levy for renewable energy.

The distributional and allocational effects of the taxation of energy goods and fuel are an upcoming topic, which is assumed to gain great relevance in the future. Besides the already discussed regressivity of indirect taxation, taxes on polluting goods could have a welfare improving character. Pigou (1920) argued that market prices do not incorporate the external costs of the consumption of these goods, e.g. the air pollution, and proposed to tax them and internalize these costs. Increasing the price for e.g. gasoline to the efficient optimum, in which all external costs are internalized would decrease the total amount of consumption of the good and reduce the emitted harmful substances that pollute the air in a way that the marginal utility of consumption equals the marginal costs (including the marginal polluting costs). In the case of gasoline other external effects like the costs of noise and congestion are also addressed by the tax. Another positive aspect of these so-called *green taxes* is that one might use the generated tax revenue from it and reduce taxes that distort the efficient allocation of the markets like the tax on labor. The double-dividend hypothesis of *green taxes* (see e.g. Lee and Misiolek, 1986) is often discussed in the literature and the taxes are widely seen as an efficient instrument to raise the fiscal budget.

Furthermore, substitution effects between the taxed energy commodities and other consumption goods have to be examined because they could be of great relevance for optimal taxation and welfare analysis. Especially the substitutional relationship to leisure demand is suggested to be important for the welfare analysis (see West and Williams, 2004a,b, 2005, 2007). The thesis at hand provides an empirical demand system that involves the demand for leisure and evaluates the cross-price relationships between fuel, heating energy and electricity as well as other non-durable consumption summarized in a composite good. The model is estimated with German household survey data and used to calculate demand and welfare effects of a hypothetical reform of the taxes on gasoline and diesel. The distributional results of the static tax simulation are then compared to the results that incorporate the behavioral effects predicted by the model.

Contributions

The contribution of this dissertation has macro- and microeconomic perspectives, both empirically analyzed with micro data. The first two chapters deal with the intertemporal allocation of consumption and the macroeconomic questions whether the current or the permanent income matters for consumption.

In the first chapter, a Keynesian consumption function is estimated using cross-sectional data on household consumption in Germany for the years 2002-2007 from the Continuous Household Budget Survey (*Laufende Wirtschaftsrechnungen*, LWR). The structural demand model framework of the Quadratic Almost Ideal Demand System (QUAIDS) (see Banks, Blundell, and Lewbel, 1997) is used to model the consumption-savings decision of the households with respect to the current income and the prices for current and future consumption, where the latter is the after-tax rate of return. An income tax module was therefore constructed to simulate differential taxation of labor income and income from the investment of capital. The estimates allow parameterizing the income elasticity as well as compensated and uncompensated elasticities with respect to inflation and the real after-tax rate of return. Including the real after-tax rate of return in micro data is challenging and only a few attempts have been made to estimate the interest rate elasticity of savings within this setting (see Attanasio and Weber, 2010, for a survey). The elasticities are evaluated at the mean and at certain quantiles of the consumption distribution using quantile regression technique to look at the distributional heterogeneity, especially against the backdrop of socially motivated policies that affect the net income and the after-tax rate of return.

The second chapter wants to answer the question whether the *Permanent Income Hypothesis* (PIH) holds and if not whether the presence of liquidity constraints could be an explanation for the failure. The hypothesis specifically predicts the effect of a non-anticipated shock to permanent income on consumption to be near one. Lifetime income is allocated to current and future consumption over the remaining periods, with respect to this new information. Consequently, in theory, a transitory shock has an influence near zero on consumption. The reason is that a positive transitory deviation from permanent income is saved nearly completely while a negative one is compensated by dissavings or taking-up a credit. The agent perceives the deviation and knows that its expected value will be zero over lifetime, and thus a transitory shock should have no relevant effect on consumption. Another aspect of the PIH, which has gained much attention in the literature, is the excess sensitivity of consumption to anticipated income changes (Flavin, 1981). Anticipated changes in income should have no effect at all on consumption because they are assumed to be already internalized. These hypotheses can be empirically tested in a dynamic consumption model. Using the same data set as in the first chapter, a pseudo panel is constructed on the repeated cross-sections and the consumption effects of income shocks in the context of liquidity constraints are investigated. For that purpose, a switching regression approach with unknown sample separation is used by applying an iterated two-step procedure with the EM algorithm (see Dempster, Laird, and Rubin, 1977) to identify the two regimes whether to be liquidity constrained or not. The marginal propensity to consume out of permanent and transitory income are evaluated for both regimes and finally compared to the income elasticity of the first chapter.

The third and last chapter shifts the focus from intertemporal consumption to the consumer demand of single commodities and the price and cross-price relationships within the consumption budget. Due to the increasing taxation of energy and fuel goods and their high prices, allocational and distributional issues regarding the private households become more important. Especially for Germany, there exist only few studies that analyze the demand of energy goods and none of them incorporate the cross-price relationships to leisure demand yet, which has been emphasized as highly relevant for welfare analysis in studies for the U.S. (see West and Williams, 2004a,b, 2005, 2007). In the third chapter, an Almost Ideal Demand System (AIDS, see Deaton and Muellbauer, 1980a) is estimated to get own-price and cross-price effects of the consumer goods "Mobility", "Electricity", "Heating" and other non-durable goods, as well as of "Leisure". This approach allows calculating the compensated and uncompensated elasticities, which can then be used to simulate behavioral responses and welfare effects of price shifts. The demand system is estimated with pooled German micro data from three survey years of the EVS (Income and Consumption Survey for Germany, *Einkommens- und Verbrauchsstichprobe*). The structural approach applied in this chapter allows for leisure responses at the *intensive* as well as at the *extensive* margin, where reactions at the *extensive* margin refer to changes in labor market participation (or at the macro level in the number of working persons), while changes at the *intensive* margin refer to changes in the average number of hours worked for the working population (see e.g. Blundell, Bozio, and Laroque, 2011). The estimates of the Almost Ideal Demand System referring to leisure demand or accordingly to labor supply are interpreted as elasticities at the *intensive* margin, while the *extensive* labor market participation elasticities are estimated in a preceding discrete choice model, which is then linked to the AIDS and used for selectivity correction. The elasticities of both margins are combined to get elasticities of total leisure demand, which are then used in the simulation and welfare analysis. There are deviations in the present approach compared to the West and Williams framework, where selection issues are also addressed but the distinction between *extensive* and *intensive* leisure demand is not handled explicitly.

Finally, the static and behavioral effects of a potential reform of the existing tax on gasoline and diesel consumption are simulated and then used for a distributional and welfare analysis.

Chapter 1

The Consumption-Savings Decision in the Short-Run[‡]

1.1 Introduction

According to the *Life Cycle-Permanent Income Hypothesis* of Modigliani and Brumberg (1954) and Friedman (1957), the lifetime income of an individual should determine his periodical consumption. Therefore consumption is smoothed over the life-cycle depending on the expected lifetime income to equalize the marginal utility of consumption over the periods. So, the economic decision whether to consume current or acquired past income (wealth) now or to shift consumption to the future should not be affected by changes in the current income, because these changes are normally transitory and thus small compared to the lifetime income. However, the assumptions of the *Life Cycle-Permanent Income Hypothesis* are crucial when it comes to reality. Firstly, it is hard to identify if a change in current income is really transitory or if there is path dependency and a lasting effect on permanent income. This case occurs e.g. if unemployment, which is initially expected to be a short phase results in a serious slump in the career. Secondly, if it is a true transitory shock of income and we do observe reactions to consumption, there seem to be other determinants that influence the allocation between current and future consumption. The literature lists a lot of factors that could explain these reactions which reject the *Life Cycle-Permanent Income Hypothesis* (see e.g. Shea, 1995a). The presence of liquidity constraints is listed as one important factor that increases the importance of current disposable income (Chapter 2 will address this topic). Myopic acting individuals and increasing volatility on labor and capital markets could even

[‡]This chapter is based on joint work with Richard Ochmann from DIW Berlin, see Beznoska and Ochmann (2012a) or in an earlier version Beznoska and Ochmann (2010).

enforce this point. Finally, fiscal policy controls the after-tax parameter of income and interest rates and thus has an impact on the consumption-savings decision. Especially policy makers are often not interested in the rather abstract long-run effects of their politics, because their is justifiable scepticism about relevance of the long-run in practice since Keynes (1936).

So, this chapter wants to rise the question how the current disposable income and volatility in the after-tax rate of return affect consumption behavior in the short-run accounting for differences over the consumption distribution of households. Importantly, the current disposable income is used to estimate the income effect on consumption but the main point of interest will be the effect of the after-tax rate of return on consumption. Note that although the setting will be a short-run one, the theoretical effect of the interest rate also appears in the long-run because theory predicts the after-tax rate of return to determine the consumption plan of a household by shifting the intertemporal prices and thus the attractiveness of consumption between the time periods.

The change in household savings, which are nothing else than postponed consumption, with respect to a shift in the after-tax rate of return, as well as in the current or future consumer prices, is theoretically undetermined. On the one hand, a price effect shifts the relative returns of current and future consumption, and on the other hand, an income effect alters the disposable budget. While the substitution effect of an interest rate change on savings should be positive, the income effect has the opposite sign, such that the total effect is ambiguous.[1] The sign and the size of the interest rate elasticity of savings are of great relevance for social and tax policies concerned with fostering private savings or with taxation of capital returns. Public subsidization of household savings, which increases the relative returns to savings, for example in the form of improved tax deductibility or exemption of savings for old-age provision with the goal of increasing the private contribution for retirement consumption, may in total well have a zero effect, or even a negative effect, on the amount of savings. In this chapter, an empirical analysis of the interest rate and income elasticities of current and future household consumption is provided. Applying a structural QUAIDS demand model for intertemporal consumption allocation allows for an analysis with household survey data on consumption for Germany.

A structural demand model is a non-standard framework for the intertemporal consumption allocation decision. Since the seminal work by Hall (1978), a vast literature empirically investigates either the interest rate elasticity of savings in aggregate consumption functions,

[1] Sandmo (1985) provides a survey on general theoretical implications of taxation effects on savings, while both Boadway and Wildasin (1994) and Bernheim (2002) provide surveys on the empirical literature in this field. For a survey on the effects of interest rate changes on the consumption-savings decision in various model frameworks, see Elmendorf (1996). Elmendorf (1996) also argues for an additional relevant effect of interest rate changes on the stock of wealth.

or structural preference parameters, as the intertemporal elasticity of substitution, in Euler equations, see Muellbauer and Lattimore (1995) for a survey. This approach allows modeling of long-term dynamics in intertemporal consumption. It is usually applied to macro data, or – if available – to panel data on household consumption over a long period of time (Attanasio and Weber, 2010). However, as consumption panel data from official statistics is not available for Germany and the Euler equation approach does not apply well if the focus is on evaluation of tax reforms and immediate effects on household consumption behavior induced by changes in after-tax asset returns and income, it is not the convenient model here (see Carroll, 2001).[2] This is because the predicted reaction of household savings to policies, regarding the interest rate, relies strongly on further assumptions about the underlying model (Bernheim, 2002). Moreover, approaches with time-series data often suffer from potential identification problems if changes in the interest rate are themselves determined by agents' consumption decisions (Gruber, 2006).

Only a few attempts have been made with micro data to estimate the interest rate elasticity of savings (see Attanasio and Weber, 2010, for a survey). Blundell, Browning, and Meghir (1994) estimate an Euler equation using micro data from the Family Expenditure Survey for the UK, based on a preference structure that they derive from demand system estimation. There is some evidence for non-durable consumption with data from the Family Expenditure Survey for the UK (Attanasio and Browning, 1995) and with data from the Consumer Expenditure Survey for the US (Attanasio and Weber, 1995), where variation in the interest rate is restricted to time series data, however. For Germany, there is not much evidence on the interest rate elasticity of household savings at all. In particular, there exists – to my knowledge – no empirical application of a structural intertemporal consumption model to micro data for Germany that estimates the interest rate elasticity of savings.[3]

In general, estimation of the interest elasticity using micro data can be empirically challenging. Limited cross-sectional variation in the pre-tax interest rate and the consumption price, at the household level, makes the identification of price effects on the savings decision difficult. In order to better identify price effects, additional price variation at the household level through differential taxation of capital income is usually exploited in the literature (e.g. Shea, 1995b). Cross-sectional variation in after-tax rates of returns results from variation in households' income and portfolio structure and thus in marginal tax rates (e.g. Feldstein, 1976, in the context of portfolio choice). Simulation of tax rates secures that variation in after-tax

[2] Carroll (2001) provides evidence that standard (first and second order) approximations of consumption Euler equations perform very poorly in identifying structural preference parameters and in testing for excess sensitivity of consumption.

[3] Lang (1998) applies a demand system in the framework of a two-stage budgeting model to the consumption-savings decision. However, he does not give a structural interpretation in terms of the interest rate elasticity of savings, but rather models the interest rate as a control variable.

returns is exogenous to the savings decision (e.g. Gruber, 2006). In case the data spans a time frame overlapping with a major tax reform, variation in after-tax returns over time can be used in addition (e.g. Ochmann, 2010a).[4]

In this chapter, a two-period model analysis is provided for estimating income and intertemporal substitution effects that are related to relative shifts in consumer prices and after-tax rates of return. This approach allows to infer directly (uncompensated and compensated) own-price and cross-price elasticities from the two-period neoclassical consumption model, which is relevant for welfare analyses. Additionally, there may be differences in the MPC out of current disposable income between poor and rich households because the empirical literature finds a regressive consumption to savings ratio (e.g. Caspersen and Metcalf, 1994).[5] To cover up these differences in the income effect across the consumption distribution, quantile regressions are added. The model is estimated with official cross-sectional data on household consumption in Germany for the years 2002-2007 (LWR data). This is the only micro data on household consumption for Germany that comprises detailed information on income, consumption, and savings over a time frame of six consecutive years. This detailed structure allows us to exploit exogenous household-level variation in after-tax returns to savings through differential taxation of capital income. In addition, changes in tax rules over time resulting from a major tax reform in Germany between 2000 and 2005 are used. This heterogeneity in the tax schedule is exploited, in addition to variation in the interest rate and in consumer prices over time, to construct individual after-tax rates of return and cluster-specific consumption prices. Marginal tax rates are simulated in an income taxation module. And it is also accounted for an appropriate treatment of durable goods by applying user costs.

The results indicate that savings are a superior good, while consumption is an inferior good. The compensated own-price elasticities for savings as well as consumption are found significantly negative, while the theoretical model implications of homogeneity and symmetry must be rejected. The interest rate effect is estimated robustly in varying specifications. Importantly, the uncompensated interest rate elasticity of savings is estimated to slightly below, but not significantly different from zero. Households do not adjust their level of compound savings to rate-of-return-related incentives. These findings are in line with results from other studies. While the literature is generally inconclusive with respect to the size and even the sign of the interest elasticity, most studies find elasticities not significantly different from zero.[6]

[4]Yet another approach evaluates specific tax reforms or subsidization programs and their effects on savings. For example, see Disney, Emmerson, and Wakefield (2010) for an evaluation of a new private pension arrangement in the UK. See Bernheim (2002) for a survey on this literature.

[5]See e.g. Caspersen and Metcalf (1994) for a discussion of the regressive tax burden of a value added tax and the differences between annual (current) measured income and lifetime income.

[6]See inter alia Makin and Couch (1989); Skinner and Feenberg (1989); Montgomery (2007). Some earlier studies find significantly positive uncompensated elasticities, in the range of 0.3 (Gylfason, 1981) to 0.4 (Boskin,

The quantile regressions show that the marginal income effect differs significantly across the consumption distribution. This leaves a positive uncompensated interest rate elasticity of savings for the ten percent quantile of consumption rate distribution, which means that only households with the lowest consumption to income ratio actually increase savings with increasing after-tax rates. Households with higher consumption rates do not react or even reduce savings due to the income effect.

It is concluded that policy reforms causing variation in the net rate of return, e.g. through a reduction of tax rates on capital income, a bonus on the interest rate of special savings products or an increase in the tax deductibility of savings for old age, are expected to have no significant effects on the level of compound consumption and savings. Increases in the current disposable income of households rise savings disproportionately high. In the next section, a model for the consumption-savings decision is presented. Section 1.3 deals with the estimation approach, and Section 1.4 presents the data set and descriptive statistics on consumption. In Section 1.5, the results are discussed, with Section 1.6 concluding.

1.2 The Model

It is assumed that the household's budget is allocated between two periods, where the second period can be interpreted as an approximation for all future periods. Another interpretation of this set up is that every period a given budget is allocated discretely to *immediate* consumption and *future* consumption. Assuming that current income may have a stronger influence in the short-term consumption-savings decision than the life-cycle/permanent income hypothesis predicts, a savings function is modeled in the Keynesian style that additionally allows for shifting between current and future consumption as an immediate reaction to changes in the consumption price and the real after-tax rate of return.[7] This assumption implies that transitory and permanent income shifts affect the consumption-savings decision in the same way, i.e. the same marginal effect.[8]

1978). Some studies even find evidence for a slightly negative interest elasticity of savings (Evans, 1983; Friend and Hasbrouck, 1983; Hall, 1988). A survey can be found in Smith (1990). Summers (1984) finds variation between effects of permanent and transitory interest rate shifts on savings.

[7] In the classical Keynesian framework, savings only depend on *current* income. The literature motivates the relevance of current income with either liquidity constraints, or myopia, or savings for precautionary motives. See Browning and Lusardi (1996) for a survey about relevant savings motives.

[8] In Beznoska and Ochmann (2010), we extend the model by permanent income and transitory income uncertainty and find evidence that the effects of permanent income and current income do not differ significantly, while effects of transitory income uncertainty do matter additionally.

1.2.1 Consumption and Savings in a Demand Context

The consumption-savings decision is embedded in a structural demand system for a two-period model, i.e. an Almost Ideal Demand System (AIDS) (Deaton and Muellbauer, 1980a), which is flexible concerning the factors of influence. The AIDS is based on price-independent generalized logarithmic (PIGLOG) preferences and Engel curves in the Working-Leser form, where budget shares are linear in the log-budget (see Working, 1943; Leser, 1963). It is applied here in an extended version, which allows for more flexible Engel curves, i.e. the Quadratic Almost Ideal Demand System (QUAIDS), where budget shares are modeled in a quadratic function of the log-budget (see Banks et al., 1997). Let $Q_{i,j}$ denote the demand of household i for good j in levels and $s_{i,j} = Q_{i,j} \cdot p_{i,j}/y_i$ the respective demand share from the budget. Then, demand for consumption and savings in this two-good QUAIDS is represented by the following system of $J = 2$ equations:

$$s_{i,j} \;=\; \alpha_{0j} \;+\; \beta_{1j}\, \ln(y_i/P_i^*) \;+\; \beta_{2j}\, \ln(y_i/P_i^*)^2 \;+\; \sum_{k\in\{s,c\}} \gamma_{jk}\, \ln(p_{i,k}) \tag{1.1}$$

for households $i = 1, ..., N$ and goods $j, k = c, s$, where c denotes consumption and s savings. y_i is household i's budget, $p_{i,k}$ is the price of good k for household i, and α_{0j} is a good-specific constant. β_{1j} and β_{2j} denote parameters of the budget effects of demand and γ_{jk} a parameter of the effect of relative price changes. $\ln(P_i^*)$ is the translog price index, which can generally be approximated by a linear price index, e.g. by the log-linear Laspeyres index ($\ln(P_i^*) = \sum_j \bar{s}_j \ln(p_{i,j})$), resulting in the linearized QUAIDS. This functional form implies an income elasticity for demand levels which is non-constant in the budget (see Banks et al., 1997). Omitting household indices for simplicity, the income elasticity corresponds to:

$$\eta_j \;\equiv\; \frac{\partial Q_j}{\partial y}\frac{y}{Q_j} = 1 \;+\; \left(\beta_{1j} + 2\beta_{2j}\ln(y/P^*)\right)/s_j \tag{1.2}$$

where Q_j is demand for good j in levels. The uncompensated price elasticity for the demand level of good j w.r.t. price of good k is:

$$\varepsilon^u_{jk} \;\equiv\; \frac{\partial Q_j}{\partial p_k}\frac{p_k}{Q_j} = \gamma_{jk}/s_j - \delta_{jk} - \left(\beta_{1j} + 2\beta_{2j}\ln(y/P^*)\right)\bar{s}_k/s_j \tag{1.3}$$

where $\bar{s}_k$ is the average share of good k and δ_{jk} is the Kronecker delta, i.e. $\delta_{jk} = 1$ if $j = k$ and $\delta_{jk} = 0$ if $j \neq k$. By the Slutsky equation, the compensated price elasticity follows as:

$$\varepsilon^c_{jk} \;\equiv\; \varepsilon^u_{jk} + s_k\eta_j \;=\; \gamma_{jk}/s_j - \delta_{jk} + s_k + \left(\beta_{1j} + 2\beta_{2j}\ln(y/P^*)\right)(s_k - \bar{s}_k)/s_j \tag{1.4}$$

The two-good consumption-savings demand model in Equation (1.1) then is linear in the budget parameters (linear Engel curves) and linear in the price parameters. It imposes the following *across*-equations constraints on the parameters: $\alpha_{0c} + \alpha_{0s} = 1$, $\beta_{1c} + \beta_{1s} = 0$, $\beta_{2c} + \beta_{2s} = 0$, and $\gamma_{ss} + \gamma_{cs} = 0$ as well as $\gamma_{cc} + \gamma_{sc} = 0$, where γ_{cs} is the coefficient on the savings price in the consumption equation and γ_{sc} the coefficient on the consumption price in the savings equation. These restrictions together imply adding-up of the budget shares to one for each household: $\widehat{s}_{i,c} + \widehat{s}_{i,s} = 1 \; \forall \, i = 1, ..., N$.[9] It follows in this two-good case that only one equation can be estimated. While adding-up is fulfilled by definition of the model, other properties of a consistent demand function that make the model consistent with demand theory can be imposed or tested for the QUAIDS: compensated own price elasticities shall be non-positive ($\varepsilon^c_{cc} \leq 0$, $\varepsilon^c_{ss} \leq 0$), the Slutsky-matrix is symmetric if the cross-price effects coincide, $\gamma_{cs} = \gamma_{sc}$, and compensated demand is homogeneous of degree zero in prices if the *within*-equation constraints, $\gamma_{cc} + \gamma_{cs} = 0$ as well as $\gamma_{ss} + \gamma_{sc} = 0$, hold (see Deaton and Muellbauer, 1980b).

There are two prices in the two-good consumption-savings demand model: $\ln(p_c)$ and $\ln(p_s)$. For consumption, cluster-specific prices are constructed (see Lewbel, 1989), in order to exploit price variation between households within a time period. The aggregate Consumer Price Index for the commodity groups is weighted by cluster-specific expenditure shares:

$$\ln(p_{lc}) = \sum_{g}^{G} w_{lg} \ln(p_g), \quad \forall \, l = 1, ..., L \tag{1.5}$$

where p_g is the Consumer Price Index for commodity group g and w_{lg} is the budget share of commodity group g in cluster l.[10]

The savings price is the price for substituting immediate consumption for future consumption. It is modeled as a function of the expected level of future prices and a household-specific discount rate.[11] The latter shall be a function of the household-specific real net return to savings,[12] which is approximated by average real gross returns and the household's marginal tax rate on capital income, both differentiated by three types of assets and weighted by the household's structure of capital income: $r^n_i = \sum_a^A w_{ia} r^g_a (1 - t_{ia})$, where w_{ia} is household i's

[9] Adding-up of the predicted shares can not be tested, though, given adding-up of observed shares by construction (see Deaton and Muellbauer, 1980a, p. 316).

[10] Clusters are constructed by household income, age of household head, and household composition. There follow $L = 252$ clusters. In order to control for resulting cluster effects, p_{lc} is regressed on cluster dummies and the residuals are then applied in the demand model.

[11] See Virén (1984) for empirical evidence on the relevance of anticipated inflation in the household savings function.

[12] Grimes, Wong, and Meads (1994) argue that the specification of the financial portfolio share model that is consistent with the AIDS is a function of the *real* interest rate, as also the budget is denoted in real terms.

share of capital income from asset a, r_a^g is the average gross return to assets of type a, and t_{ia} is household i's marginal tax rate on income from asset a (also see Section 1.4).[13] For the expected level of future prices in period t, an autoregressive-moving-average process in first differences (ARIMA(1,1,1)) is estimated, as proposed in Feige and Pearce (1976), on the cross-sectional averaged consumption prices.[14]

$$\Delta \ln(p_t) \;=\; \ln(p_t) - \ln(p_{t-1}) \;=\; \rho\,(\ln(p_{t-1}) - \ln(p_{t-2})) + \varepsilon_t + \phi\,\varepsilon_{t-1} \tag{1.6}$$

where $\ln(p_t)$ is the cross-sectional average consumption price at time t. The expected level of future prices then consists of the current consumption price level $\ln(p_{lc})$, as defined in Eq. (1.5), and the expected inflation $\widehat{\pi}_t^e = \Delta\,\widehat{\ln(p_t)}$ which is the one-period-ahead prediction of the ARIMA process. An expectation error term u_i is added to it which should account for the uncertainty about the assumed household's expectation process by increasing its variation.[15] The household-specific price of savings in logs corresponds to:

$$\ln(p_{is}) \;=\; \ln\left(\frac{p_{ic}^e}{\left(1+\sum_a^A w_{ia} r_a^g (1-t_{ia})\right)}\right) \;=\; \ln\left(\frac{p_{ic}^e}{(1+r_i^n)}\right) \tag{1.7}$$

where

$$\ln(p_{ic}^e) \;=\; \ln(p_{lc}) + \widehat{\pi}_t^e + u_i \tag{1.8}$$

is the level of the future consumption price for household i in cluster l at time t and $\ln(p_{lc})$ refers to Eq. (1.5). It follows from Eq. (1.7), that the price elasticity of e.g. savings w.r.t. $\ln(p_{is})$ can be equally interpreted as a percentage reaction to a one-percent increase in the expected consumption price as well as to a one-percent decline in the real net interest rate.[16] The aggregate price index, $\ln(P_i^*)$, is approximated by the log-linear Laspeyres index for the two goods: $\ln(P_i^*) = \bar{s}_c \ln(p_{lc}) + \bar{s}_s \ln(p_{is})$, where $\bar{s}_c$ denotes the average consumption ratio and $\bar{s}_s$ denotes the redundant savings ratio.

[13]For interest income, a time series of the return on medium-term deposits is applied. As a proxy for the return to stocks, the current yield to bonds is applied, and for housing assets, a rate of return to rental income is calculated. For households reporting zero capital income, the return on medium-term deposits is applied.

[14]Effectively, this is a time-series model for 24 quarterly price observations. The ARIMA(1,1,1) model is not differentiated by clusters; it is estimated with maximum likelihood.

[15]This expectation error term (u_i) is drawn from a log-normal distribution with zero mean and a standard deviation equal to that of the error terms from a regression of the true price level in $t+1$ on the predicted expected price level for $t+1$.

[16]The proof can be found in Appendix 1.9.

1.3 Empirical Strategy

Firstly, the definition of consumption and savings in the context of the demand model is explained. Then some estimation issues are addressed. The consumption equation will be estimated on six pooled repeated cross-sections from household consumption survey data for Germany, which will be presented in Section 1.4.

1.3.1 Definition of Consumption and Savings

In the introduced consumption-savings demand model, current disposable income is allocated to consumption and savings, where consumption is durable and non-durable consumption. In order to treat durable consumption consistently, user costs or service flows are applied and thus "effective" consumption is analyzed, as opposed to actual expenditures.[17] For *non*-durable consumption, expenditures and effective consumption coincide. However, expenditures for durable consumption goods are reallocated among households: those reporting a purchase have lower effective consumption than actual expenditures, while those not purchasing get a positive value imputed for effective consumption to account for the service flow of the good. Effective consumption then results from adding up non-durable expenditures and user costs for durable goods.[18]

Savings are defined residually from income and effective consumption. By the residual savings definition, the concept of *net* savings is implicitly followed. This concept allows for dissaving. Households that consume more than their income have negative net savings. They either take up a loan to finance spending or they liquidate their stock of wealth. As a result, net savings can be derived from the household balance sheet equivalently in two ways: either by 1) taking income minus effective consumption, or by 2) summing up expenditures for asset purchases, deducting revenue from asset sales, and adding the durable component of consumption that is not currently consumed in terms of user costs. Any net changes to the stock of assets resulting from 2), apart from mere asset substitution, either increase or decrease current consumption and thus at the same time affect savings in terms of 1).

This definition of savings focuses on the "active" savings behavior of households. It covers changes households actively undertake to their assets. It does not capture "passive" savings in terms of changes in wealth that result from shifts in asset prices.[19] In contrast, defining savings

[17] For a similar treatment of durable goods in aggregate consumption, see Slesnick (1992) or Christensen and Jorgenson (1969).

[18] For details on the calculation of user costs, see Appendix 1.7.2.

[19] One can think, for example, of asset holdings in stocks issued by a company. For this kind of asset, the effect is probably most relevant, as these assets are often subject to frequent changes in market value, which are typically related to changes in stock prices. Wealth holdings in these stocks that are evaluated by market values are directly affected by changes in stock prices. The latter leads to changes in wealth for the households

to equal changes in wealth would result in a different savings concept. The latter concept of savings is not applied as wealth is not observed in the data, and applying the imputations (see Appendix 1.7.4) as a left-hand side variable does not seem to allow for an appropriate econometric analysis. Instead, concept 1) is followed by substracting effective consumption from income to derive a measure for net savings.

If the only two possibilities to spend income are consumption and savings, the resulting consumption ratio defined by consumption related to income falls in the open interval $[0, \infty]$ while the redundant net savings ratio falls in the open interval $[-\infty, 1]$. Both ratios could be used as dependent variable in the estimated equation to attain the coefficients that are of interest.

1.3.2 Estimation

Observing the fact that a great number of households have a consumption ratio that falls in the part above the interval $[0, 1]$, for econometric concerns, the consumption-savings decision could be separated into the decision whether to hold the budget constraint at all given by current income (the alternative is dissaving) and the decision of what share of income to allocate to current consumption conditional on being within the budget constraint. However, no evidence of significant selection effects is found when estimating demand in a Tobit approach on all observations, where consumption ratios of one or bigger are treated as censored. The relevant marginal effects do not differ much from the OLS estimates on the non-censored observations, which is why the results are reported as a robustness check in Section 1.5. It is concluded that selection is of no relevance in the consumption-savings decision and thus reduce the estimation to the conditional decision of income allocation, whereby the estimation is restricted to households with a consumption ratio between $[0, 1[$ and apply OLS. As mentioned earlier, because of the adding-up implication of the two-good demand system in Eq. (1.1), only one equation can be estimated (either the consumption or the savings equation), and estimates for the second equation follow residually.[20] Thus a single equation for consumption demand

holding stocks. Such wealth changes can be interpreted as "passive" savings, as the households do not actively change their asset composition, and they are thus not captured by the savings concept applied here.

[20]Note that adding-up moreover implies that all elasticities, on both savings and consumption, can be calculated from the marginal effects for the estimated consumption equation.

is estimated on cross-sectional data:

$$
\begin{aligned}
s_{i,c} = \alpha_{0,c} + x_i'\beta + \beta_{1,c} \ln(y_i/P_i^*) + \sum_{h=1}^{H} \beta_{1(h),c} \ln(y_i/P_i^*) * hhcomp_h \\
+ \beta_{2,c} \ln(y_i/P_i^*)^2 + \sum_{h=1}^{H} \beta_{2(h),c} \ln(y_i/P_i^*)^2 * hhcomp_h \\
+ \gamma_{cs} \ln\left(\frac{p_{ic}^e}{(1+r_i^n)}\right) + \gamma_{cc} \ln(p_{lc}) + \xi_{i,c}, \quad s_{i,c} \in [0,1[\quad \forall\, i = 1, ..., N
\end{aligned}
\tag{1.9}
$$

where x_i denotes a $K \times 1$-vector of household-specific characteristics, the stock of net assets, and the level of debt. Interactions allow budget effects to vary with household composition.[21] The error-term $\xi_{i,c}$ is assumed to be independent, identically distributed, and also uncorrelated with the stochastic term in $\ln(p_{ic}^e)$ (see Eq. (1.8)).[22]

The stock of net assets as well as the level of debt are potentially endogenous in Eq. (1.9). As the stock of net assets was imputed by observed capital income flows (see Appendix 1.7), endogeneity should be less of a problem with the former if it is assumed that observed capital income relates to *past* savings decisions, but that it is unaffected by the current savings decision under consideration here. For the level of debt, which was imputed from current interest payments, an instrumental variables approach is applied, where the potentially endogenous level of debt is instrumented by the interest rate on debt and some of its polynomials in a Tobit regression (see Appendix 1.7 for details).

1.3.3 Quantile Regressions

The reaction of consumption on changes in prices or budget may differ across the consumption distribution. Matzkin (2007) proposed quantile regressions in consumer demand analysis to deal with this case of heterogeneity. Especially, the marginal income effect in Engel curves is expected to vary across the distribution for commodities within the consumer budget and this characteristic could also appear in the consumption-savings decision.[23] For policy reform simulation, different marginal effects would then have significant consequences for the results. Therefore, quantile regressions are added subsequently to the OLS results to consider the income effect over the consumption distribution. Eq. (1.9) is estimated for the 10, 25, 50, 75,

[21]For the relevance of household composition in consumption-savings decisions, see e.g. Blundell et al. (1994). In the literature on demand for consumer goods, various specifications are applied to take into account effects of household composition in demand system estimation, see Pollak and Wales (1981) for an overview.

[22]The regression in Eq. (1.9) was repeated some 20 times to make sure that the estimates for γ_{ss} lie in the confidence interval around the mean estimate.

[23]See e.g. Koenker and Hallock (2001) who discuss quantile regression analysis in Engel curve estimation.

and 90 percent quantile using the least absolute deviation estimation method.[24]

1.4 Data and Descriptive Evidence on Household Consumption

Firstly, the data set applied is introduced and the simulation of the tax rate is briefly summarized. Then, some descriptive evidence on consumption for the various groups of household composition is presented.

1.4.1 Data and Simulation of the Tax Rate

The cross-sectional consumption data applied in this analysis stems from the Continuous Household Budget Survey for Germany (*Laufende Wirtschaftsrechnungen*, LWR). The LWR is maintained by the German Federal Statistical Office (*Statistisches Bundesamt*).[25] It contains information on income, consumption, and savings, very detailed by single components, at the household level. In this approach, the detailed information about the structure of consumption by commodity groups and savings by asset types is used from which individual prices are constructed (see Section 1.2). Identification of price effects heavily relies on variation in these individual prices and the marginal tax rates. The detailed consumption structure moreover allows to measure effective consumption more precisely (see Section 1.3.1 and Appendix 1.7.1 for details). Thus, the repeated cross-sections from the LWR data are preferred in this approach instead of panel data from the German SOEP, where no consumption but only aggregate savings at the household level are observed. The six repeated cross sections for the years 2002 to 2007 used here contain 92,091 households when pooled.

In order to apply after-tax returns to savings in Eq. (1.7), income taxation is simulated for each household on the basis of information on income components that is observed for the time when the consumption-savings decision is taken (see Appendix 1.8 for details on the income taxation module). A marginal tax rate is generated for each household member who is considered relevant for the allocation decision by incrementing taxable income and assuming the increment is fully taxable and is not accompanied by any deductible expenses. Individual marginal tax rates are aggregated to a household marginal tax rate on taxable income in general, which is assumed relevant for the household's consumption-savings decision.

[24]Note, that the adding up condition is fulfilled for the opposing quantile in the two-good case (which means that e.g. $\alpha_{0c,10\%} + \alpha_{0s,90\%} = 1$ or $\beta_{1c,25\%} + \beta_{1s,75\%} = 0$).

[25]The LWR data were provided by the Research Data Centre of the Statistical Offices of the Federal States *(Forschungsdatenzentrum der Statistischen Landesämter, FDZ).*

1.4.2 Descriptive Micro Evidence on Household Consumption

Over the time frame analyzed here, there is not much variation in the aggregate consumption rate of private households in Germany. It decreased only slightly from 90.1% in 2002 to 89.2% in 2007 (see national accounts from Statistisches Bundesamt (2009b)). In the full sample of the used micro data (including all observations), the consumption ratio is, on average, similar in size to the macro consumption rate from national accounts. It decreases from 90.4% in 2002 to 86.4% in 2007. It should be noted, though, that comparability is limited as the sums for private households are derived residually in national accounts and include non-profit institutions serving households (*private Organisationen ohne Erwerbszweck*), which are not included in the micro data. Comparability of the micro consumption ratio with the macro consumption rate is moreover limited by the definition of consumption. The definition of consumption is changed in the micro data by imputing service flows from durable goods instead of expenditure. Additionally, the interest component of loans, and expenditures for contributions to several private insurances are declared as savings, see Appendix 1.7.3 for details, which shifts the mean consumption ratio slightly downwards.[26]

Based on this micro consumption ratio, the sample of households is restricted for estimation purposes. Some 1% outliers are excluded with a consumption ratio above 2, whereby the consumption ratio is shifted downwards by about 3 percentage points on average. This results in what is labeled the "unconditional" consumption ratio (see Table 1.1). The unconditional consumption ratio increases on average from 86.0% in 2002 to 84.9% in 2007. In the OLS estimation, the sample is further restricted to households with a consumption ratio below one ("conditional" consumption rate in Table 1.1), as argued in Section 1.3.2, which shifts the consumption ratio further downwards, as Table 1.1 reveals. The average unconditional consumption ratio in the population – when weighting the micro data by population weights – is 85.6%, and the average conditional consumption ratio is 74.2%.

Taking a closer look at the descriptive statistics in Table 1.1 reveals that there is great cross-sectional variation in income and consumption by household composition. An average household is equipped with a monthly disposable household income, in real terms[27] and on a six-year average, of 2,785 euros in the unconditional and of 3,113 euros in the conditional population. Households with below-average income (singles and single parents) have a above-average mean consumption ratio (92.2% and respectively 90.5% in the unconditional population), while households with above-average income (couples with one kid, with two and more

[26]Slesnick (1992) also finds a great downward shift in the consumption rate when accounting for service flows from durable consumption.

[27]Income is deflated by the Laspeyres index for consumption and savings, P^*.

kids, and large households[28]) have an below-average mean consumption ratio (78.8%, 74.7%, and 76.6%). Couples without any kids have about-average income and average consumption ratios.

Table 1.1: Descriptive Statistics on Income and Consumption by Household Composition

	Unconditional				Conditional			
	N	N_j/N	$\bar{s}^u_{(h)c}$	$\bar{y}^u_{(h)}$	N	N_j/N	$\bar{s}^c_{(h)c}$	$\bar{y}^c_{(h)}$
average household:	90,778	100.0	85.6	2,785	72,236	100.0	74.2	3,113
Singles	22,363	38.0	92.2	1,691	15,559	33.5	77.4	1,919
Single parents	3,282	3.5	90.5	1,859	2,485	3.3	79.1	2,035
Couples, no kids	32,044	29.4	85.7	3,188	24,967	29.6	74.3	3,450
Couples, 1 kid	4,853	5.8	78.8	3,465	4,163	6.5	71.8	3,667
Couples, 2 and more kids	10,278	9.6	74.7	4,158	9,278	11.5	70.1	4,295
Large households[a]	17,958	13.6	76.6	3,957	15,784	15.7	70.1	4,156

Notes: $\bar{s}^u_{(h)c}$ is the average consumption ratio in percent, $\bar{s}^c_{(h)c}$ is the average consumption ratio conditional on consumption ratios smaller than one, $\bar{y}^u_{(h)}$ is current monthly disposable household income in real terms, and $\bar{y}^c_{(h)}$ is current monthly disposable household income conditional on consumption ratios smaller than one. Data weighted by population weights for all figures, except for N.

[a]: Large households is a residual group. It is defined in footnote 28.

Reading example: The share of single parents in the population is 3.5%. Among this group, the average consumption ratio is 90.5%. In the population conditional on consumption ratios smaller than one, there are 3.3% single parents and their average consumption ratio is 79.1%.

Source: Own calculations using the LWR data (2002-2007) provided by the FDZ.

This between-group variation in the consumption ratios is greatly reduced if the population is conditioned on consumption ratios below one. The average conditional consumption ratio varies by household composition between 79.1% for single parents and 70.1% for couples with two and more kids as well as large households.[29]

In Table 1.2, where the variables are evaluated at certain quantiles of the consumption ratio distribution, the general impression of a negative correlation between income and consumption ratio appears. The higher the consumption ratio, the lower the disposable income, which gives a average income of 5,599 euros per month at the lower end (10% quantile) and 1,127 euros at the upper end of the distribution (90% quantile). Couples with kids and large households seem to have a lower consumption ratio than singles and couples without kids at every given point in the respective distribution. Singles and single parents have nearly the same ratio in

[28] The group "large households" is the residual group of all remaining households. It mainly consists of households with more than two adults.

[29] By conditioning on consumption ratios below one, the relative group sizes of singles as well as single parents slightly decrease, as there are relatively more households who dissave or borrow in these groups compared to e.g. couples with two and more kids, whose relative group sizes increase in turn. As a consequence, the consumption ratios of singles and single parents are shifted downwards significantly by conditioning.

the upper quantiles, although single parents have more disposable income. Singles have lower ratios and more income than single parents in the lowest quantiles.

Table 1.2: Descriptive Quantile Statistics on Income and Consumption by Household Composition

	10%		25%		50%		75%		90%	
	$s^c_{(h)c}$	$y^c_{(h)}$	$s^c_{(h)c}$	$y^c_{(h)}$	$s^c_{(h)c}$	$y^c_{(h)}$	$s^c_{(h)c}$	$y^c_{(h)}$	$s^c_{(h)c}$	$y^c_{(h)}$
pooled households:	52.7	5,599	63.8	3,937	75.7	2,684	86.5	1,687	94.0	1,127
Singles	55.7	3,347	67.8	2,308	80.1	1,581	89.7	1,099	95.8	825
Single parents	60.4	3,152	70.5	2,422	80.8	1,807	89.5	1,304	95.7	1,040
Couples, no kids	52.8	5,894	64.1	4,157	75.9	2,950	86.5	2,142	93.7	1,623
Couples, 1 kid	50.7	5,988	61.6	4,368	72.5	3,223	83.4	2,525	92.9	1,872
Couples, 2 and more kids	50.4	6,752	60.2	5,025	70.6	3,761	81.2	3,035	90.0	2,448
Large households[a]	49.9	6,744	59.4	5,139	70.2	3,747	81.6	2,722	90.5	1,917

Notes: $s^c_{(h)c}$ is the consumption ratio conditional on consumption ratios smaller than one and $y^c_{(h)}$ is current monthly disposable household income conditional on consumption ratios smaller than one. Data weighted by population weights for all figures.

[a]: Large households is a residual group. It is defined in footnote 28.

Reading example: The consumption ratio of single parents at the ten percent quantile of its conditional distribution is 60.4% and the monthly disposable household income at this point is 3,152.

Source: Own calculations using the LWR data (2002-2007) provided by the FDZ.

The variation that is relevant for the identification of substitution effects is related to the interest rate and the consumer price. In this model, the cross-sectional variation in the interest rate is significantly greater than in the consumer price, which is mainly driven by the variation in marginal tax rates over the households. The standard deviation of net returns to savings is about four times as great as the standard deviation of the consumer price for a given cross section. As a result, the estimate for the effects of interest rate changes turns out to be much more robust in the empirical analysis as the estimate for consumer price effects, see Section 1.5.

1.5 Results

The results that are focused on are related to the budget elasticities and the interest elasticity of savings. Budget and price elasticities are calculated and interpreted on consumption and savings levels for the conditional population of consumers with a consumption ratio below one.[30] Afterwards, differences in the elasticities over the consumption ratio distribution are

[30]Although the results for savings follow implicitly from the results for consumption by definition (and vice versa), nevertheless resulting elasticities are presented for both of them for the sake of illustration.

considered. The dominant result from the literature can be confirmed that the uncompensated interest elasticity of consumption (and therefore of savings too) is not significantly different from zero. Apparently, a shift in the rate of return to postponed consumption does not induce agents to alter their projected consumption path. In turn of an interest rate increase, current consumption on the one hand decreases due to a significantly negative substitution effect, while on the other hand it increases by a significantly positive income effect. In sum, these two effects leave the levels of consumption and savings essentially unchanged. Budget and price elasticities are computed according to Eqs. (1.2)-(1.4) based on the coefficient estimates from the estimation of the consumption equation in various specifications and evaluated for a mean conditional consumption share of $\bar{s}^c_{(h)c} = 74.2$ and a mean conditional savings share of $\bar{s}^c_{(h)s} = 25.8$.[31] The results are presented in Table 1.3 and will in the following be interpreted in more detail. Coefficient estimates for the estimation of the consumption equation in all specifications are compiled in Table 1.6 in Appendix 1.10.

In the main specification "OLS (1)" (unconstrained OLS estimation, columns 1 and 2 of Table (1.3)), the point estimate for the income elasticity of the level of consumption is 0.7 for single households, i.e. consumption is found to be a relatively inferior good, and the income elasticity of savings is therefore 1.91, i.e. savings are found to be a superior good.[32] If current income of singles increases by 10% from a monthly average income of 1,919 euros, the average household that consumes 1,485 euros (share of 77.4%) and saves 434 euros (share of 22.6%), would allocate the additional 192 euros more or less evenly between consumption and savings. As $1,919 * 0.774 * 0.07 = 104$ euros are consumed, savings are increased by the residual $1,919 * 0.226 * 0.191 = 83$ euros. This implies a marginal savings ratio of 43.2%, which is, as a result of the finding that savings are a superior good, greater than the average (conditional) savings ratio of 22.6%. Considering the differences over household composition, households with kids seem to be restricted in adjusting consumption to income changes because of the significantly lower elasticities for couples with one and more kids. The estimates for the budget elasticities are relatively robust while in the Tobit estimation, they are slightly lower for savings (1.82 for singles) and in turn slightly higher for consumption (0.73). The specification "OLS

[31] As there are no selection effects found for estimating the demand system on the conditional sample (see Section 1.3.2), it is concluded that the estimated coefficients for the budget effects could be considered as valid for the entire population. However, as the QUAIDS model applied here is only defined for the conditional population of consumption ratios below one, the budget elasticities are evaluated for this population only. Also, the interpretation of the estimated coefficients for the price effects should rather be restricted to the conditional population.

[32] Note that by adding-up, the weighted budget elasticities sum up to unity: $\bar{s}^c_{(h)s}\eta_s + \bar{s}^c_{(h)c}\eta_c = 1$. The estimated budget effects are comparable in size to the results in Lang (1998). For consumption, he finds an income elasticity of 0.85 and for savings, an income elasticity of 1.5-2.0, where 1.5 is for savings in financial assets and 2.0 for housing assets. A lower income elasticity of consumption is found here, as the budget effects are evaluated for the conditional population of consumers with a consumption ratio below one and thus with a relatively great average savings share.

Table 1.3: Estimated Demand Elasticities[a] for Levels of Consumption and Savings

	OLS (1)[b]		**Tobit**		**OLS (2)**[b]	
	Sav	Con	Sav	Con	Sav	Con
Budget Elasticities:[c]						
Singles	1.91***	0.70***	1.82***	0.73***	1.90***	0.70***
Single parents	2.06***	0.68***	1.93***	0.72***	2.05***	0.68***
Couples, no kids	1.81***	0.70***	1.72***	0.73***	1.81***	0.70***
Couples, 1 kid	1.88***	0.62***	1.75***	0.68***	1.88***	0.62***
Couples, 2 and more kids	1.86***	0.60***	1.71***	0.67***	1.86***	0.60***
Large households	1.75***	0.66***	1.63***	0.71***	1.75***	0.66***
Price Elasticities:[c]						
Compensated:						
savings price (p_s)	−0.37***	+0.14***	−0.46***	+0.18***	−0.35***	+0.14***
consumer price (p_c)	+1.57***	−0.62***	+1.82***	−0.72***	+0.35***	−0.14***
Uncompensated:						
savings price (p_s)	+0.09	−0.04	+0.03	−0.01	+0.11*	−0.04*
consumer price (p_c)	+0.19	−1.07[d]	+0.54***	−1.21***[d]	−1.04***	−0.59***[d]
Homogeneity:						
$F_{1,\ 72105}$	15.09		–		–	

Notes: Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, based on robust standard errors.
[a]: Price elasticities evaluated for the population of savers, at a mean conditional savings share of $\bar{s}^c_{(h)s} = 25.8$ and a mean conditional consumption share of $\bar{s}^c_{(h)c} = 74.2$.
[b]: Specification "OLS (1)" is unconstrained, whereas specification "OLS (2)" is constrained for symmetry and homogeneity.
[c]: Budget elasticities computed according to Eq. (1.2). Price elasticities computed according to Eqs. (1.3) and (1.4).
[d]: The null hypothesis for the consumption own-price elasticity is -1, see Eq. (1.3).
Reading example: In the unconstrained estimation ("OLS (1)"), savings are increased by 1.84% in turn of a 1%-increase in income. A 1%-increase in the net rate of return to savings lowers savings in total by 0.09% and increases current consumption in total by 0.04%.
Source: Own calculations using the LWR data (2002-2007) provided by the FDZ.

(2)" with the price constraints does not change the budget effects at all as expected.

The estimated savings price effects shall be evaluated for an increase in the interest rate. The compensated savings own-price elasticity is estimated at -0.37, which corresponds to an interest rate elasticity of 0.37 (see Appendix 1.9). The uncompensated own-price elasticity of savings is estimated at +0.09 (interest rate elasticity of -0.09) but this effect is not significantly different from zero.[33] Everything else unchanged, an increase in the interest rate only marginally decreases the level of savings, as on the one hand, consumption is substituted for savings due to the shift in relative prices (positive substitution effect), but on the other hand, the implied increase in income increases consumption and thereby decreases savings (negative income effect). The latter effect slightly dominates the former here, but the difference is statistically zero. This means that the hypothesis, that the total effect of changes

[33]The resulting total effect on consumption in $t+1$ is greater and goes in the opposite direction (uncompensated own-price elasticity of -0.91) than the effect on savings as it additionally includes the effect of the interest rate change on the budget.

in the net rate of return on the level of household savings is zero, cannot be rejected on the empirical evidence found here. It can thus be concluded that households do not respond to incentives from rate-of-return changes by adjusting savings. This finding also holds for the specifications "Tobit" and "OLS (2)", as the effects of the savings price are estimated robustly over all specifications. The effects of an interest rate increase on the level of consumption follow implicitly. The compensated consumption cross-price elasticity is estimated at 0.14 in specification "OLS (1)". The negative substitution effect largely offsets the positive income effect, and the resulting total effect of an interest rate increase on consumption is not significantly different from zero (uncompensated cross-price elasticity of -0.04). This result is also robust over all specifications.

The picture is a bit different regarding the effects of the consumption price, estimates for which vary in size over the specifications. If not constrained, effects of a shift in the consumption price are found to be greater than interest rate effects. In the main specification ("OLS (1)"), the compensated own-price elasticity of consumption is estimated at -0.62 and the uncompensated own-price elasticity at -1.07, statistically not different from -1.00. This implies that a 1%-decrease in the consumption price increases consumption effectively by 1% and in turn leaves savings unchanged (uncompensated cross-price elasticity of 0.19, statistically not different from zero).[34] The entire effect of a consumption price change is absorbed by current consumption such that the level of savings remains unaffected.These effects are though found to vary over the specifications. When the OLS estimation is constrained for homogeneity ("OLS (2)"), the point estimate for the consumer price is adjusted downwards in the direction of the interest rate, so that the uncompensated cross-price elasticity of savings is found to be significantly negative (-1.04). This result should though be interpreted with caution as a test for the homogeneity constraint ($\widehat{\gamma}_{cs} + \widehat{\gamma}_{cc} = 0$, implying symmetry) is rejected ($\widehat{\gamma}_{cs} = -0.10$, $\widehat{\gamma}_{cc} = -0.24$; F-test statistic $F_{1,\,72105} = 15.09$, see results in Table 1.3 and coefficient estimates from Table 1.6), which is why "OLS (1)" is considered as the main specification.[35] However, support is found for the main results again in the Tobit specification, in which the uncompensated cross-price elasticity of savings is positive again (0.54), this time significantly different from zero.

[34] This result is precisely the Cobb-Douglas case, where cross-price effects are zero and thus uncompensated own-price effects are -1.

[35] It was already mentioned at the end of Section 1.4 that the variation found in the estimate of the consumer price is due to relatively lower variation in this price. Moreover, the consumer price estimate suffers from multicollinearity with the time dummies. The correlation between the consumption price and the time dummies is very high (R^2 of 0.92 in a linear regression). If the time dummies are ommitted in the unconstrained model for another specification not presented here, consumer price effects turn out to be similar to the constrained model. In the main specification, nevertheless the time dummies are kept, as evidence is found for their joint significance (F-test statistic $F_{4,\,72105} = 17.12$). Lawrance (1991) also argues that time dummies are relevant for the identification of the interest rate elasticity.

Table 1.4: Estimated Demand Elasticities at the Quantiles of Consumption Ratio Distribution

	10%		**25%**		**50%**		**75%**		**90%**	
	Sav	Con	Sav	Con	Sav	Con	Sav	Con	Sav	Con
Budget Elasticities:[a]										
Singles	1.63***	0.41***	1.84***	0.54***	2.10***	0.68***	2.32***	0.82***	2.33***	0.93***
Price Elasticities:[a]										
Compensated:										
savings price (p_s)	−0.31***	+0.32***	−0.29***	+0.19***	−0.29***	+0.11***	−0.25***	+0.05***	−0.19**	+0.02**
consumer price (p_c)	+1.01*	−1.02*	+1.00	−0.65	+2.00***	−0.74***	+2.46**	−0.45**	+4.57**	−0.36**
Uncompensated:[b]										
savings price (p_s)	−0.14***	+0.14***	−0.02	+0.01	+0.14*	−0.05*	+0.38***	−0.07***	+0.63*	−0.05*
consumer price (p_c)	+0.19	−1.19[c]	−0.12	−0.92[c]	+0.46	−1.17[c]	+0.46	−1.09[c]	+2.25	−1.18[c]

Notes: Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, based on robust standard errors.
[a]: Budget elasticities computed according to Eq. (1.2) and price elasticities computed according to Eqs. (1.3) and (1.4).
[b]: Uncompensated elasticities are evaluated with the marginal income effect of single households.
[c]: The null hypothesis for the consumption own-price elasticity is -1 (see Eq. (1.3)), which cannot be rejected at any point of the distribution.
Reading example: At the ten percent percentile of consumption ratio distribution, savings for single households are increased by 1.63% in turn of a 1%-increase in income while consumption is increased by 0.41%. A 1%-increase in the net rate of return to savings rises savings in total by 0.14% and decreases current consumption in total by 0.14% (again the opposite sign of the *savings price* elasticity).
Source: Own calculations using the LWR data (2002-2007) provided by the FDZ.

The effects estimated so far have been evaluated at the mean conditional savings share ($\bar{s}^c_{(h)s} = 25.8$) and the mean conditional consumption share ($\bar{s}^c_{(h)c} = 74.2$). It can however be expected that income and price effects vary across the distribution of the consumption ratio as well as wealth. Possibly, households with higher savings, or more wealth, exhibit smaller responses to income changes because they can utilize their wealth to smooth out income shifts, whereas households above the median, and at the higher end of the distribution, might be more responsive to income effects. The latter can be the case if households, e.g., can not perfectly adjust their intertemporal consumption streams because they face borrowing constraints and thus are more elastic w.r.t. income changes.

Table 1.4 reveals differences in the income effect over the consumption ratio distribution, here only shown for singles, reflecting the results from quantile regressions.[36] In the first panel, the estimates for the budget elasticities of single households are displayed. Compared to the “OLS (1)” results in Table 1.3 (1.84 for savings and 0.67 for consumption), the budget elasticity of consumption is lower at the lower quantiles (which means a high savings ratio and therefore possibly high levels of income and wealth) and nears one for the high quantiles. This fact is not surprising as the households at the upper end of the consumption ratio distribution, who consume nearly their whole income, are in general the poor ones and have therefore really low levels of savings. But these savings are quite sensitive to income rises as the elasticity of savings is higher than at the lower quantiles (e.g. 2.33 at the 90 percent

[36]See Table 1.7 in Appendix 1.10 for the estimated parameters of the quantile regressions and Table 1.8 for the budget elasticities by household composition.

quantile).[37] For the price elasticities in the second panel, there are two main results found. Firstly, the compensated own-price effect of consumption shows a lower absolute value at the upper quantiles than at the lower ones. It follows that the substitution effect of the interest rate on consumption diminishes as well at the upper quantiles. Therefore, households with a high consumption ratio are more inelastic to changes in intertemporal prices than households with lower consumption ratio. Secondly, if the popular uncompensated interest rate elasticity of savings[38] is considered, only households at the lowest quantile have a positive one while household at the 50 percent quantile and above have significantly negative ones. The intuition is that the poor households have to compensate a decline in the interest rate by higher savings because they already have a low calculated future consumption level. Therefore, abstaining from current consumption to keep up a minimum future consumption level explains the high elasticity of savings to changes in the interest rate.

Furthermore, several specifications that allow for heterogeneity in the income and price effects by socio-demographic characteristics and across the wealth distribution were tested. For the price effects, no significant heterogeneity was found in any specification. The interest rate elasticity of consumption does not differ between households with high wealth and households with low wealth as well as by socio-demographics. This also holds for consumption and savings responses to changes in consumer prices. Also income effects do not differ significantly between different groups of household composition and neither by education of the household head.

In contrast, there is evidence for heterogeneity in income effects along the distribution of wealth. Allowing for interactions between income effects with quartiles of the wealth distribution reveals differences in these effects. These differences are however not large. The estimate for the budget elasticity slightly decreases over the wealth distribution. It decreases for consumption from 0.71 in the lowest quartile (1.94 for savings) to 0.62 in the highest quartile (1.81). Households with greater stocks of wealth respond more inelastically to income changes. For them, changes to current income are less relevant as they can utilize their wealth to compensate income shifts. In contrast, households that do not hold significant stocks of wealth exhibit greater responses to income volatility because they do not have the means to smooth out income changes. This result is in line with the previous findings of lower responses among households with higher savings (Table 1.4). These interactions between wealth and income could be explained with the presence of liquidity constraints in consumption.

There is empirical evidence that households with low asset holdings face a higher probability to be unable to borrow against future income or their wealth (e.g. Zeldes, 1989a). If indeed those households that are placed at the lower end of the wealth distribution are to a

[37] Note that these effects on the elasticities are not only driven by the different consumption shares at the quantiles, but also by changing marginal effects (see Table 1.7 in Appendix 1.10 for details).

[38] Remember that this is the displayed own-price elasticity of savings times minus one.

greater extent affected by borrowing constraints they are expected to exhibit stronger reactions to income changes. This can however not be inferred from the results we provide in this analysis alone. It would need a proper identification of liquidity constrained households and a distinction between income changes that are anticipated and such that are non-anticipated, as well as between transitory and permanent changes to income.[39]

The effects found in this chapter have important policy implications.[40] Finding an uncompensated interest rate elasticity for savings with a slightly negative point estimate (-0.09 in "OLS (1)") that is though statistically zero, it is concluded that policy-induced variation of net returns to savings is expected to have no effects on the amount of savings. According to the results from the quantile regressions, interest rate subsidies intended to enforce savings of poor households are expected to provoke a contrary effect. Moreover, a compensated interest rate elasticity of savings that is significantly different from zero (0.37 in "OLS (1)"), though, indicates that such a variation would not be welfare neutral. Increasing the incentives to postpone consumption by increasing the net return to certain assets, e.g., would not have any effects on the exterior margin, as the amount of total savings is unchanged. Increases of savings in a certain type of assets, for example private old-age savings, can thus only be obtained on the interior margin by shifting savings from other assets, while the general consumption-savings behavior is not affected by price-related incentives. The level of total savings could only be increased by indirect incentives through disposable income. As savings are found to be a superior good, policy reforms that increase disposable income could induce households to increase their level of savings. These qualitative policy implications also hold for policy reforms affecting the consumption price. An increase, e.g., in the value-added tax would induce households to reduce their current consumption, but would leave their level of savings unchanged. Again, only by reforms affecting disposable income, the level of savings could be affected.

In the theoretically consistent context of the demand system, rejection of the homogeneity constraint indicates that in the consumption equation, either the estimate for the own-price elasticity ($\widehat{\varepsilon}^c_{cc}$) is too high (in the absolute value), or the estimate for the cross-price elasticity ($\widehat{\varepsilon}^c_{cs}$) is too low. This empirical finding suggests that households react slightly differently in response to a shift in the consumption price and in response to a change in the interest rate.

[39] In Chapter 2, a test for the effect of liquidity constraints on intertemporal household consumption is applied using the same data set. There is evidence found that households that are liquidity constrained exhibit a significantly greater response to transitory income shocks than households that are not constrained.

[40] When evaluating price effects, one generally has to make an assumption about the duration of the shock. If a rise in consumption tax was assumed to affect consumption prices in the current as well as all future periods, theory would predict no effect on intertemporal consumption allocation at all. If one, however, assumes that an increase in consumption tax is rather perceived as a shock to the inflation rate that disappears after one period – meaning that it has a short-term effect through the distortion of relative prices only – then the estimates suggest that the consumption own price elasticity lies between -1.1 in the unconstrained and -0.6 in the constrained model. The argument holds in a similar manner for a shock to the interest rate.

This could be interpreted as an overreaction to shocks on the consumption price in a sense of surprise inflation compared to interest rate shocks that are perceived less sensitively. Or households mistake a nominal interest rate increase for an increase in the real rate so that effects of the consumption price may to some extent also reflect reactions to shifts in the nominal interest rate.[41] As mentioned before, the coefficient of the interest rate is estimated with more precision due to relatively more cross-sectional variation and problems of multicollinearity between time and the consumer price. However, despite the violation of the homogeneity constraint, the elasticities estimated in the main specification can be applied for evaluating specific price changes in welfare analysis. If households' demand for savings is more elastic to price shocks than to shocks in the interest rate, one possible policy implication, from a welfare point of view, could be that a tax on capital income would be favorable compared to a consumption tax. But this issue needs further empirical research.

1.6 Conclusion

The theory as well as the empirical literature are not unambiguous about the question whether tax reforms that are supposed to set incentives to increase private household savings – by e.g. reductions in capital income taxation or subsidies on savings for old-age – have an effect on the intertemporal consumption decision of households at all. The predominant result from the literature can be confirmed that the uncompensated interest rate elasticity of savings is effectively zero. In this chapter, an empirical analysis of income, price, and interest rate effects on the consumption-savings decision was conducted with consumption survey data from official statistics on private households in Germany for the 2002 to 2007 period. The approach deals with a structural demand system for the consumption-savings decision. Effects of the consumption price can be identified by expenditure-specific price weights and effects of cross-sectional as well as longitudinal interest rate variation with the help of household heterogeneity in marginal tax rates on capital income. An income tax module was constructed to simulate differential taxation of labor income and income from the investment of capital. Additionally, it is accounted for differences in the marginal effects over the consumption ratio distribution and an appropriate treatment of durable goods in the definition of savings by applying user costs.

The major findings suggest that savings are a superior good and thus consumption is an inferior good, estimating the income elasticity of savings at 1.9 and of consumption at 0.7 for single households. The uncompensated interest rate elasticity of savings is estimated not

[41] Lusardi and Mitchell (2009) in evaluating questions on financial literacy find that only about half of the respondents understand the basic implications of interest rates and inflation. They moreover conclude that this fundamental lack of financial knowledge has relevant effects on households' decision to save for retirement.

significantly different from zero. These results are found to be robust over various model specifications. It is concluded that policy reforms that mainly aim at an increase in aggregate savings should thus focus on increasing households' disposable income, rather than on the net rate of return. Short-term policy-induced variation of net returns to savings, e.g. through a reduction of tax rates on capital income or an increase in the tax deductibility of savings for old age, is expected to have no significant effects on the level of savings. Especially, for poor households with a high consumption ratio, the interest elasticity of savings is significantly negative so that achieving the policy goal of fostering private savings for old-age by interest rate subsidies is counterfactual. The intuition is that the poor households have to compensate a decline in the interest rate by higher savings because they already have a low calculated future consumption level. Reversely, they would reduce savings with rising interest rates.

In general, policy reforms that affect the net rate of return would moreover not be welfare neutral, as the *compensated* interest elasticity of savings is estimated significantly different from zero, with a point estimate of 0.4 at the mean. Here, as the income effect offsets this substitution effect, the total effect is zero.

These policy implications should be limited to short-term effects on household savings that are related to the taxation of capital income or deductibility of savings for old-age provision. The introduction of a withholding tax on capital income with a flat rate of 25% in Germany in 2009 is one example where the elasticities could be of relevance. This reform would be expected to have no effect on the aggregate amount of savings. However, there might be effects on the interior margin when households adjust their portfolio structure and shift savings between assets, which are not covered here.[42] For a concrete conclusion on the consumption-savings changes of such a reform, further microsimulations are needed. Moreover, the elasticities shall rather not be applied to the evaluation of introductions of new forms of subsidized saving contracts, for example for private old-age pensions. Such contracts usually have a long-term perspective in the sense that a fixed amount is saved on a regular basis for a long period of time and transaction costs occur at the beginning. These aspects are not explicitly considered in the short-term elasticities for the two-period model.

[42]See Ochmann (2010b) for a tax reform simulation that accounts for asset reallocation.

1.7 Appendix - Data and Definition of Income and Savings

1.7.1 Data

For the LWR consumption data, households are recruited voluntarily for reports every year, according to stratified quota samples from Germany's current population survey (*Mikrozensus*), and report for a time of four months (one month out of each quarter of the year). Since 2005, recruited households stem from a subsample of the Income and Consumption Survey for Germany (*Einkommens- und Verbrauchsstichprobe*, EVS). They are aggregated to the population according to a marginal distribution of demographic variables. The entire population covered by the LWR is restricted, as there are groups that are not covered: self-employed, institutionalized people (i.e. military people in caserns, students in dormitories, elderly and disabled people in nursery homes or hospitals, nurses or migrant workers in residences, people in jails), homeless people, and households with monthly net household income greater than 18,000 euros. When descriptive statistics on the LWR data are presented (see Section 1.4), data are weighted by population weights. Population weights for the LWR are constructed w.r.t. the marginal distribution of households in the *Mikrozensus*-population by strata of household composition, social status, and net household income. For further details on the LWR data, see Statistisches Bundesamt (2007).

1.7.2 Treatment of Durables

The investment character of the consumption of durables goods is accounted for by calculating user costs or depreciation rates for these goods for current consumption, and the residual of actual expenditures and user costs is interpreted as savings. For most of the "relevant" durable goods, user costs are computed by mean imputation. A durable good is considered "relevant" if nearly every household can be assumed to consume at least a small amount of the good every period and the macroeconomic expenses on that good are above an arbitrary threshold. These goods include e.g. furniture, electric devices, entertainment electronics, clothes, shoes, and carpets.

In performing the mean imputation, household clusters are constructed depending on six age groups, seven income groups, and six household types. Then, the expenditures are summed up for a durable good in each cluster, and the sum is reallocated equally among all observations in the cluster. Afterwards, an estimated quarter effect is added to every adjusted category of expenditure to avoid a bias in the quarter dummies of the main equation. This is necessary because non-durable consumption is not adjusted for quarter effects.

Expenditures for car purchases form the most significant durable good related to the macroeconomic expenditures, except for housing expenditures. Cars have been treated a little differently from the described mean imputation. Firstly, a tobit-regression is estimated for households owning exactly one car with the reported expenditures for leasing as dependent variable and the disposable income and household characteristics as explanatory variables. Then, the unconditional value is predicted for each household owning at least one car assuming that 90% of the leasing rate is depreciation and 10% is interest payment.[43] The depreciation is calibrated dependent on the number of cars in the household and their characteristics (newly or second-hand bought). If the household reports expenditures for car purchases, 15% of this value is taken directly as depreciation for the first year (5% in case of second-hand purchase). Furthermore, if there are expenditures reported for preventive maintenance or spare parts then these are taken into account in calculating the depreciation. Finally, it has been guaranteed that the population-aggregate sum of expenditures for all the relevant durable goods is roughly conserved after adjustment.[44]

Following Garner and Verbrugge (2009), the market rental value approach has also been applied to the measurement of services from owner-occupied housing. For owner-occupied housing, rents that are provided with the data have been applied and imputed both in current income as well as in consumption. The rents applied have been computed by the Federal Statistical Office as follows: an average gross rent (excluding heating and maintenance) per square meter differentiated by federal states is applied to the reported size of the house or flat, and this is added to the reported expenditures for heating and maintenance (Statistisches Bundesamt, 2005).

1.7.3 Definition of Income and Savings

For the relevant budget in the basic consumption-savings model, the disposable household income is applied. Disposable household income is defined as net household income added income from sales of home-made products, second-hand goods, and jewelry. Net household income results from subtracting compulsory contributions to the social security funds and to employer-based pension funds as well as income tax prepayments from gross household income. Gross household income in turn is defined as the sum of income from agriculture and forestry, income from trade or business, income from self-employment,[45] income from

[43]In case positive leasing payments are reported, they are applied here.

[44]On arguments for this market rental value approach for the measurement of services from durables, see Garner and Verbrugge (2009). For a survey on various approaches for the measurement of durable service flows, see Katz (1983).

[45]Although there are no households with a self-employed head in the LWR data, some 2% of all households report positive income from self-employment. In this group, 50% of the households are categorized as white collar workers by main source of income. However, given the low number of households with any income from self-employment, it is assumed that additional income from self-employment does not affect the group of

dependent employment, income from transfers from the social security funds, income from inter-household transfers, income from investment of capital, and income from renting and leasing. Income from renting and leasing additionally includes the imputed rent for owner-occupied housing, as explained in the previous subsection.

As explained in Section 1.3.1, savings are defined residually from disposable household income and effective consumption. In detail, this definition of savings includes net accumulations of the following assets: housing assets that are owner-occupied or rented, financial assets such as bank deposits (i.e. savings accounts, fixed deposits, and money market investments), building society deposits (or home-building savings plans), stocks (including mutual stock funds, certificates, and other shareholdings), and bonds (i.e. private and public securities). Savings moreover include contributions to capital life and private pension insurances net of payouts, and net repayments of loans such as mortgages and consumer credits, where the interest component is included, because it is usually not disposable given the fixed annuity of a loan, see Morgan (1951) for a similar argumentation.

Additionally, in this definition of savings, the residual of expenditures and user costs for durable consumption goods, such as cars and furnitures, is implicitly included (see the previous subsection for details). Furthermore, savings include expenditures for contributions to several private insurances such as term life insurances, private health and long term care insurances, and voluntary contributions to the statutory pension insurance funds, and moreover premiums to personal liability insurances, to household insurances, and to liability as well as own-damage insurances for cars. The treatment of these private insurance premiums as savings is debatable, as it is for insurance premiums in general. Premiums to insurances with a pure risk-insuring character, rather than a provisional character, could equally well be treated as consumption. Yet, it is argued with the investment character of insurances, as claims for future payoffs are generated by current contributions. Forgoing current consumption and insured future consumption form a trade off that attaches an intertemporal dimension to insurance premiums that allows a treatment as savings. For a comparison of the effects of applying various concepts of the definition of savings on the household savings ratio as well as on the national savings rate, see Blades and Sturm (1982).

1.7.4 Imputation of Wealth

Accounting for owner-occupied housing tax allowances and for wealth and debt as control variables in the demand equations, Eq. (1.9), requires information that is not available in the LWR data. For this purpose, calculations on the basis of income values and imputations on the basis of the EVS data are implemented. Three types of wealth are considered: financial wealth,

white-collar worker households differently than all other groups in the savings reaction to price effects.

owner-occupied housing, and rented housing. Financial wealth is imputed via capital income components assuming a market interest rate (varying with time period and maturity). Note that also capital income is partly imputed. Two methods for the imputation of housing wealth are applied and then compared. Firstly, classical regression imputation is used to match the housing market values given in the EVS data with the LWR data. In both data sets, almost the same information on household characteristics and income components is available. Secondly, tax payments on land and real estate are reported in the LWR for owner-occupied housing in each sample wave and for rented housing in the 2002 sample wave. With this information and applying the reverse assessment of tax on land and real estate, an assessed tax value of housing wealth can be inferred.[46] Using the correlation between the assessed tax value and the market value of the housing wealth, again estimated with the EVS, the value of housing wealth can be determined and then compared to the one resulting from classical regression imputation. By this procedure, an improvement of imputed housing wealth can be achieved for those households that do not report tax payments on land and real estate. Additionally, information on income from renting and leasing is used to improve the imputation of rented housing wealth.

[46] There are different tax parameters for the tax on land and on real estate varying across municipalities. Here, average parameters available on federal-state level differentiated by levels of agglomeration are applied.

1.8 Appendix - A Module of Income Taxation

In order to apply after-tax returns to savings, a marginal tax rate on capital income is simulated at the household level in a tax simulation module that implements the German income tax law as of the time of 2002 to 2007. This is necessary, because the actually assessed income tax burden is not observed in the data. Households only report tax prepayments in the LWR data based on the current income from dependent employment in the particular month (for the years 2002 to 2004), respectively in the particular three months period (2005 to 2007). Thus, to simulate a tax assessment for each household, the observed income and expenditure components need to be aggregated for an entire year. Generally, this is done assuming the monthly/quarterly observation is representative for the entire year and thus multiplying it by twelve/four. Deviations from this procedure, in case of strong irregularities or seasonal patterns observed, are explicitly stated in the following.

The household head is assumed the relevant taxable person, with the possibility of joint assessment if a spouse is observed in the household. In case of joint assessment, the progressive tax scale is applied to half of the spouses' joint taxable income and the resulting tax burden is doubled. In addition, several tax-exempt amounts in the assessment are doubled. The procedure is advantageous for the couple in most cases and thus all eligible households are assumed to exercise the option of joint assessment. If there are other adult persons in the household beyond the household head (in case of single assessment), respectively the married couple (in case of joint assessment), household income, deductions, and additional income components that influence the marginal tax rate (*Progressionsvorbehalt*, see below) are cut by an arbitrary percentage rate.[47]

Taxable income at the household level is derived according to the scheme in Table 1.5. In the following, the single income components are described in further detail with respect to its subcomponents, with respect to specific regulations on eligibility, maximum amounts, lump-sum amounts, and application, and with respect to the implementation in the module of income taxation. As mentioned in Section 1.4, there are structural differences between the LWRs 2002 to 2004 and the LWRs 2005 to 2007. In the years 2002 to 2004, every household is observed one month per quarter, which results in four observations per household. This household panel structure is used for most of the income components to improve on the annual values. In the years 2005 to 2007, however each household is observed only once with a quarterly value. This is accounted for in the treatment.

Income from agriculture and forestry, **income from trade or business**, as well as

[47] In case of single assessment, the amounts are cut by 30% for the first additional person and another 10% for the second and every other person, while for married couples they are cut by 20% for the first additional person and 10% for the second and every other person.

Table 1.5: Derivation of Taxable Income According to German Income Tax Law (EStG)

	Single income components:
	income from agriculture and forestry
+	income from trade or business
+	income from self-employment
+	income from dependent employment
+	income from investment of capital
+	income from renting and leasing
+	other income
=	**sum of all forms of income**
-	allowance for agriculture and forestry
-	relief for elderly retired people
=	**adjusted sum of all forms of income**
-	special expenses
-	extraordinary financial burden
-	tax shields for owner-occupied housing
-	loss deductions
=	**income**
-	child allowances
-	household allowance for single parents
=	**taxable income**

Source: § 2 German income tax law (EStG).

income from self-employment are corrected for seasonal variation and multiplied by four from quarterly values to annual values.[48] **Income from dependent employment** as considered in the tax module includes basic salaries, contributions to capital formation, gross income from part-time work, in-kind transfers, retirement pensions for public servants from own occupation or as a surviving relative. These income components are aggregated as observed to annual values. Moreover, irregular components are included: compensations for early termination of a contract, bridge money, income from employee profit sharing, and bonuses. These values are treated as annual, no matter in which sample wave they are observed. Further, Christmas bonuses and vacation bonuses are included. For them, a seasonality is observed, they occur more often in the 4th quarter than in all others. If such payments are not observed

[48]There are no households in the LWR data with a self-employed head or self-employment as main source of income. Moreover, there are only about 2% of all households with any income from agriculture, trade or business. Thus, these sources of income are generally under-represented in the data.

but the household receives salary, a value is imputed based on a tobit-regression on salary, employment status, age of household head, employment level, etc. For retirement pensions for public servants, there is an allowance granted: 40% of the pensions, a maximum of 3,000 euros, were tax exempt in 2005. This allowance is slightly reduced in every year since 2005, when the Retirement Income Act (*Alterseinkünftegesetz*) was enacted (see also below at "Other income"). For compensations for early termination of a contract, there are tax allowances increasing with age granted, for persons aged 50 and older. Generally, income from dependent employment can be reduced by income-related expenses, where for every individual, the lump-sum allowance of 920 euros since 2004 is applied (before 2004, it was 1,044 euros).

Income from investment of capital is observed differentiated by dividends, interests, and other payouts, such as those from mutual funds. It is assumed that all taxable income from exogenous investment of capital is captured by these components. Since there occurs some seasonality (dividends are paid mainly in the first or second quarter) and sporadic reporting of these income components, values are imputed by a tobit-regression. For this procedure, all capital income components are aggregated, imputed by the regression, and then reallocated to the components according to the observed structure. If there is no capital income observed, the imputed value is assumed to be interest income. The single income components are reported net of withholding tax on capital income (Kapitalertragsteuer, KEST), a prepayment on income tax. The KEST payment is not observed, it is inferred here from the sum of all income from investment of capital. An allowance is granted on income from investment of capital, 1,550 euros in 2002 shrinking to 750 euros in 2007 for each individual. It is assumed that this allowance is simultaneously applied to income from interests and to income from dividends. Income that exceeds the allowance is assumed to be subject to KEST. KEST was 30% on income from interests in all years. Dividends were subject to personal income taxation, where only 50% of the dividend are taxable (the so called *Halbeinkünfteverfahren*). KEST on income from dividends was 20% in all years. The KEST payments can be credited against the income tax liability as a tax credit. Generally, income from investment of capital can be reduced by income-related expenses, where for every individual, the greater of reported expenses for financial services and a lump-sum of 51 euros is applied. Income from interest payments included in premiums to capital wholesale and private old-age pension insurances were tax exempt before 2005 if there are contributions paid for at least 5 years and the entire contract duration is at least 12 years. This is assumed here for any income from selling insurance assets.

Income from renting and leasing is observed as income from renting and income from subleasing. These components are reported net of income-related expenses, such as depreciation, interest payments, maintenance costs, insurances, and administration costs. The sum of these net income components is applied here as income from renting and leasing. The annual value is derived by multiplying the seasonally adjusted quarterly, respectively monthly amount.

Other income is observed as income from retirement and other pensions (e.g. private pension insurances), income from speculative trading, and income from alimony. Income from any pensions is applied with a taxable fraction of 27% for the years 2002 to 2004.[49] By the Retirement Income Act, retirement pensions are taxable with a fraction of 50% in 2005, increasing to 54% in 2007. Income from speculative trading occurs if households sell certain assets in a specific time frame from the point of acquisition. If equities (i.e. stocks and bonds here) are sold within 12 months from acquisition net profits generated (i.e. income from selling equities, less costs of their acquisition) are applied here as income from speculative trading.[50] Income from selling owner-occupied housing was tax exempt, whereas income from selling non-owner occupied housing was tax exempt if there are at least 10 years between acquisition and realization, otherwise net profits are fully taxable. The values for capital gains from selling stocks and bonds were imputed. Profits from selling non-owner occupied housing were inferred from reducing observed revenues by imputed acquisition costs.[51] Generally, income from speculative trading was only taxable in case net profit generated exceeded 512 euros, but in this case the entire net profit was taxable. Income from alimony is assumed taxable here upon approval of the recipient.[52]

The **sum of all forms of income** is reduced by two allowances: An **allowance for agriculture and forestry** is granted up to 670 euros if income from agriculture and forestry does not exceed 30,700 euros. A **relief for elderly retired people** is granted, 40% of income from dependent employment less income-related expenses, up to a maximum of 1,900 euros, are tax exempt in 2005 (decreasing to 36.8% and a maximum of 1,748 euros in 2007). There results the adjusted sum of all forms of income.

Further deductions are granted in the form of **special expenses**, such as alimony payments, donations and membership fees devoted to certain public institutions, church tax payments, tuition fees, expenses for child care, and expenses for insurance premiums with provisional character. **Alimony payments** are deductible (given the assumed approval of the recipient) up to a maximum of 13,805 euros. The sum of **donations and membership fees devoted to certain public institutions** is deducted as far as it does not exceed 5% of the adjusted sum of all forms of income (since 2007: 20%). **Church tax payments** are

[49]Since there is no information on the age at which income from old-age pensions was received for the first time, the statutory retirement age of 65 years is assumed here for all income from pensions.

[50]There may occur losses from speculative trading, which may be deducted from any profits from speculative trading. Such losses are assumed to be zero here.

[51]See Appendix 1.7, for imputation of wealth and parameters of the portfolio.

[52]In this case, the payer may deduct the alimony payments as special expenses.

imputed for self-employed and retirement pensioners since they are not regularly paid every month/quarter in these groups. **Tuition fees** for taxpayer's children under the age of 18 are deductible. **Expenses for child care** of children under the age of 14 can be deducted dependent on the tax year. In 2006, the maximum deduction for child care expenses was raised to 4,000 euros per child.

Expenses for insurance premiums with provisional character that are applied here as special expenses are only those expenses that can be considered "inevitable" for the individual. These are compulsory as well as voluntary contributions to the statutory pension insurance, to the statutory health insurance, and to the social long-term care insurance, contributions to private health and long term care insurances, contributions to the unemployment insurance, premiums to personal liability insurances, and premiums to casualty insurances. The greater of actual expenses and a lump-sum allowance for provisional expenses is applied, where the lump-sum allowance is a stepwise function of income from dependent employment reduced by the relief for elderly retired people and the allowance for retirement pensions for public servants (§10c EStG). There is a section for low incomes, one for mid-level incomes, and one for high incomes. For pensioners and employees who do not contribute to the statutory pension insurance, there is an alternative lump-sum allowance. The resulting expenses can only be deducted up to a maximum allowance for provisional expenses. This maximum is a function of income from dependent employment reduced by income from retirement pensions for public servants. Again, there are three sections by level of applied income. Actually deductible expenses for insurance premiums with provisional character result.[53] The greater of the sum of all special expenses and a lump-sum allowance of 36 euros is deducted.

Further deductions are granted for expenses due to **extraordinary financial burden**. These may be related to illness, to disability, to the death of relatives, or to the presence of household members in need of care. Households report expenses for drugs, medical care, services related to assistance for old people, disabled people, and people in need of care. Since neither the degree of disability, nor the degree of need for care are observed, it is assumed that all reported expenses exceeding the level of reasonable burden[54] can be deducted. Children that are not members of the household are identified by the difference between the number of children reported and the number of children derived by received child benefits. For these children, a lump-sum allowance of 924 euros per child is deducted. Other extraordinary financial burden may result from occupation of domestic help, for which households report expenses. They are deductible up to 624 euros for individuals aged 60 or older.

[53]The calculations of the maximum deductible expenditures and the lump-sum allowance slightly differ since 2005.

[54]The reasonable burden is determined by a specific percentage rate of the sum of all forms of income, see §33 (3) EStG.

Further deductions are granted in the form of **tax shields for owner-occupied housing**. The relevant tax shield regulations are found in §10e, §10h, and §10i EStG. §10e and §10h EStG are relevant in case construction of the building was started before 01.01.1996, §10i EStG in case it was started after this date. According to **§10e and §10h EStG**, if construction was started before 01.01.1996, 6% of the costs of purchasing the building (a maximum of 10,124 euros) may be deducted each year in the first four years, and another 5% in the following four years (a maximum of 8,437 euros). The building needs to be occupied by the owner and may not be occupied for weekends or holidays only. Here, for the sake of simplicity and because of the fact that only old cases are faced (anyway only in 2002 and 2003), a fraction of 5% of imputed purchasing costs[55] (up to 8,437 euros) of owner-occupied housing are assumed to be deductible. Because the date of purchasing or construction is not observed in the data, an exclusion restriction is implemented with the help of observed information, i.e. year of construction has to be after 1991, mortgage interest payments greater than zero, and mortgage interest payments exceed the loan repayments.

There is no information observed on **loss deductions**. It is assumed that households do not deduct any losses that emerged in the current or in any previous year. Reducing the adjusted sum of all forms of income by special expenses, expenses due to extraordinary financial burden, and tax shields for owner-occupied housing results in **income** according to tax law.

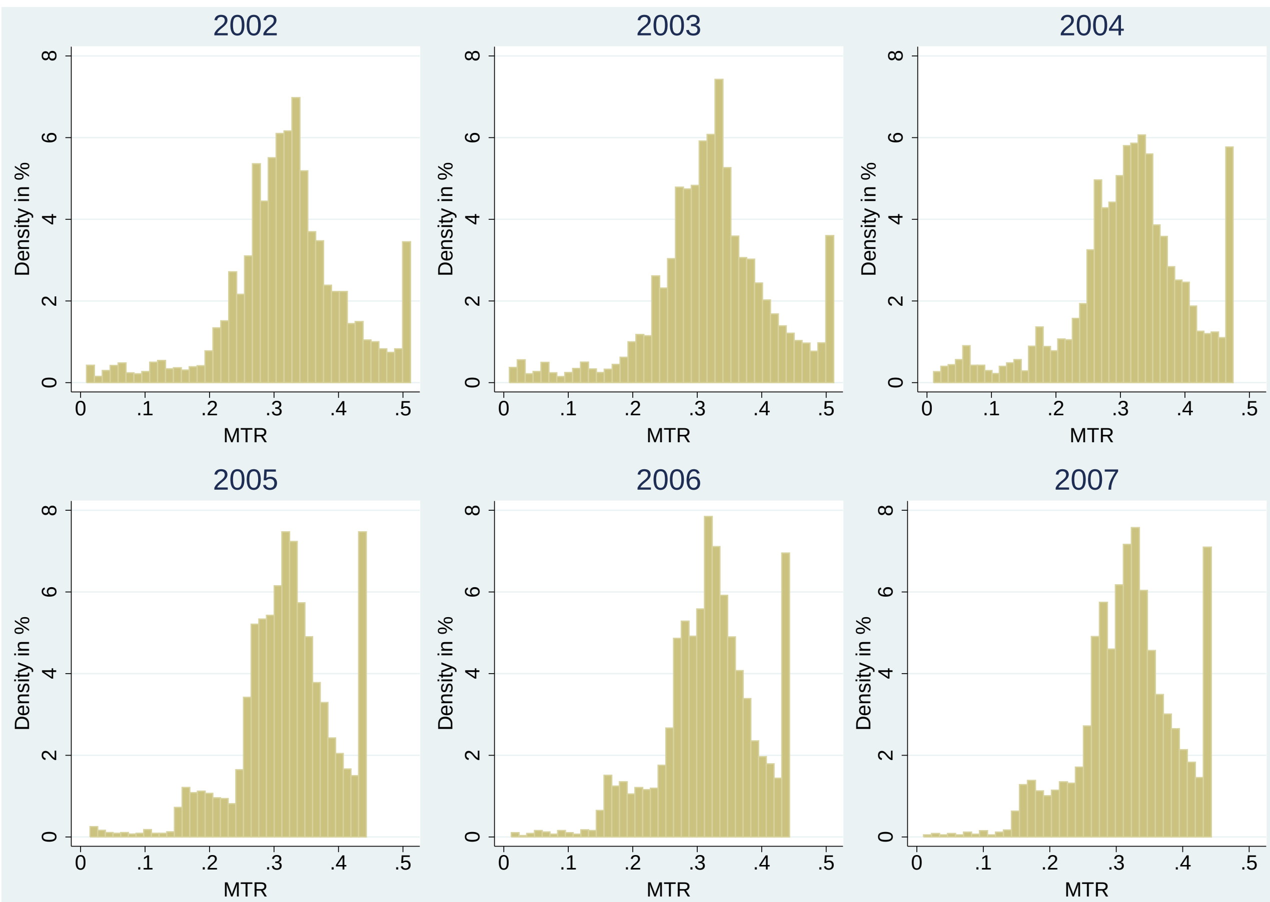
Income may be reduced by a child allowance as well as a household allowance for single parents. Either a **child allowance** is deducted or households get the monthly child benefits which amounted to 154 euros. There is a check undertaken here for which variant is the more favorable for the household, a so called higher-yield test. In case the child benefits are more favorable, the child allowance is not applied and households keep the received child benefits. The child allowance applied amounts to 2,904 euros in each year. It is deducted for both, the household head and its partner. In case spouses are jointly assessed for income taxation, the child allowance is doubled. Children are eligible for child allowance if they are aged below 18, or if they are aged between 18 and 21 and searching for a job, while unemployed, or if they are younger than 27 and currently in education. Furthermore, a **household allowance for single parents** is granted for individuals who are not married and are either eligible for child allowance or live in a household with children that are eligible for child benefits. This allowance amounts to 2,340 euros until 2003 and to 1,308 euros since 2004.

Deducting the household allowance for single parents and the child allowance in case it is more favorable than child benefits, results in **taxable income**. There remain some income components that are not taxable, but that affect **progressive taxation** (Progressionsvorbe-

[55] For the imputation of wealth, see Appendix 1.7.

halt). As such are treated here: unemployment benefits, unemployment assistance, transfers related to employment promotions, compensations for short-time work, benefits for part-time retirement, benefits for maternity leave, sickness benefits and other transfers from the statutory health insurance, and transfers from the European Social Fund. The relevant tax rate is derived by adding these income components to taxable income and applying the tax tariff according to §32a EStG to this sum. The resulting tax rate is then applied to taxable income and the tax burden results. As noted above, married couples are assumed to choose joint assessment which means applying the tax tariff to the half of the spouses' joint taxable income and then doubling the resulting tax burden.

Figure 1.1: Conditional Distributions of the Marginal Tax Rate by Cross-Section (2002-2007)



Source: Own calculations with the LWR data (2002−2007).

Household specific marginal tax rates are generated by incrementing taxable income assuming the increment is fully taxable and is not accompanied by any deductible expenses. The difference in tax burdens resulting from the increment is applied as a general marginal tax rate on income. Zero is imputed for the tax rate in case the allowance on income from investment of capital is not fully exploited at the household level yet. Thus, the resulting marginal tax rate can be interpreted as a tax rate on capital income specifically.

Figure 1.1 plots the conditional distributions of the resulting household marginal tax rate over time, where the condition is on a positive tax rate. Comparing the distribution over time, the variation that results from the final implementations of the income tax reform starting in the year 2000 becomes apparent. The marginal tax rate on the lowest incomes was reduced from 23% (excluding solidarity surcharge and church taxes) in 1998 to 15.0% in 2005 and the top income tax rate was reduced from 51.0% in 2002 to 42.0% in 2005 and raised again to 45.0% in 2007,[56] while the general tax-free allowance was steadily increased.

[56]There are no cases in the data, though, that are affected by this increase in the tariff at the top, see Figure 1.1.

1.9 Appendix - Interest Rate Elasticity

The price elasticity that is derived from the coefficient of the savings price in Eq. (1.7) can be interpreted as a one-percent reaction of the dependent variable to a one percent increase in the expected consumption price as well as to a one percent decline in the real after-tax interest rate. This can be proved by calculating the derivatives of $\ln(p_{is})$ to its arguments and comparing them.

$$\frac{\partial \ln(p_{is})}{\partial p_{ic}^{e}} = \frac{1+r_i^n}{p_{ic}^{e}} \cdot \frac{1}{1+r_i^n} = \frac{1}{p_{ic}^{e}} \tag{1.10}$$

$$\frac{\partial \ln(p_{is})}{\partial r_i^n} = \frac{1+r_i^n}{p_{ic}^{e}} \cdot \left(-\frac{p_{ic}^{e}}{(1+r_i^n)^2}\right) = -\frac{1}{1+r_i^n} \tag{1.11}$$

where (1.10) equals (1.11) with inverse sign if

$$\begin{aligned} \frac{1}{p_{ic}^{e}} &= \frac{1}{1+r_i^n} \\ p_{ic}^{e} &\approx 1+r_i^n \end{aligned} \tag{1.12}$$

which can be assumed fulfilled since p_{lc} is normalized around 1, and $\widehat{p}_{ic}^{e} = p_{lc}\,(1+\widehat{\pi}_t^{e})$, following from Eq. (1.8).

1.10 Appendix - Results

Table 1.6: Estimates for Consumption Demand Equation

	OLS (1)[a]		**Tobit**		**OLS (2)**[a]	
dep. var.: $s_{i,c}$	Coeffs	(SE)	Coeffs	(SE)	Coeffs	(SE)
Income Polynomial:						
y	0.425	(0.05)***	0.179	(0.05)***	0.435	(0.04)***
$y * hhtype2$	0.213	(0.13)*	0.147	(0.18)	0.229	(0.16)
$y * hhtype3$	0.232	(0.07)***	0.247	(0.06)***	0.233	(0.06)***
$y * hhtype4$	0.179	(0.18)	0.001	(0.14)	0.175	(0.13)
$y * hhtype5$	0.000	(0.12)	-0.224	(0.12)*	-0.005	(0.11)
$y * hhtype6$	0.478	(0.08)***	0.415	(0.08)***	0.462	(0.07)***
y^2	-0.038	(0.00)***	-0.027	(0.00)***	-0.038	(0.00)***
$y^2 * hhtype2$	-0.013	(0.01)*	-0.009	(0.01)	-0.014	(0.01)
$y^2 * hhtype3$	-0.010	(0.00)**	-0.011	(0.00)***	-0.010	(0.00)***
$y^2 * hhtype4$	-0.009	(0.01)	-0.000	(0.01)***	-0.009	(0.01)
$y^2 * hhtype5$	0.006	(0.01)	0.012	(0.01)**	0.001	(0.01)
$y^2 * hhtype6$	-0.023	(0.01)***	-0.020	(0.00)***	-0.022	(0.00)***
Prices:						
interest rate (p_s)	-0.099	(0.02)***	-0.101	(0.02)***	-0.105	(0.02)***
consumer price (p_c)	-0.242	(0.09)***	-0.437	(0.10)***	0.105	(0.02)***
Control Variables:						
age (household head)	yes		yes		yes	
gender (head)	yes		yes		yes	
education (head)	yes		yes		yes	
marital stat. (head)	yes		yes		yes	
hh-comp	yes		yes		yes	
social status	yes		yes		yes	
net assets (2^{nd} pol.)	yes		yes		yes	
(asset pol.)*(renting)	yes		yes		yes	
durables dummies	yes		yes		yes	
dummy for renting	yes		yes		yes	
location (fed. states)	yes		yes		yes	
time dummies	yes		yes		yes	
Observations	72,236		90,778		72,236	
R^2	0.4086		—		0.4084	

Notes: y is current disposable income in logs. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, based on robust standard errors.
[a]: Specification "OLS (1)" is unconstrained, whereas specification "OLS (2)" is constrained for symmetry and homogeneity.

Source: Own calculations using the LWR data (2002-2007) provided by the FDZ.

Table 1.7: Estimates for Consumption Quantile Regressions

	10%	**25%**	**50%**	**75%**	**90%**
dep. var.: $s_{i,c}$	Coeffs (SE)	Coeffs (SE)	Coeffs (SE)	Coeffs (SE)	Coeffs (SE)
Income Polynomial:					
y	0.109 (0.06)*	0.346 (0.05)***	0.541 (0.05)***	0.791 (0.06)***	0.680 (0.06)***
$y * hhtype2$	-0.443 (0.19)**	-0.052 (0.18)	0.061 (0.19)	0.424 (0.20)**	0.741 (0.19)***
$y * hhtype3$	0.137 (0.08)*	0.090 (0.07)	0.194 (0.07)***	0.213 (0.08)***	0.292 (0.08)***
$y * hhtype4$	0.342 (0.18)*	0.196 (0.15)	0.111 (0.15)	-0.031 (0.18)	0.445 (0.23)**
$y * hhtype5$	-0.066 (0.14)	-0.136 (0.13)	-0.173 (0.13)	-0.187 (0.14)	0.071 (0.14)
$y * hhtype6$	0.737 (0.10)***	0.544 (0.09)***	0.355 (0.09)***	0.252 (0.09)***	0.283 (0.10)***
y^2	-0.022 (0.00)***	-0.036 (0.00)***	-0.046 (0.00)***	-0.057 (0.00)***	-0.047 (0.00)***
$y^2 * hhtype2$	0.024 (0.01)**	0.003 (0.01)	-0.004 (0.01)	-0.025 (0.01)**	-0.043 (0.01)***
$y^2 * hhtype3$	-0.006 (0.00)	-0.002 (0.00)	-0.008 (0.00)*	-0.009 (0.00)**	-0.014 (0.00)***
$y^2 * hhtype4$	-0.017 (0.01)*	-0.009 (0.01)	-0.005 (0.01)	0.002 (0.01)	-0.025 (0.01)**
$y^2 * hhtype5$	0.005 (0.01)	0.009 (0.01)	0.010 (0.01)	0.010 (0.01)	-0.005 (0.01)
$y^2 * hhtype6$	-0.036 (0.01)***	-0.026 (0.00)***	-0.016 (0.00)***	-0.011 (0.01)**	-0.014 (0.01)**
Prices:					
interest rate (p_s)	-0.093 (0.03)***	-0.123 (0.02)***	-0.119 (0.02)***	-0.092 (0.02)***	-0.053 (0.02)**
consumer price (p_c)	-0.256 (0.14)*	-0.155 (0.11)	-0.344 (0.11)***	-0.251 (0.11)**	-0.265 (0.11)**
Control Variables:					
see Table 1.6	yes	yes	yes	yes	yes
Observations	72,236	72,236	72,236	72,236	72,236
Pseudo-R^2	0.318	0.284	0.244	0.187	0.121

Notes: y is current disposable income in logs. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, based on robust standard errors.

Source: Own calculations using the LWR data (2002-2007) provided by the FDZ.

Table 1.8: Budget Elasticities at the Quantiles of Consumption Ratio Distribution by Household Composition

	10%		**25%**		**50%**		**75%**		**90%**	
	Sav	Con	Sav	Con	Sav	Con	Sav	Con	Sav	Con
Budget Elasticities:[a]										
Singles	1.63***	0.41***	1.84***	0.54***	2.10***	0.68***	2.32***	0.82***	2.33***	0.93***
Single parents	1.69***	0.48***	1.91***	0.56***	2.23***	0.67***	2.46***	0.81***	2.16***	0.94***
Couples, no kids	1.61***	0.41***	1.76***	0.54***	1.96***	0.67***	2.08***	0.81***	2.04***	0.92***
Couples, 1 kid	1.63***	0.32***	1.79***	0.45***	1.99***	0.59***	2.24***	0.72***	2.56***	0.85***
Couples, 2 and more kids	1.59***	0.36***	1.74***	0.46***	1.94***	0.56***	2.27***	0.67***	2.59***	0.81***
Large households[b]	1.61***	0.35***	1.70***	0.49***	1.85***	0.62***	2.03***	0.75***	2.03***	0.88***

Notes: Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, based on robust standard errors.
[a]: Budget elasticities computed according to Eq. (1.2) and price elasticities computed according to Eqs. (1.3) and (1.4).
[b]: Large households is a residual group. It is defined in footnote 28.
Reading example: At the ten percent percentile of consumption ratio distribution, savings for single households are increased by 1.63% in turn of a 1%-increase in income while consumption is increased by 0.41%.
Source: Own calculations using the LWR data (2002-2007) provided by the FDZ.

Chapter 2

Consumption over the Life Cycle - The Relevance of Liquidity Constraints[†]

2.1 Introduction

There is extensive empirical literature on the question whether households smooth consumption over the life-cycle or rely mainly on their current income. The validity of either the former or the latter hypothesis has great importance for the implications of fiscal policy, in a structural sense as well as in the context of business cycles. The *Life Cycle-Permanent Income Hypothesis* refers to the work of Modigliani and Brumberg (1954) and Friedman (1957) and assumes that agents have rational expectations on their lifetime income and wealth. Lifetime resources are allocated among all periods of the life-cycle according to the marginal utility of period consumption. Thereby, *permanent income* results as a long-term resource flow, which subsequently determines consumption in each period following the theory. If this hypothesis holds in reality, it would have many policy related implications, e.g. current income could not hold as a proxy for welfare or measuring inequality any more. Short-time fiscal spending in recessions should have no effect on consumption demand of private households, whereas tax cuts in the income taxation should have effects, and so on.

The permanent income hypothesis (PIH) specifically predicts the effect of a non-anticipated shock to permanent income on consumption to be near one. Lifetime income is allocated to current and future consumption over the remaining periods, with respect to this new informa-

[†]This chapter is based on joint work with Richard Ochmann from German Institute for Economic Research (DIW Berlin), see Beznoska and Ochmann (2012b).

tion. Consequently, in theory, a transitory shock has an influence near zero on consumption. The reason is that a positive transitory deviation from permanent income is saved nearly completely while a negative one is compensated by dissavings or taking-up a credit. The agent perceives the deviation and knows that its expected value will be zero over lifetime, and thus a transitory shock should have no relevant effect on consumption.

However, households are often found to behave differently in response to a shock than theory predicts (Jappelli and Pistaferri, 2010). There are numerous empirical findings suggesting that the PIH does not hold in the data.[1] Consumption has been found to be excessively smooth with respect to permanent income shocks (e.g. Campbell and Deaton, 1989; Attanasio and Pavoni, 2011), as well as excessively sensitive towards transitory income shocks (e.g. Hall and Mishkin, 1982; Souleles, 2002). In particular, the elasticity of permanent income is frequently estimated below one while the elasticity of transitory income is found to lie below the permanent one, but significantly different from zero (e.g. Blundell, Pistaferri, and Preston, 2008b). Excessive response to transitory shocks has been put in the context of transitory income uncertainty. It implies that current income is relatively more important for intertemporal consumption allocation than permanent income. This has been motivated in the literature with either precautionary motives (e.g. Carroll and Samwick, 1998), or deviations from rational behavior, such as myopia, inertia, loss aversion, or habit formation (e.g. Shea, 1995a), or with the presence of liquidity constraints (e.g. Zeldes, 1989b).[2]

Another aspect of the PIH, which has gained much attention in the literature, is the excess sensitivity of consumption to anticipated income changes (Flavin, 1981). Anticipated changes in income should have no effect at all on consumption because they are assumed to be already internalized. The literature on this topic finds significant evidence for excess sensitivity rejecting the PIH, which is also explained by the appearance of liquidity constraints (e.g. Zeldes, 1989a; Jappelli, Pischke, and Souleles, 1998; Pozzi and Malengier, 2007). However, there is also evidence for the validity of the PIH regarding the anticipated changes, especially if subsamples of persons with accumulated wealth are considered who are therefore not expected to be liquidity constrained (see e.g. Beznoska and Steiner, 2012, for consumption before and after retirement for Germany).

In this chapter, it is empirically investigated to which extent deviations from the PIH can be traced back to the presence of liquidity constraints in household consumption, utilizing a pseudo panel constructed on rich German consumption survey data. In a switching regression

[1] See Jappelli and Pistaferri (2010), or Attanasio and Weber (2010) for literature reviews on the consumption response to anticipated income changes and non-anticipated income shocks.

[2] See Browning and Lusardi (1996) for a survey on savings motives and empirical evidence on household savings behavior. Fossen and Rostam-Afschar (2012) provide recent evidence for the precautionary savings motive for Germany.

framework, marginal propensities to consume out of permanent and transitory income shocks are estimated, and it is tested for excess sensitivity of consumption to anticipated income changes. While the latter analysis is based on the approach by (Garcia, Lusardi, and Ng, 1997), the switching regression framework is also applied to an income shock model. The findings suggest a strong rejection of the PIH for households that are identified as liquidity constrained, in both the shock model as well as the excess sensitivity test.

The concept of liquidity constraints in intertemporal consumption is usually placed in the environment of incomplete markets, where agents' possibilities to insure consumption levels are limited to self insurance (Kaplan and Violante, 2010). The necessary condition for liquidity constraints is that agents do not hold enough liquid assets to keep up *permanent* consumption, which is determined by lifetime income. The sufficient condition is usually assumed fulfilled if agents are not able to borrow as desired at an interest rate that is in an acceptable range around the market lending rate or can not allocate the amortization payments in the preferred periods.[3] Instead of offering a higher interest rate, the credit institution would typically turn down the agent's request because of adverse selection issues.

Evidence for liquidity constraints in the literature is mixed. There are numerous studies that find evidence for liquidity constraints (e.g. Zeldes, 1989b; Kaplan and Violante, 2010), while other studies do not find any support for their relevance (e.g. Shea, 1995b). Evidence is also found to be mixed with respect to the size of the income change (e.g. Hsieh, 2003). Many studies that find evidence for liquidity constraints affecting consumer behavior focus on clear identification of exogenous income changes. In this context, several papers have looked at spending of tax rebates (e.g. Souleles, 2002; Johnson, Parker, and Souleles, 2006), others at repayment of car loans (e.g. Stephens, 2008); again others have utilized external information, such as credit card data (e.g. Gross and Souleles, 2002).

Often, availability of adequate data in this context is an issue. Household panel data on (total) consumption is only rarely available over a longer period of time. Thus, often repeated cross-sections on micro consumption data are applied in the literature to investigate intertemporal consumption decisions (e.g. Blundell, Low, and Preston, 2008a). In addition, typically, information on income and detailed consumption (non-durable as well as durable consumption) is not available jointly in micro data, so that information must be imputed (Blundell et al., 2008b), or consumption (pseudo) panel data be constructed (Alessie, Devereux, and Weber, 1997).

In this analysis, a pseudo panel constructed on repeated cross-sections of rich consumption survey data for Germany is used to investigate the consumption effects of income shocks in the context of liquidity constraints. In this data set, which is also used in Chapter 1,

[3] This is in line with the definition of liquidity constraints in the literature (see e.g. Garcia et al. (1997)).

income and consumption are observed jointly, both durable and non-durable consumption, very detailed by purchases of durable goods and spending on non-durable commodities. By applying specific treatment for purchases of durables it is accounted for relevant effects of liquidity constraints among durable consumption (Alessie et al., 1997; Attanasio, Goldberg, and Kyriazidou, 2008). Thus, there are relatively precise measures of the individual income and consumption processes whose joint evolution over time can be utilized to disentangle the consumption effects of income shocks into transitory and permanent elements.

Two models appear here, one is referring to the marginal propensities to consume out of permanent and transitory shocks and the other to test for excess sensitivity. For the former, a two-stage approach is applied to pseudo panel data, where current disposable income has to be split up into a permanent and a transitory part to identify its shocks at the first stage. At the second stage, a consumption growth equation is estimated including the permanent and transitory income shocks from first stage estimation as explanatory variables. For the latter, the consumption growth equation is re-specified to perform the excess sensitivity test.

For the consumption growth equations, a switching regression approach with unknown sample separation is used by applying an iterated two-step procedure with the EM algorithm (see Dempster et al., 1977) to identify the two regimes whether to be liquidity constrained or not. The contribution is twofold. While these kinds of models are used in the literature to test for excess sensitivity (Garcia et al., 1997), identification of two regimes based on the two income components has not been applied yet. Also, consumption processes based on a pseudo panel of rich consumption data have not been analyzed for Germany so far in this context to the best of my knowledge; in particular not allowing for explicit treatment of durable consumption. The findings suggest that for households in the constrained regime, reactions to changes in transitory income are significantly greater than for households in the unconstrained regime. In addition, there is evidence for excess sensitivity to anticipated income changes for households in the constrained regime if total consumption, durable as well as non-durable, is considered.

The remainder of the paper is organized as follows. In the next section, the model and the empirical strategy are introduced. Section 2.3 presents the data and some descriptive evidence. Results are provided in Section 2.4, and Section 2.5 concludes.

2.2 The Model

The model is presented in three steps. Firstly, the underlying income process and the integration of income shocks into a consumption growth equation are derived. Then, the model is adjusted to allow for a test for excess sensitivity and finally, estimation of the models in a switching regression approach with unknown sample separation is explained.

2.2.1 The Income Process and the Consumption Growth Equation

Firstly, it is focussed on the estimation of the marginal propensities to consume out of permanent and transitory shocks. Therefore, the first stage relates to the income process. Current disposable household income is the observed variable and thus has to be split up into a permanent and a transitory part. For this issue, current disposable income is regressed on covariates in a fixed-effects model at the pseudo-panel level (see Section 2.3 for details on constructing the pseudo-panel). The associated equation looks like this:

$$\ln(y_{it}) \;=\; \delta_1 \mathrm{age}_{it} + \delta_2 \mathrm{age}_{it}^2 + X_{it}^{'}\beta + \alpha_i + \omega_{it} \tag{2.1}$$

where the error-term ω_{it} is allowed to be autocorrelated

$$\omega_{it} \;=\; \rho\omega_{it-1} + \epsilon_{it}. \tag{2.2}$$

$\ln(y_{it})$ denotes the natural logarithm of current disposable income. The covariates include age, age squared and a vector X_{it} that contains interactions of the age polynomials with the employment status of the household head and household composition. Additionally, other household characteristics are included in X_{it}, such as skill-level of the household head and information on the partner. α_i is a cluster-specific fixed effect, ω_{it} is an autocorrelated error-term and ϵ_{it} is white noise. See e.g. Miles (1997), for a similar approach of separating permanent from transitory income components.

At this point, predictions for the permanent and transitory parts of current disposable income can be defined, which are

$$\pi_{it}^P \;\equiv\; \widehat{\ln(y_{it})} \;=\; \hat{\delta}_1 \mathrm{age}_{it} + \hat{\delta}_2 \mathrm{age}_{it}^2 + X_{it}^{'}\hat{\beta} + \hat{\alpha}_i \tag{2.3}$$

for permanent income and

$$\pi_{it}^T \;\equiv\; \hat{\omega}_{it}\,, \quad E[\omega_{it}] = 0 \tag{2.4}$$

for transitory income.

The *non*-anticipated shock to permanent income is the term of interest, in this first analysis. Therefore, the dynamic processes underlying π_{it}^P are investigated. Non-anticipated permanent income changes should be free of any autocorrelation structures; they should have an expected value of zero. This should also hold for π_{it}^T so that the autoregressive parameter in Eq. (2.2) should be close to zero. More details on this procedure are provided in Section 2.4.1, where the dynamics of the income process are further investigated and discussed. The assumption for the further analysis is that changes to permanent income (π_{it}^P) and transitory income (π_{it}^T) can be interpreted as non-anticipated income shocks.[4]

At the second stage of the approach, a consumption equation is applied, in which the validity of the permanent income hypothesis can be tested. Jappelli and Pistaferri (2010) show how starting from an Euler equation and making some assumptions about the consumption and income processes leads to a consumption growth equation, in which the parameters can be interpreted as structural, and thus they allow for testing the theory. Hall and Mishkin (1982) identify these parameters via contemporaneous and serial correlation between income growth and consumption growth. For the switching regression approach, a parameter identification via variance-covariance matrix is not feasible. Instead, it is started off with a reduced form level equation for the empirical specification:

$$\ln(c_{it}) \;=\; \phi\pi_{it}^P + \psi\pi_{it}^T + M_i^{'}\gamma_1 + Z_t^{'}\gamma_2 + \gamma_3\text{age}_{it} + \gamma_4\text{age}_{it}^2 + \xi_{it} \tag{2.5}$$

where $\ln(c_{it})$ denotes the natural logarithm of consumption, M_i is a vector of time-invariant household characteristics, Z_t is a vector of time dummies and ξ_{it} is an independent error-term. In the main specification, consumption contains all non-durable consumption. In a robustness check, total consumption, non-durable as well as durable, is analyzed by adding generated user costs for durable goods to non-durable consumption. See Appendix 1.7.2 for details on how user costs have been generated.

First-differencing of Eq. (2.5) leads to:

$$\Delta\ln(c_{it}) \;=\; \phi\Delta\pi_{it}^P + \psi\Delta\pi_{it}^T + Z_t^{'}\gamma_2 + \gamma_5\text{age}_{it} + \Delta\xi_{it} \tag{2.6}$$

where $\Delta\xi_{it}$ is an independent error-term, which is assumed to be uncorrelated with the shocks $\Delta\pi_{it}^P$ and $\Delta\pi_{it}^T$.[5] This assumption is crucial to gain consistent coefficients. Eq. (2.6) is consistent with the one derived from the Euler equation in Jappelli and Pistaferri (2010).[6] The non-differenced time dummies Z_t appear here, because this equation should allow for an in-

[4]Non-anticipated changes in the context of permanent income are mainly changes in the occupational status and in the number of adults, which represents the working capability of the household. Not all these changes are in fact non-anticipated but this has to be the assumption due to no further information in the data.

[5]Note that first-differencing of the age polynomial yields: $\Delta(\text{age} + \text{age}^2) \;=\; 1 + 2 \cdot \text{age}$.

[6]Jappelli and Pistaferri (2010) derive Eq. (2.6) under the assumptions of a martingale process in permanent income and a constant interest rate over time that equals the intertemporal discount rate. In the specification of Eq. (2.6), the interest rate is omitted on the right hand side because it exhibits too little variation over time in the data. Note that also if additional variation in the interest rate is generated in terms of "personalized interest rates" at the household level by utilizing differentials in after-tax rates of return, this variation gets averaged out at the pseudo-panel level.

tercept for estimation purposes.[7] However, this captures all variation over time that would be captured with differenced time dummies.

In order to identify two regimes of Eq. (2.6), which allow for different parameters ϕ and ψ dependent on whether households are liquidity constrained or not, a switching regression approach with unknown sample separation is applied. Details on this approach are discussed in the last subsection below.

The implications that are given by theory suggest the null hypothesis of $\phi = 1$ and $\psi = \kappa$, where κ depends on the interest rate and the marginal propensity to consume out of assets and should be a small value (see Hall and Mishkin (1982)). κ declines if remaining life time increases. As a rule of thumb, κ can be approximated by $\frac{1}{T}$ where T is the expected number of remaining periods of lifetime.[8] This approximation is used in the following to test the permanent income hypothesis. It suggests that κ is a function of age. Thus, in a robustness check, age is interacted with the transitory income shock to test whether reactions to transitory shocks differ by age of the household head.

2.2.2 The Excess Sensitivity Test

Another testable part of the PIH deals with the response to *anticipated* income changes. In the absence of excess sensitivity, the response to *anticipated* permanent and transitory income changes should be zero. The PIH predicts that consumption has already been adjusted with respect to anticipated income changes when the intertemporal consumption allocation has been planned for all periods in advance. There should be no additional response to anticipated changes. This is what is tested here. The basic model is extended from the first analysis to allow for a test for excess sensitivity to anticipated income changes.

Flavin (1981) pointed out that, in the absence of excess sensitivity, consumption should follow a martingale, in which information gained in the past does not matter for the present consumption decision.

$$\ln(c_{it+1}) = \ln(c_{it}) + \nu_{it+1} \tag{2.7}$$

where ν_{it+1} is an error-term that covers all *new* information that is available to the household in $t+1$, including shocks. If $\ln(c_{it})$ is subtracted on both sides of the Eq. (2.7) and a rational expectation term of income changes is added on the right-hand side, which is based on information available at time t and should thus be zero, this should not alter the basic functional relation. Thereby, the excess sensitivity test is nested within an Euler equation derived from

[7] Stability in the switching regression improves significantly if the time dummies appear not differenced in Eq. (2.6).

[8] This approximation assumes that one extra transitory Euro in the current period will be allocated equally to consumption over all remaining periods of lifetime.

dynamic utility optimization in the context of intertemporal consumption allocation, following Runkle (1991) and Zeldes (1989a):

$$\Delta \ln(c_{it+1}) = \delta E_{it}\left[\Delta \ln(y_{it+1})\right] + Z'_{t+1}\gamma_6 + \gamma_7 \text{age}_{it+1} + \gamma_8 \Delta \text{adults}_{it+1} + \gamma_9 \Delta \text{kids}_{it+1} + \nu_{it+1} \quad (2.8)$$

where in the empirical specification, the same control variables are added that are included in the consumption growth equation Eq. (2.6). To control for taste shifts of the household, the first differences of the numbers of adults as well as children in the household are included, where the specification follows the ones applied in Garcia et al. (1997) and Jappelli et al. (1998). In these specifications, it is suggested to substitute in the estimation the expectational term $E_{it}\left[\Delta \ln(y_{it+1})\right]$ by the observed income in t, $\ln(y_{it})$.

The null hypothesis on the validity of the PIH in the context of excess sensitivity which can be tested here is $\delta = 0$ in Eq. (2.8). Applying the switching regression approach again is aimed to identify two regimes according to the presence of liquidity constraints and test the PIH for both of them.

2.2.3 The Switching Regression Approach

For identification of the two regimes, whether to be liquidity constrained or not, a switching regression approach with unknown sample separation is applied to test for the validity of the PIH in the shock model (Eq. (2.6)) as well as for excess sensitivity (Eq. (2.8)).

The exact classification of households facing liquidity constraints is difficult in household survey data. Questions directly relating to this issue, like "Do you have access to as much credit as desired in your credit institution?" appear rather rarely in common surveys, and there is no such information in the used data. Variables that are related to the issue of liquidity constraints are current disposable income and the ratio of financial wealth to permanent income, for example, which refer to the aspect of available household liquidity. Then there are proxies for the uncertainty of future income flows, such as the status of current unemployment or being in education, as negative examples, and being a civil servant, as a positive example. Another indication that should reflect the absence of liquidity constraints, and a status of good creditworthiness, is whether households can afford to repay their loans, i.e. if they have a high ratio of amortisation payments related to the level of debt. But despite all these indicators, which are potentially related to liquidity constraints, it remains challenging to separate the sample into two regimes. Besides the problem that all these variables are continuous so that setting a sample-separating threshold can only be arbitrary, other difficulties arise in terms of multidimensions when interactions between the indicators are constructed.[9]

[9]Note that in the pseudo-panel the information about being unemployed, in education or in civil service is

Zeldes (1989a) splits the sample on the basis of various criteria on the wealth to income ratio and tests the permanent income hypothesis against several thresholds. He finds his results to be quite sensitive with respect to different sample splits. However, because of the arbitrary splitting criteria and the resulting need to estimate the model for numerous specifications of sample splits, the application of a switching regression approach with unknown sample separation is preferred here, as suggested by Garcia et al. (1997). While on the one hand, this appears to be an elegant way to "let the data speak" about which two regimes can be identified via selection equation, on the other hand, Maddala (1986) points out that one maybe "asks too much from the data" in this kind of switching regression and that maximum likelihood estimation may result in local, rather than global maxima due to unboundedness of the likelihood function. But he also states that the results from empirical applications are "surprisingly" good.

The switching regression approach is presented here for the shock model (Eq. (2.6)); it applies equivalently to the excess sensitivity test (Eq. (2.8)). The model consists of equations for the two regimes mentioned earlier and a selection equation, resulting in the 3-equation-model

$$\begin{aligned} \Delta \ln(c_{it}) &= \phi_1 \Delta\pi^P_{it} + \psi_1 \Delta\pi^T_{it} + \Delta\xi_{1it}\,, \qquad \text{if} \quad K'_{it}\lambda + u_{it} < 0 \\ \Delta \ln(c_{it}) &= \phi_2 \Delta\pi^P_{it} + \psi_2 \Delta\pi^T_{it} + \Delta\xi_{2it}\,, \qquad \text{if} \quad K'_{it}\lambda + u_{it} \geq 0 \end{aligned} \tag{2.9}$$

where control variables have been omitted for clarification reasons, see Eq. (2.6) for details.[10] The subscripts 1 and 2 denote the belonging to the respective regime and K_{it} is a vector of variables that are assumed to determine the presence of liquidity constraints. K_{it} contains current disposable income, the ratio of financial wealth to permanent income, and the ratio of amortisation payments to the level of debt.[11] Additionally, K_{it} includes household characteristics, such as age of the household head, household composition, and interactions between the characteristics and current income, as well as time dummies.[12] The error-terms $\Delta\xi_{1it}$, $\Delta\xi_{2it}$ and u_{it} are assumed to be independent and normally distributed with variances $\sigma^2_{\xi_1}$, $\sigma^2_{\xi_2}$ and σ^2_u. The latter is set to be 1 for identification purposes.[13]

a continuous variable, too. It only reflects the cluster share of household heads that are in the specific status.

[10] The parameters of the control variables are of course allowed to vary between the two regimes, too.

[11] Similar indicators have been suggested in the relevant literature. E.g. Johnson and Li (2010) suggest to use the debt-payments-to-income-ratio as an additional indicator of borrowing constraints.

[12] The variables in K_{it} that actually identify the selection are allowed to vary among the various specifications for stability reasons in the iteration of the switching regression.

[13] For the shock model, the proxies for the income shocks (π^P_{it}, π^T_{it}) in Eq. (2.9) are derived from the income equation (Eqs. (2.1) and (2.2)) estimated separately from the switching regression at a first stage. There is potentially heterogeneity in the income processes over the two regimes. However, the switching regression approach that is applied here does not allow for an integration of the income processes, the selection equation, and the consumption growth equation. It is assumed that the two regimes face identical income processes.

The model can be estimated by maximizing the likelihood function (Garcia et al., 1997)

$$f(\Delta \ln(c_{it})) \;=\; P_{it} f(\phi_1, \psi_1, \Delta\xi_{1it}) + (1 - P_{it}) f(\phi_2, \psi_2, \Delta\xi_{2it}) \tag{2.10}$$

where the $f(\cdot)$ function denotes the density of the normal distribution. This maximization problem is solved by applying an iterated two-step procedure with the EM algorithm (see Dempster et al. (1977)).[14] In the second step (the main equation) of the two-step algorithm, the observations are weighted by their probability of belonging to each of the regimes, which in turn depends on the first step (the selection equation).

Let therefore

$$P_{it} \;=\; \frac{f(\Delta\xi_{1it})\Phi(-K'_{it}\lambda)}{f(\Delta\xi_{2it})(1 - \Phi(-K'_{it}\lambda))} + f(\Delta\xi_{1it})\Phi(-K'_{it}\lambda) \tag{2.11}$$

denote the probability of belonging to the first regime, where the $\Phi(\cdot)$ stands for the normal cumulative distribution function.[15]

2.3 Data and Descriptive Evidence

Firstly, the data set applied is introduced and the conversion from the household level to the synthetic panel level is described. Then, some descriptive evidence for the composition of the clusters generated for the pseudo panel, as well as on cluster-average income and consumption shares is presented.

2.3.1 Data

The micro data applied in this analysis stems from the Continuous Household Budget Survey for Germany (*Laufende Wirtschaftsrechnungen*, LWR) as in Chapter 1. The LWR data is repeated cross-sectional consumption survey data, which is repeated every year since 2002 containing information on income, consumption, and savings, very detailed by single components, at the household level. Six waves are used covering the time period from 2002 to 2007, where a break in data structure is faced since 2005.[16]

In the first three waves, the sampled households are observed for a time of four months (one month out of each quarter of the year). Since 2005, recruited households stem from a subsample of the Income and Consumption Survey for Germany (*Einkommens- und Verbrauchsstichprobe*, EVS) and are observed for an entire quarter. This means that a monthly

[14] This has been done here using the user-written Stata routine "switchr" (see Zimmerman (1999)).
[15] In the first iteration, the densities that stem from the residuals of the main equation have been set to one.
[16] See Appendix 1.7.1 for more details on the data set.

data structure is available from 2002 to 2004 and a quarterly one from 2005 to 2007. This structural break in the data has been accounted for in the analysis and it is addressed in further detail in Section 2.4. Altogether, the pooled data set contains 91,359 observation at the household level.

2.3.2 Construction of the Pseudo-Panel

In order to eliminate a cluster specific fixed-effect and to be able to model the dynamics in this approach, a pseudo panel is constructed from the repeated cross sections. In the particular analysis, a pseudo panel has the advantage compared to a standard panel analysis that it can more accurately capture income and consumption streams across the entire life cycle. In a real panel, we typically observe households over a limited time span, in which the observed income and consumption streams might be affected by age effects. Thus, a life-cycle analysis based on a real panel would probably need averaging over age groups. In a pseudo panel defined on birth cohorts, income and consumption streams can be smoothed out over the entire life-cycle, naturally also only on cohort-average.

The pseudo panel is constructed by forming 17 clusters, which are observed over 48 time periods (3×12 in the waves 2002-2004 and 3×4 in the waves 2005-2007). The 91,359 observations at the household level are organized into these 17 clusters by three dimensions: birth cohort group, gender, and level of education. This results in 816 cells at the pseudo-panel level where the criteria, especially the size of the birth cohort group, are set in such a way that there is a similar number of observations in each cell. In the end, the average number of observations per cell is about 112, where the smallest cell has 77 and the biggest cell reaches 175 observations. More details can be found in the next subsection. All variables that are available at the household level are averaged over all observations in a cell.[17] These averaged variables become the pseudo-panel variables, which are measured with measurement error if the composition of the cells varies over time in the selected criteria.

Due to the fact that the measurement error, and thus the potential bias in the estimated coefficients, diminishes with the number of observations per cell, Verbeek and Nijman (1992) suggest that at least about 100 observations per cell should be reached to fulfill consistency. While the population per cell in the pseudo-panel is slightly above 100 on average, and additionally there is nearly the same composition per cluster within the waves 2002, 2003 and 2004, it is suggested that consistency is given in the constructed pseudo-panel, and further correction for measurement error is neglected. As mentioned above, the specific characteris-

[17] Note that dummy variables at the household level only form dummies in the pseudo-panel if all observations face the same outcome, which is the case e.g. for time dummies and gender. If the observations in a cell have heterogeneous outcomes for a dummy the averaging will lead to a proportion variable at the pseudo-panel level, which can be treated as a normal variable in the regressions.

tic of the data structure, which consists of half monthly and half quarterly data, has been accounted for in the dynamic estimations (see Section 2.4 for details).

2.3.3 Descriptives

Table 2.1 displays descriptive statistics on cluster composition and on income and total consumption on cluster averages, as well as over all clusters. Total consumption contains non-durable consumption as well as generated user costs for durable consumption. User costs for durable consumption have been imputed such that the longevity nature of durable goods is better accounted for, instead of merely looking at expenditure for durable purchases (also see Appendix 1.7.2).[18] In the regression analysis, the focus is on total consumption as well as non-durable consumption.

The composition on the clusters reveals that households are distributed sufficiently evenly across the 17 cluster. Clusters are composed of between 4,699 and 6,726 observations over all points in time (which corresponds to 5.1% and, respectively, 7.4% of all observations). As a result, clusters are filled, on average over all points in time, with about 112 households (ranging between 98 and 140).

For an average household, current income in monthly terms amounts to 2,791 euros, on average over the 48 points in time. The average household consumes 88.8% of current income and saves the rest. Its head is 55.0 years of age on average. When current household income in monthly terms and consumption as a share of current income (in %) are broken down by the 17 clusters, between-cluster heterogeneity is revealed. Generally speaking, current income is around average, or lower than average, for all clusters with a female head. As would be expected, income is relatively greater for the highly educated than for the less educated. Incomes are also greater for the younger cohorts than for older cohorts. The greatest incomes are found for the clusters of highly educated male heads and the lowest among households headed by less educated females.

There is also between-cluster variation in the total consumption share, averaged over the 48 time periods. The main apparent pattern is that consumption shares are relatively lower for younger cohorts. While they are above 90% for cohorts born before 1943, they are between 85% and 90% for most of the cohorts born between 1943 and 1960, and they are lower than 80% for some of the cohorts born after 1960. This pattern is, of course, a mixture of an age effect and potential cohort and time effects, which are not be separable in this interpretation. As one would expect the consumption share to increase in old age when agents run down their

[18]One could argue that durable expenditures are more relevant, when it comes to liquidity constraints, than consumption streams. It should however be noted that in the pseudo-panel approach, durable expenditures are smoothed anyway by the clustering. The imputation approach will do no harm to the data here. It should rather be considered as a kind of selection correction for zero observed expenditures.

Table 2.1: Income and Consumption by Clusters

Cluster[a]	N	N_j/N	N_j/T	age	$\bar{y}_j^{curr}$	$\bar{c}_j(\%)$
All clusters	91,359	100.0	1,903	55.0	2,791	88.8
(m, h, <1937)	6,726	7.4	140	74.4	2,870	90.9
(m, h, 1937-1942)	5,547	6.1	116	64.8	3,287	91.7
(m, h, 1943-1950)	5,654	6.2	118	58.1	4,193	87.9
(m, h, 1951-1956)	5,584	6.1	116	51.2	4,483	82.8
(m, h, 1957-1962)	5,180	5.7	108	44.8	4,532	77.5
(m, h, >=1963)	5,187	5.7	108	36.8	4,088	76.1
(m, l, <1938)	5,207	5.7	108	74.2	2,124	92.3
(m, l, 1938-1945)	4,699	5.1	98	62.9	2,782	94.7
(m, l, 1946-1954)	4,985	5.5	104	54.3	3,205	88.7
(m, l, 1955-1962)	5,129	5.6	107	46.1	3,254	87.8
(m, l, >=1963)	4,895	5.4	102	36.6	2,964	82.2
(f, h, <1948)	5,618	6.1	117	68.5	1,959	94.6
(f, h, 1948-1958)	5,577	6.1	116	51.6	2,615	89.5
(f, h, >=1959)	5,431	5.9	113	38.2	2,605	83.4
(f, l, <1942)	5,482	6.0	114	72.8	1,379	96.5
(f, l, 1942-1958)	5,581	6.1	116	54.4	2,007	91.7
(f, l, >=1959)	4,877	5.3	102	38.4	1,959	90.9

Notes: $\bar{y}_j^{curr}$ is current household income in monthly averages, in real terms, and weighted by population weights. The pseudo-panel weight for permanent income is the average household weight in each cell. N_j/T is the average number of observations in the cluster over the 48 points in time. $\bar{c}_j(\%)$ is the average consumption rate, as a share from current income, in percent and weighted.
[a]: Clusters defined by gender of household head, education of household head, and year of birth of household head. E.g., (m, h, 1937-1942) is for males, highly educated, born between 1937 and 1942.

Source: Own calculations using the LWR data (2002-2007), provided by the FDZ.

assets according to the life-cycle hypothesis, and the cohorts are only observed for a period of seven years here, one would expect the consumption shares of the older cohorts to be relatively greater.

Consumption shares are furthermore slightly greater for the clusters of the less educated household heads (82.2%-96.5%) than for those of highly educated ones (76.1%-94.6%). They are also slightly greater for clusters with a female household head (83.4%-96.5%) than for those with a male head (76.1%-94.7%). This descriptive consumption evidence is probably contaminated by an income effect that is not controlled for here.

2.4 Results

This section is divided into three parts: 1) results for the income process, 2) for the consumption growth equation, and 3) for the excess sensitivity test. Due to the two different data structures underlying the constructed pseudo panel (see Section 2.3), a differentiated treatment is required at some points. Firstly, some conceptual points resulting from these structural differences for the estimation of the income process are discussed. Results from this first stage are used to estimate the consumption growth equation and the excess sensitivity test, by both OLS and the switching regression technique. Results for the main specification as well as for some alternative specifications and robustness checks are presented and discussed in the second and the third subsection.

2.4.1 Results for the Income Process

While estimation of Eq. (2.1), the fixed effect model, is quite standard and leads to plausible results if it is estimated with the whole pseudo-panel (see Table 2.6 in Appendix 2.6 for results), the results for the dynamic specification are further elaborated on. An autocorrelation coefficient ρ of -0.1 is estimated in Eq. (2.2), which indicates a relatively small persistence in the error-term. This result indicates that one can probably assume that the household preceives this part of the income variation as truely transitory, so this residual effect is interpreted as a proxy for transitory income shocks.

As already mentioned in Section 2.2, the *non*-anticipated permanent income shock is the term of interest at this point. Thus, the dynamics of the proxy for permanent income, π_{it}^P, are investigated. To serve as a good proxy for non-anticipated permanent changes, the residual of the dynamics should be free of any autocorrelation structure and should have an expected value of zero. Thus, if an estimate for the autocorrelation term in the dynamics of π_{it}^P is found that is significantly smaller than 1, this would result in a non-zero expected value for the residual and the residual could not be interpreted as a shock to permanent income, which has not been anticipated by the household.

In the estimation of the dynamics of permanent income, it has to be accounted for the structural break from monthly to quarterly waves in the survey data. Firstly, the autocorrelation structure of π_{it}^P is analyzed for the quarterly waves, where an AR(1)-process for $\widehat{\ln(y_{it})}$ is estimated. Applying the Arellano-Bover system GMM estimator, using the second lag as an instrument for the endogenous first lag, to estimate the AR(1)-process for the waves 2005, 2006 and 2007 separately, the null hypothesis of an autocorrelation coefficient of 1 cannot be rejected for each wave.[19] This result provides evidence for the assumption that the residual of the permanent income dynamics can be interpreted as a proxy for true shocks that are non-anticipated. Conclusively, the first difference in permanent income is expected to be stationary and deals as a proxy for permanent shocks in the consumption growth equation

[19]This implies a unit root for permanent income. The Sargan test statistic suggests valid instruments in all cases with p-values of 0.33 (2005), 0.75 (2006) and 0.50 (2007).

Eq. (2.6).

On the contrary, the monthly waves (2002 to 2004) are autocorrelated per construction within a year because a household is observed for one month of each quarter. This break in the data structure requires an alternative treatment. Therefore, the first-difference of permanent income in t is regressed on the respective first-difference in $t-3$. The autocorrelation coefficient is estimated at 0.92 in 2002, not significantly different from 1, which implies that a unit root cannot be rejected. However, in 2003 and 2004, the coefficient is found to be significantly smaller than one (0.88 and 0.78). To correct the first-difference for the quarterly autocorrelation, the residual of this regression is used as an estimate for $\Delta\pi_{it}^{P}$ in the waves 2002 to 2004.[20]

2.4.2 Results for the Shock Model

Table 2.2 displays the results from the estimation of the consumption growth equation, Eq. (2.6), where firstly only non-durable consumption is considered as the dependent variable. Coefficient estimates for the permanent shock (ϕ) and the transitory shock (ψ) from the OLS estimation of the pooled model, as well as the switching regression for the regime model, are presented. Effects of covariates are left out here; full results are relegated to Table 2.7 in Appendix 2.6. The effects in Table 2.2 can be interpreted as the marginal propensity to consume (MPC) out of permanent income, respectively transitory income. Additionally, test results for hypotheses on the effects from theory are presented.

In the pooled model, the MPC out of permanent income is estimated at 0.667 and the MPC out of transitory income at 0.204. If permanent income increases by 10% consumption increases by 6.7%, on average for the entire sample. However, if the 10%-increase in income is of transitory nature consumption increases only by 2.0%. Although the reaction to transitory shocks is found to be significantly smaller than to permanent changes (χ^2-statistic = 40.12), these effects do not correspond to the PIH. The hypothesis that the reaction to a permanent shock is unity must be rejected at the 1% level (32.99). For a transitory shock, it shall be tested whether the reaction equals $\kappa = 0.05$, which results from the approximation in Section 2.2. This hypothesis must also be rejected at the 1% level (11.41).

In the regime model, estimated by the switching regression, the results are generally in the same range as for the linear model. For the constrained regime, which is expected to contain households that are identified to be liquidity constrained, the MPC out of permanent income is estimated at 0.626. This is significantly lower than unity (χ^2-statistic = 46.72), but it is not

[20] In a robustness check, a specification was tested where quarterly pseudo panel observations are constructed from pooling the monthly micro data within a quarter. While this reduces the number of pseudo panel observations drastically, the OLS results do not vary much. However, switching regression estimation was not feasible for this specification due to non-convergence of the EM algorithm. Also see footnote 22.

Table 2.2: Marginal Effects for the Consumption Growth Equation (**Non-durable** Cons.)

	OLS	**Switching Regression**	
Dep. var.: $\Delta \ln(c_{it})$	Pooled Model	Regime 1 (Constrained)	Regime 2 (Unconstrained)
Permanent shock (ϕ)	0.667***	0.626***	0.787***
	(0.058)	(0.055)	(0.133)
Transitory shock (ψ)	0.204***	0.427***	0.048
	(0.046)	(0.040)	(0.049)
Probability of regime 1 (P_{it})	-	0.422	
N (cells)	748	748	748
R^2	0.215	0.586	0.146
Tests (χ^2-statistic):			
$\phi = \psi$	40.12	11.05	24.79
$\phi = 1$	32.99	46.72	2.56
$\psi = \kappa = 0.05$	11.41	86.94	0.00
$\phi_1 = \phi_2$	-	1.26	
$\psi_1 = \psi_2$	-	35.58	
$\phi_{SWR} = \phi_{OLS}$	-	0.27	0.68
$\psi_{SWR} = \psi_{OLS}$	-	13.33	5.44

Notes: See Table 2.7 in Appendix 2.6 for complete estimation results and full list of covariates. Significance levels: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$; robust standard errors in parentheses, adjusted for clustering, not adjusted for two-step estimation.

Source: Own calculations using the LWR data (2002-2007), provided by the FDZ.

significantly different from both the unconstrained regime (1.26) and the pooled model (0.27). Most remarkably, the MPC out of transitory income is estimated at 0.427, which is notably large and in particular larger than for the other groups. It is significantly different from 0.05 (86.94) and from the coefficient for the pooled sample (13.33). The initial probability of being in the constrained regime is estimated at 42.2%. However, the interpretation of this estimate is limited as it only splits the sample into two regimes and is not a structural parameter.[21]

Considering the coefficients for the unconstrained regime, the MPC out of permanent income is estimated at 0.787, which is not significantly smaller than unity at the 5% level (χ^2-statistic = 2.56), but not significantly different from the result for the pooled model either (0.68). The standard error here is quite large compared to the other ones found in the OLS

[21] The exact classification of each household into being constrained or not is not possible in the model. This is because within a pseudo panel observation, which consists of 112 households on average, not every household will face the same regime. Therefore interpreting this probability as a share of constrained households in the population would involve an aggregation bias.

equation and in Regime 1. The effects for the *transitory* shock differ significantly over the regimes. The MPC out of transitory income is estimated at 0.048 for the unconstrained regime, which is neither significantly greater than 0 nor than 0.05, but it is significantly lower than for the constrained regime (35.58), and also lower than for the pooled model, at least at the 5% level (5.44). Furthermore, a test on equality of the two parameters within the regime is strongly rejected (24.79).

In a robustness check, the switching regression model was estimated again, this time allowing switching to be determined endogenously. But there were no significant differences found in the coefficients, although the selection term in the constrained regime is significant (see Table 2.9 in Appendix 2.6 for details). A remarkable difference is that the standard error of $\widehat{\phi}$ in the unconstrained regime is clearly smaller with 0.077 than in the model with exogenous switching. Here, the test for $\widehat{\phi} = 1$ is rejected at the 1% level. Also, it is significantly different from the coefficient in the constrained equation, at least at the 10% level (χ^2-statistic = 3.29), which means that the two regimes are significantly different in both coefficients, the permanent and the transitory one. A limitation that has to be taken into account when applying the switching regression with unknown sample separation, besides converging issues, is that the standard errors can only be approximated. Therefore, the results based on this smaller standard error in the model with endogenous switching are only interpreted as a robustness check.[22]

In an alternative specification, the measure for consumption is extended from non-durable to total consumption. It is tested whether there are differences in the reaction to income changes if allowing consumption to consist of non-durable commodities as well as a constructed depreciation for durable consumption goods, in terms of user costs. In Table 2.3, the results for the consumption growth equation on *total* consumption are shown.

Although the point estimates slightly differ, no significant differences are found in the coefficients compared to the analysis on non-durables. The point estimate in the unconstrained regime for the permanent shock is a bit smaller with 0.660 and estimated more robustly. Now, as in the model for non-durables with endogenous switching, it is significantly different from 1 (27.44) and the PIH would be rejected even for the unconstrained households. The transitory reaction is with an MPC of 0.071 found to be only slightly greater. Importantly, the difference in the effect on transitory income between the two regimes is actually significant at the 1% level (6.47) because of more efficient estimates.[23]

[22]Furthermore, the consumption growth equation was re-estimated by constructing quarterly observations from the monthly waves for 2002-2004 as a robustness check. This specification ended up with 374 pseudo panel observations, and the OLS results turn out to be not significantly different from the ones shown in Table 2.2: $\widehat{\phi} = 0.643\,(0.083)$ and $\widehat{\psi} = 0.265\,(0.064)$. However, the switching regression analysis could not have been applied here due to non-convergence of the EM algorithm.

[23]Again, the model was also estimated with endogenous selection and no significant differences were found.

Table 2.3: Marginal Effects for the Consumption Growth Equation (**Total** Cons.)

	OLS	**Switching Regression**	
Dep. var.: $\Delta \ln(c_{it})$	Pooled Model	Regime 1 (Constrained)	Regime 2 (Unconstrained)
Permanent shock (ϕ)	0.648***	0.610***	0.660***
	(0.058)	(0.060)	(0.065)
Transitory shock (ψ)	0.246***	0.410***	0.071
	(0.043)	(0.035)	(0.053)
Probability of regime 1 (P_{it})	-	0.435	
N (cells)	748	748	748
R^2	0.303	0.487	0.593
Tests (χ^2-statistic):			
$\phi = \psi$	38.18	12.10	58.46
$\phi = 1$	36.97	42.99	27.44
$\psi = \kappa = 0.05$	20.30	108.12	0.15
$\phi_1 = \phi_2$	-	0.32	
$\psi_1 = \psi_2$	-	28.39	
$\phi_{SWR} = \phi_{OLS}$	-	0.21	0.02
$\psi_{SWR} = \psi_{OLS}$	-	8.73	6.47

Notes: See Table 2.8 in Appendix 2.6 for complete estimation results and full list of covariates. Significance levels: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$; robust standard errors in parentheses, adjusted for clustering, not adjusted for two-step estimation.

Source: Own calculations using the LWR data (2002-2007), provided by the FDZ.

This is the central finding for the shock model. On the one hand, the reaction of average households to non-anticipated changes in income do not correspond to the PIH. Their reaction to permanent shocks is lower than theory would predict, and transitory shocks are perceived more sensitively than the model would tell. On the other hand, two groups have been identified according to indicators for presence of liquidity constraints. Households in the group that is identified as constrained react significantly stronger to transitory shocks to income than households in the unconstrained group. The findings for the unconstrained regime tend to confirm the validity of the PIH for this group. The results are in line with findings from the relevant literature, where rejections of the PIH are interpreted in terms of liquidity constraints (see inter alia Blundell et al., 2008b).

Looking at the distribution of the probability for being in the *un*constrained regime across the pseudo panel clusters, above-average probabilities are found for the older birth cohorts (<1943 high skilled men, <1948 high skilled women, and <1942 low skilled women), except for the oldest birth cohorts of low skilled men (<1946). The latter group in fact also faces the highest probability compared to the younger birth cohorts of low skilled men, but is still only at about the overall mean of 57.8%. The probability for high skilled men in the oldest birth cohorts, averaged over all time periods, is about 69%; for high skilled women, it is 76%, and for low skilled women 66%. Among the oldest birth cohorts, conditional on gender, the high skilled birth cohorts have clearly higher probabilities to be unconstrained than the lower ones, as expected, but this relationship does not hold over all birth cohorts. Interestingly, women tend to have slightly higher probabilities than men in the oldest birth cohorts, and the youngest birth cohorts (>=1963 for men and >=1959 for women), surprisingly, never have the lowest probabilities within a skill level.[24]

The results for the consumption growth equation are found to be robust to a couple of alternative specifications. In the regime equation, an initial guess is needed to determine the two regimes according to the presence of liquidity constraints. This initial guess has been made for three indicators of liquidity constraints, namely the unemployment rate in the cell, the ratio of financial wealth to permanent income, and the ratio of loan repayments to the level of outstanding debt (also see Section 2.2). The model has been re-estimated for several alternative guesses on these indicators: the 25%, 50%, and 75% quantiles of the unemployment rate, respectively of the wealth ratio, and respectively of the loan repayment ratio. The results are robust for all these nine estimations.

As it has already been mentioned in the introduction of the model (Section 2.2), due to its construction, the effect of the transitory shock (ϕ) potentially varies by age of the household head. Therefore, an interaction switching regression is estimated to test the hypothesis that, if the PIH holds, the relevance of transitory shocks should increase in age. This is because transitory shocks gain more weight related to the lifetime income with increasing age. Table 2.4 shows the results for the interaction model with total consumption as dependent variable.[25]

In the OLS equation, the interaction term for age is not significantly different from zero, while the effect on transitory income is slightly higher than in Table 2.3. The switching regression reveals an interesting result. While there is no age varying effect found for the constrained households, a positive significant interaction term is found for the unconstrained regime. This means that the transitory income shocks become more important with higher age. This result is consistent with the PIH. Evaluating the marginal effect $\widehat{\psi}$ at the lowest cluster mean age of 36.6 gives still a negative but insignificant effect of -0.037 (standard error of 0.054), which is due to the linear unrestricted specification. But at the age of 55, we get a significant effect of 0.115 (0.057) and at the statutory retirement age of 65, the effect is

[24]Another relevant factor determining the probability of being unconstrained, which has not been separated from the probabilities interpreted here, is household composition.

[25]The results for non-durable consumption could not be checked because the switching regression computation was not feasible for this model due to non-convergence of the EM algorithm.

Table 2.4: Effects for Consumption Growth with **Age Interaction** (Total consumption)

	OLS	**Switching Regression**	
Dep. var.: $\Delta \ln(c_{it})$	Pooled Model	Regime 1 (Constrained)	Regime 2 (Unconstrained)
Permanent shock (ϕ)	0.646***	0.609***	0.692***
	(0.061)	(0.062)	(0.069)
Transitory shock (ψ)	0.296*	0.480***	−0.339**
	(0.152)	(0.158)	(0.149)
Age of household head	−0.000	0.000*	0.000
	(0.000)	(0.000)	(0.000)
Transitory shock * Age	−0.001	−0.001	0.008**
	(0.003)	(0.003)	(0.003)
Quarter dummies	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes
Constant	−0.043***	−0.062***	−0.121***
	(0.004)	(0.012)	(0.010)
Probability of regime 1 (P_{it})	–	0.433	
N (clusters)	748	748	748
R^2	0.303	0.481	0.602

Notes: Significance levels: $*p < 0.10$, $**p < 0.05$, $***p < 0.01$; robust standard errors in parentheses, adjusted for clustering, not adjusted for two-step estimation.

Source: Own calculations using the LWR data (2002-2007), provided by the FDZ.

0.197 (0.079). Following the strict PIH, the reaction to transitory shocks should approach 1 when agents reach the end of the life-cycle. However, there are several explanations for an MPC smaller than 1 at old ages. The exact length of the life-cycle is in fact unknown to the households and there are several motives for savings that become increasingly relevant towards the end of the life-cycle, such as the bequest motive, that give reasonable explanations and that have been supported with evidence in the literature (Lusardi, 1997).

2.4.3 Results for the Excess Sensitivity Test

The results from the consumption growth equation suggest an appearance of two kinds of households. The first ones are unable to smooth consumption over the life-cycle and depend on changes in transitory income. For them, reactions to non-anticipated changes in transitory income are thus observed. However, the other ones do not respond to non-anticipated changes in transitory income, but also do not fully consume non-anticipated increases in permanent income.

Another question related to the PIH is whether households respond to income changes that are *anticipated*. One would expect that for a liquidity constrained household the realization of an income change matters, rather than its anticipation. Table (2.5) presents the main results of estimating the Euler equation in Eq. (2.8) by OLS and by the switching regression approach. In the right column, for means of robustness check, the OLS results for the model based on non-durable consumption are shown.[26]

Table 2.5: Marginal Effects for the **Excess Sensitivity** Test (Total Cons.)

	OLS	**Switching Regression**		**OLS**
Dep. var.: $\Delta \ln(c_{it+1})$	Pooled Model	Regime 1 (Constr.)	Regime 2 (Unconstr.)	Pooled Model (**Nondur.** Cons.)
Anticipated Income[a] (δ)	-0.019^{**}	-0.039^{***}	-0.015	-0.014^{*}
	(0.008)	(0.008)	(0.010)	(0.008)
$\Delta\text{adults}_{it+1}$	0.210^{***}	0.244^{***}	0.208^{***}	0.276^{***}
	(0.027)	(0.027)	(0.031)	(0.026)
Δkids_{it+1}	0.093^{***}	0.091^{***}	0.085^{***}	0.081^{***}
	(0.024)	(0.031)	(0.028)	(0.027)
Probability of regime 1 (P_{it})	-	0.482		-
N (cells)	799	782[b]	782[b]	799
R^2	0.191	0.597	0.223	0.154
Tests (χ^2-statistic):				
$\delta_1 = \delta_2$	-	3.87		-
$\delta_{SWR} = \delta_{OLS}$	-	3.44	0.09	-

Notes: See Table 2.10 and Table 2.11 in Appendix 2.6 for complete estimation results and full list of covariates. Significance levels: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$; robust standard errors in parentheses, adjusted for clustering, not adjusted for two-step estimation.
[a]: The anticipated income term $E_{it}[\Delta \ln(y_{it+1})]$ is approximated by $\ln(y_{it})$.
[b]: Some 17 observations are dropped from the EM algorithm two-step procedure due to a zero in the denominator of Eq. (2.11).

Source: Own calculations using the LWR data (2002-2007), provided by the FDZ.

In the pooled model, the coefficient δ is estimated at -0.019 and significantly different from zero on the 5% level. This result suggests excess sensitivity to anticipated income for the whole sample. An estimate for δ that is significantly lower than zero is not consistent with the PIH. It is, however, consistent with the empirical evidence for excess sensitivity in the relevant literature (e.g. Zeldes, 1989a). It implies that households do respond to changes in income that have been anticipated. The negative coefficient implies that consumption increases at a slower rate than income has increased in the previous period because anticipated income changes have been proxied by observed income (also see Section 2.2).

Two regimes are again identified through the selection covariates, where only the ratio of financial assets to permanent income has been applied to identify liquidity constraints,

[26]In the switching regression, two stable regimes cannot be found for non-durable consumption.

besides the usual socio-demographics.[27] While the first regime is found to react more strongly to anticipated income changes than in the pooled model, the reaction for the second regime is slightly smaller, and it is estimated with a greater standard error.[28]

This is the central finding of the test for excess sensitivity, and it supports the excess sensitivity hypothesis. Households that are identified to be liquidity constrained are found to respond more strongly to changes in *anticipated* income changes than households that are not liquidity constrained. This result is also in line with the findings from the relevant literature on excess sensitivity (see e.g. Zeldes, 1989a; Garcia et al., 1997; Jappelli et al., 1998).

The estimated effects for the control variables of changing household composition suggest that an additional adult in the household increases consumption by around 20% while an additional child increases consumption only by around 9%. These results vary only slightly over the regimes, suggesting a slightly higher reaction among constrained households. The hypothesis of equality of the excess sensitivity coefficients over the regimes is marginally rejected on the 5% level (χ^2-statistic = 3.87). Furthermore, equality compared to OLS cannot be rejected at the 5% level, for both regimes. Further considering the OLS results for non-durable consumption, there is less evidence for excess sensitivity than in the unconstrained regime for total consumption. The response on only food consumption is also checked and an even smaller and insignificant coefficient is found. This could indicate that consumption reactions to anticipated income changes do not affect convenience goods or necessities.

2.5 Conclusion

In this chapter, the relevance of the permanent income hypothesis (PIH) was analyzed empirically with German consumption survey data. Evidence was found for deviation from theory predictions and it was investigated to which extent these deviations from the PIH can be traced back to the presence of liquidity constraints in household consumption. A pseudo panel constructed on repeated cross-sections of consumption survey data for Germany was used to investigate the consumption effects of income shocks in the context of liquidity constraints. This data set has proven to be rich in the sense that it provides relatively precise measures of the individual income and consumption dynamics, whose joint evolution over time was utilized to disentangle the consumption effects of income shocks into transitory and permanent elements.

In a switching regression approach with unknown sample separation, two regimes of house-

[27] This is done to avoid endogeneity issues by having the current and lagged income in both the selection and the main equation. Another reason is to have a stable switching regression.

[28] Slightly different coefficients are found for some alternative initial guesses. However, these do not affect the validity of these results.

holds were identified. One that can be assumed to be affected by liquidity constraints and a second one that seems to be rather unconstrained. Households in these two regimes behave differently w.r.t. permanent and transitory income shocks as well as w.r.t. anticipated income changes. This is the central finding of the analysis. While for the unconstrained regime, the results are largely in line with the PIH, life-cycle consumption planning predicted by theory must be strongly rejected for households in the constrained regime.

The findings suggest that for households in the constrained regime, reactions to changes in transitory income are significantly greater than for households in the unconstrained regime. The contribution to the literature is evidence for liquidity constraints, based on a pseudo panel of rich German consumption survey data, which has not been exploited for Germany so far in this context to the best of my knowledge.

On the one hand, households' responses to non-anticipated changes in income are at odds with the PIH. Their reaction to permanent shocks is lower than theory predicts and transitory shocks are perceived more sensitively than the model would tell. On the other hand, two groups were identified according to indicators for presence of liquidity constraints. Households identified as constrained react significantly stronger to transitory income shocks than households in the unconstrained group. These results are in line with findings from the relevant literature, where relevance of liquidity constraints has been found. These results have been found to be robust with respect to various model specifications as well as different consumption concepts.

Furthermore, there is evidence for excess sensitivity to anticipated income changes for households in the constrained regime if total consumption, durable as well as non-durable, is considered. Households that are identified to be liquidity constrained are found to respond more strongly to *anticipated* income changes than households that are not liquidity constrained. The conclusion is here that there seems to be a different reaction to anticipated income changes due to the presence of liquidity constraints among the two groups, at least if one considers total consumption, but the two different types of households have proven to be more difficult to identify.

Comparing the income elasticity from Chapter 1 to the reactions with respect to permanent income shocks shows that they are not significantly different from each other, neither for the OLS results nor for the two separate regimes. If this relationship holds, an implication would be that analyses of income elasticities could also be made with the current income as a proxy for permanent income, which means that the assumption of intertemporal separability is fulfilled. But further research with real panel data on consumption will be necessary to confirm this thesis.

2.6 Appendix - Results

Table 2.6: Estimation Results for the **Income** Equation

Dep. var.: $\ln(y_{it})$	**Coefficient**	**Standard Error**
Age of household head	0.0013	(0.0175)
Age squared of household head	−0.0000	(0.0002)
Interactions:		
Singles × age (ref.)		
Single parents × age	0.0377**	(0.0173)
Couples, no kids × age	0.0136**	(0.0054)
Couples, one kid × age	0.0304**	(0.0120)
Couples, two and more kids × age	0.0255**	(0.0118)
Large households[a] × age	−0.0074	(0.0082)
Singles × age^2 (ref.)		
Single parents × age^2	−0.0007*	(0.0004)
Couples, no kids × age^2	−0.0002**	(0.0001)
Couples, one kid × age^2	−0.0005*	(0.0002)
Couples, two and more kids × age^2	−0.0004*	(0.0002)
Large households[a] × age^2	0.0002	(0.0001)
Unemployed × age (ref.)		
Civil servants × age	0.0471***	(0.0109)
White collar × age	0.0362***	(0.0085)
Blue collar × age	0.0158	(0.0107)
Pensioners × age	−0.0038	(0.0091)
Civil pensioners × age	0.0166	(0.0124)
Unemployed × age^2 (ref.)		
Civil servants × age^2	−0.0006***	(0.0002)
White collar × age^2	−0.0004***	(0.0002)
Blue collar × age^2	−0.0001	(0.0002)
Pensioners × age^2	0.0001	(0.0001)
Civil pensioners × age^2	−0.0001	(0.0002)
Other Effects:		
High skill (ref.)		
Medium skill	−0.2268***	(0.0632)
Low skill	−0.3067***	(0.1119)
Number of adults in household	0.2314***	(0.0827)
Year effects	yes	
Quarter effects	yes	
Fixed effects	yes	
ρ	-0.098	
N (cells)	799	
R^2	0.567	

Notes: Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; robust standard errors in parentheses.
[a]: The group "large households" is the residual group of all remaining households. It mainly consists of households with more than two adults.

Source: Own calculations using the LWR data (2002-2007), provided by the FDZ.

Table 2.7: Estimation Results for the Consumption Growth Eq. (**Non-durable** Cons.)

	OLS	**Switching Regression**	
	Pooled Model	Regime 1	Regime 2
Dep. var.: $\Delta \ln(c_{it})$		(Constrained)	(Unconstrained)
Permanent shock (ϕ)	0.667***	0.626***	0.787***
	(0.058)	(0.055)	(0.133)
Transitory shock (ψ)	0.204***	0.427***	0.048
	(0.046)	(0.040)	(0.049)
Age of household head	−0.000	−0.000	−0.001***
	(0.000)	(0.000)	(0.000)
Year 2002	0.002	ref.	0.035***
	(0.003)		(0.008)
Year 2003	0.006**	−0.005	0.055***
	(0.002)	(0.009)	(0.008)
Year 2004	0.003	−0.021***	0.051***
	(0.002)	(0.007)	(0.009)
Year 2005	0.019***	−0.021***	0.033***
	(0.003)	(0.007)	(0.008)
Year 2006	0.007**	−0.032***	0.050***
	(0.003)	(0.005)	(0.006)
Year 2007	ref.	−0.044***	ref.
		(0.006)	
Quarter 1 (ref.)			
Quarter 2	0.016***	0.052***	0.037***
	(0.005)	(0.012)	(0.007)
Quarter 3	0.008**	0.005	0.033***
	(0.003)	(0.005)	(0.009)
Quarter 4	−0.019***	−0.053***	0.028***
	(0.006)	(0.010)	(0.007)
Constant	−0.005	0.043***	−0.059***
	(0.003)	(0.009)	(0.010)
Probability of regime 1 (P_{it})	–	0.422	
N (clusters)	748	748	748
R^2	0.215	0.586	0.146

Notes: Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; robust standard errors in parentheses, adjusted for clustering, not adjusted for two-step estimation.

Source: Own calculations using the LWR data (2002-2007), provided by the FDZ.

Table 2.8: Estimation Results for the Consumption Growth Equation (**Total** Cons.)

	OLS	**Switching Regression**	
	Pooled Model	Regime 1	Regime 2
Dep. var.: $\Delta \ln(c_{it})$		(Constrained)	(Unconstrained)
Permanent shock (ϕ)	0.648^{***}	0.610^{***}	0.660^{***}
	(0.058)	(0.060)	(0.065)
Transitory shock (ψ)	0.246^{***}	0.410^{***}	0.071
	(0.043)	(0.035)	(0.053)
Age of household head	−0.000	0.000^{**}	0.000
	(0.000)	(0.000)	(0.000)
Year 2002	0.004^{*}	0.031^{***}	-0.066^{***}
	(0.002)	(0.009)	(0.004)
Year 2003	0.011^{***}	0.051^{***}	-0.050^{***}
	(0.002)	(0.009)	(0.005)
Year 2004	0.010^{***}	0.051^{***}	-0.059^{***}
	(0.002)	(0.008)	(0.005)
Year 2005	0.008^{**}	0.012^{*}	-0.007^{*}
	(0.003)	(0.007)	(0.004)
Year 2006	0.016^{***}	0.017^{**}	ref.
	(0.003)	(0.008)	
Year 2007	ref.	ref.	-0.016^{***}
			(0.004)
Quarter 1 (ref.)			
Quarter 2	0.057^{***}	0.048^{***}	0.166^{***}
	(0.005)	(0.007)	(0.008)
Quarter 3	0.027^{***}	0.023^{***}	0.089^{***}
	(0.004)	(0.005)	(0.005)
Quarter 4	0.055^{***}	0.068^{***}	0.175^{***}
	(0.005)	(0.010)	(0.006)
Constant	-0.043^{***}	-0.075^{***}	-0.116^{***}
	(0.004)	(0.013)	(0.012)
Probability of regime 1 (P_{it})	–	0.435	
N (clusters)	748	748	748
R^2	0.303	0.487	0.593

Notes: Significance levels: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$; robust standard errors in parentheses, adjusted for clustering, not adjusted for two-step estimation.

Source: Own calculations using the LWR data (2002-2007), provided by the FDZ.

Table 2.9: Estimation Results for the Consumption Growth Equation (Non-durable Cons. with **Endogenous** Selection)

	OLS	**Switching Regression**	
	Pooled Model	Regime 1	Regime 2
Dep. var.: $\Delta \ln(c_{it})$		(Constrained)	(Unconstrained)
Permanent shock (ϕ)	0.667***	0.608***	0.783***
	(0.058)	(0.058)	(0.077)
Transitory shock (ψ)	0.204***	0.401***	0.056
	(0.046)	(0.044)	(0.059)
Age of household head	−0.000	−0.000	−0.000***
	(0.000)	(0.000)	(0.000)
Year 2002	0.002	0.013	0.054**
	(0.003)	(0.010)	(0.025)
Year 2003	0.006**	ref.	0.080***
	(0.002)		(0.026)
Year 2004	0.003	−0.009	0.072**
	(0.002)	(0.009)	(0.025)
Year 2005	0.019***	−0.000	0.058***
	(0.003)	(0.015)	(0.020)
Year 2006	0.007**	−0.014	0.069***
	(0.003)	(0.014)	(0.020)
Year 2007	ref.	−0.021	ref.
		(0.017)	
Quarter 1 (ref.)			
Quarter 2	0.016***	0.044**	0.090***
	(0.005)	(0.016)	(0.012)
Quarter 3	0.008**	0.000	0.065***
	(0.003)	(0.006)	(0.011)
Quarter 4	−0.019***	−0.047**	0.080***
	(0.006)	(0.016)	(0.012)
Selection Term	–	−0.032***	0.014
		(0.008)	(0.009)
Constant	−0.005	0.032**	−0.135***
	(0.003)	(0.008)	(0.032)
Probability of regime 1 (P_{it})	–	0.395	
N (clusters)	748	748	748
R^2	0.215	0.564	0.212

Notes: Significance levels: $*p < 0.10$, $**p < 0.05$, $***p < 0.01$; robust standard errors in parentheses, adjusted for clustering, not adjusted for two-step estimation.

Source: Own calculations using the LWR data (2002-2007), provided by the FDZ.

Table 2.10: Estimation Results for the Excess Sensitivity Test (**Total** Cons.)

	OLS	**Switching Regression**	
	Pooled Model	Regime 1	Regime 2
Dep. var.: $\Delta \ln(c_{it+1})$		(Constrained)	(Unconstrained)
Anticipated Income δ	-0.019^{**}	-0.039^{***}	-0.015
	(0.008)	(0.008)	(0.010)
Age of household head	-0.000	0.000^{*}	0.001^{**}
	(0.000)	(0.000)	(0.000)
Year 2002	-0.000	-0.068^{***}	0.024^{***}
	(0.008)	(0.009)	(0.008)
Year 2003	-0.007	-0.048^{***}	0.019^{**}
	(0.009)	(0.008)	(0.008)
Year 2004	-0.006	-0.058^{***}	0.031^{***}
	(0.009)	(0.009)	(0.009)
Year 2005	-0.002	ref.	-0.010
	(0.011)		(0.010)
Year 2006	ref.	0.001	-0.008
		(0.009)	(0.011)
Year 2007	-0.016	-0.013	ref.
	(0.010)	(0.009)	
Quarter 1 (ref.)			
Quarter 2	0.043^{***}	0.152^{***}	0.029^{***}
	(0.007)	(0.008)	(0.009)
Quarter 3	0.012^{*}	0.066^{***}	-0.005
	(0.007)	(0.009)	(0.006)
Quarter 4	0.054^{***}	0.167^{***}	0.033^{***}
	(0.007)	(0.008)	(0.008)
$\Delta\text{adults}_{it+1}$	0.210^{***}	0.244^{***}	0.208^{***}
	(0.027)	(0.027)	(0.031)
Δkids_{it+1}	0.093^{***}	0.091^{***}	0.085^{***}
	(0.024)	(0.031)	(0.028)
Constant	0.160^{**}	0.271^{***}	0.088
	(0.079)	(0.076)	(0.095)
Probability of regime 1 (P_{it})	–	0.482	
N (clusters)	799	782	782
R^2	0.191	0.597	0.223

Notes: Significance levels: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$; robust standard errors in parentheses, adjusted for clustering, not adjusted for two-step estimation.

Source: Own calculations using the LWR data (2002-2007), provided by the FDZ.

Table 2.11: Estimation Results for the Excess Sensitivity Test (**Non-durable** Cons.)

	OLS
	Pooled Model
Dep. var.: $\Delta \ln(c_{it+1})$	
Anticipated Income δ	-0.014^{**}
	(0.008)
Age of household head	-0.000
	(0.000)
Year 2002	0.001
	(0.009)
Year 2003	-0.002
	(0.009)
Year 2004	-0.003
	(0.009)
Year 2005	0.020^{*}
	(0.011)
Year 2006	ref.
Year 2007	-0.006
	(0.011)
Quarter 1 (ref.)	
Quarter 2	0.011^{*}
	(0.006)
Quarter 3	0.002
	(0.006)
Quarter 4	-0.014^{**}
	(0.006)
$\Delta \text{adults}_{it+1}$	0.276^{***}
	(0.026)
$\Delta \text{kids}_{it+1}$	0.081^{***}
	(0.027)
Constant	0.140^{*}
	(0.076)
Probability of regime 1 (P_{it})	-
N (clusters)	799
R^2	0.154

Notes: Significance levels: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$; robust standard errors in parentheses, adjusted for clustering, not adjusted for two-step estimation.

Source: Own calculations using the LWR data (2002-2007), provided by the FDZ.

Chapter 3

A Demand System of Energy, Mobility and Leisure

3.1 Introduction

Since 1999, the taxation of consumption has gained increasing importance in Germany. Several tax reforms were introduced that raised excise taxes, which are intended to burden the consumer, but are paid by the seller, and, therefore, are called "indirect taxes". The value-added tax was increased from 16% to 19% in 2007, indirect taxes on potentially harmful commodities or behavior, like cigarettes, alcohol or gambling, were also increased and the intense taxation of energy goods and fuel was forced by the governing coalition of the Social Democratic Party and the Green Party in Germany in the course of the green tax reform from 1998 to 2003 (*Ökosteuerreform*).

Economists are mainly concerned with two issues regarding the indirect taxation. Firstly, there are allocational considerations, which focus on the optimal taxation of commodities with the aim of a reduction in the excess burden and the additional incorporation of external costs of consumption. Empirical studies that deal with this topic or with extracts of it include e.g. Decoster and Schokkaert (1990), West and Williams (2005) and West and Williams (2007). The second important stream of analyses is concerned with the incidence and distributional issues of indirect taxation (see e.g. Poterba, 1991; West and Williams, 2004b; Ochmann et al., 2012).[1] The regressivity of the indirect taxes, which means a shrinking tax burden relative to an income-based economic welfare measure, like the disposable income, is a well known

[1]The two aspects, allocation and distribution, can be combined in the analysis, which is done in Decoster and Schokkaert (1990) and West and Williams (2007). However, the main focus in both studies lies on the allocational part.

suggestion of empirical distributional studies. This result is seen as problematic because it increases inequality in an economy. It could enforce poverty and reduce the popularity of such taxes. However, the regressivity of a tax could also depend on the choice of the economic welfare measure. If the expenditures on total or on non-durable consumption are taken as reference, then the distributional results might change. Important questions of the incidence analysis include which economic welfare measure is used to plot the distributional effects (Caspersen and Metcalf, 1994) as well as whether behavioral effects are important and should be taken into account in the analysis (Banks, Blundell, and Lewbel, 1996). With demand system estimation, it is possible to simulate welfare effects that take behavioral effects, own-price effects and cross-price effects between goods, into account. The substitution between the taxed commodities and leisure demand is suggested to be especially important for the welfare analysis (see West and Williams, 2004a,b, 2005, 2007).

This chapter focuses on the incidence of indirect taxes on energy and fuel consumption. As modeled in the framework of West and Williams, an Almost Ideal Demand System (AIDS, see Deaton and Muellbauer, 1980a) is estimated to get own-price and cross-price effects of the consumer goods "Mobility", "Electricity", "Heating" and other non-durable goods, as well as of "Leisure". This approach allows the calculation of the compensated and uncompensated elasticities, which can then be used to simulate behavioral responses and welfare effects of price shifts. The demand system is estimated with pooled German micro data from three survey years of the EVS (Income and Consumption Survey for Germany, *Einkommens- und Verbrauchsstichprobe*). Finally, the static and behavioral effects of a potential reform of the existing tax on gasoline and diesel consumption are simulated.

The literature on labor supply, which considers the opposite side of leisure demand, distinguishes between *extensive* and *intensive* changes, where reactions at the *extensive* margin refer to changes in labor market participation (or at the macro level in the number of working persons), while changes at the *intensive* margin refer to changes in the average number of hours worked for the working population (see e.g. Blundell et al., 2011). The structural approach applied in this chapter allows for both effects. The estimates of the Almost Ideal Demand System referring to leisure demand or accordingly to labor supply are interpreted as elasticities at the *intensive* margin, while the *extensive* labor market participation elasticities are estimated in a preceding discrete choice model, which is then linked to the AIDS and used for selectivity correction. The elasticities of both margins are combined to get elasticities of total leisure demand, which are then used in the simulation and welfare analysis. There are deviations in the present approach compared to the West and Williams framework, where selection issues are also addressed but the distinction between *extensive* and *intensive* leisure demand is not handled explicitly.

In the next section, the AIDS framework and its theoretical properties, especially with respect to "Leisure", are presented. The discrete choice model and the estimation issues are discussed later in Section 3.3.3.

3.2 A Demand System Involving Leisure

For the purpose of modeling the demand for mobility and energy goods along with their relationships to leisure, the approach mainly follows the framework of West and Williams (see West and Williams, 2004a,b, 2005, 2007). The own-price and cross-price effects of the consumer goods "Mobility", "Electricity", "Heating" and other non-durable goods, as well as of "Leisure" are estimated together in an Almost Ideal Demand System (AIDS, see Deaton and Muellbauer, 1980a).

As a special case of the quadratic version of the AIDS was already introduced in Chapter 1.2.1, the general form of the almost ideal demand system including leisure is now presented. The AIDS specification is based on price-independent generalized logarithmic (PIGLOG) preferences and is, therefore, linear in the logarithm of the budget, while the QUAIDS allows for a quadratic and globally more flexible functional form, but is not consistent with PIGLOG preferences. The greater flexibility in the Engel curves could be important for some goods while for most applications the AIDS specification seems to be sufficient. Here, due to the already high complexity in the formulas for the elasticities, especially with respect to changes in wage, and the already high challenge for identification of the parameters due to the restrictive cross-sectional data and the instrumentation of the budget, only the linear AIDS specification is used.

Let $Q_{i,j}$ denote the demand of household i for good j in quantities and $s_{i,j} = Q_{i,j} \cdot p_{i,j}/y_i$ the respective budget share. Then, demand for consumption good j is represented by the following system of J equations:

$$s_{i,j} \; = \; \alpha_{0j} \; + \; \beta_j \; \ln(y_i/P_i^*) \; + \; \sum_k \gamma_{jk} \; \ln(p_{i,k}) \tag{3.1}$$

for households $i = 1, ..., N$ and goods $j, k = 1, ..., J$. y_i is household i's budget, which includes all expenditures spent on the consumer goods and leisure, $p_{i,k}$ is the price of good k for household i, and α_{0j} is a good-specific constant. β_j denotes the parameter of the budget effect of demand and γ_{jk} a parameter of the effect of relative price changes. Due to the exclusion of savings and durables in the household budget y_i, the assumption of "Two-stage budgeting" has to be made, which relegates the decision whether to consume, to shift consumption to the future or to invest in durable goods to a preceding step.[2]

$\ln(P_i^*)$ is the translog price index, which can be approximated by a linear price index, e.g. by the log-linear Laspeyres index ($\ln(P_i^*) = \sum_j s_{i,j} \ln(p_{i,j})$), resulting in the linearized AIDS. However, this index can be seen as endogenous because it depends on the household's shares. Therefore, the individual shares are replaced by the sample means. Additionally, the prices are normalized to have homogenous units because the log-linear Laspeyres index is not invariant to changes in the measurement unit for $p_{i,j}$ (e.g. from index number to monetary measure, see Moschini, 1995). This yields $\ln(P_i^*) = \sum_j \bar{s}_j \ln(p_{i,j}/\bar{p}_j)$. At this point without further restrictions, the system could still be estimated consistently by seemingly unrelated regressions (SUR) or because all equations contain the same explanatory variables, equation by equation by OLS.

The parameters in the structural model can be used to calculate the elasticities. Omitting household indices for simplicity, the income elasticity corresponds to:

$$\eta_j \equiv \frac{\partial Q_j}{\partial y} \frac{y}{Q_j} = 1 + \frac{\beta_j}{s_j} \, . \tag{3.2}$$

The uncompensated price elasticity for the demand level of good j w.r.t. price of good k (where k is any good except leisure) is:

$$\varepsilon^u_{jk} \equiv \frac{\partial Q_j}{\partial p_k} \frac{p_k}{Q_j} = \frac{\gamma_{jk}}{s_j} - \delta_{jk} - \frac{\beta_j s_k}{s_j} \tag{3.3}$$

where δ_{jk} is the Kronecker delta, i.e. $\delta_{jk} = 1$ if $j = k$ and $\delta_{jk} = 0$ if $j \neq k$. By the Slutsky equation, the compensated price elasticity follows as:

$$\varepsilon^c_{jk} \equiv \varepsilon^u_{jk} + s_k \eta_j = \frac{\gamma_{jk}}{s_j} - \delta_{jk} + s_k \tag{3.4}$$

A fully consistent demand system has to fulfill the following *cross*-equations constraints on the parameters: $\sum_j \alpha_{0j} = 1$, $\sum_j \beta_j = 0$, and $\sum_j \gamma_{jk} = 0$. These restrictions together imply adding-up of the budget shares to one for each household: $\sum_j s_{i,j} = 1 \, \forall \, i = 1, ..., N$.[3] It follows that only $J - 1$ equations can be estimated. The coefficients of the last equation are given by the adding-up conditions. While adding-up is fulfilled by definition of the model, other properties of a consistent demand function that make the model consistent with demand theory can be imposed or tested for the AIDS: compensated own price elasticities shall be non-positive ($\varepsilon^c_{jj} \leq 0 \, \forall \, j$), the Slutsky-matrix is symmetric if the cross-price effects are equal,

[2]See Deaton and Muellbauer (1980b) for details on the concept of "Two-stage budgeting".

[3]Adding-up of the predicted shares cannot be tested, though, given adding-up of observed shares is fulfilled by construction (see Deaton and Muellbauer, 1980a, p. 316).

$\gamma_{jk} = \gamma_{kj}$, and compensated demand is homogeneous of degree zero in prices if the *within*-equation constraints, $\sum_k \gamma_{jk} = 0 \, \forall \, j$, hold (see Deaton and Muellbauer, 1980b).

Here, the traditional model, which involves only expenditures on consumer goods, is extended to the demand for leisure. In the general notation, the expenditures on leisure are given by $(t - h_i) \cdot w_i$, where t is the time-endowment of the agents in the household, which is the same for all agents, h_i is the working-time and w_i is the net wage per hour. The budget y_i then consists of the expenditures on all included consumer goods and on leisure. Following West and Williams (2004a), the model will be estimated separately for one-adult households and two-adult households. In case of one adult per household, there is obviously only one demand for leisure. In case of two adults, there are two demand decisions for leisure per household, which are treated as two separate goods. Therefore, the demand for male leisure and for female leisure appear in the demand system. The uncompensated elasticities with respect to changes in the net wage (either female or male in the two-adult case) are slightly different from the regular price elasticities (see West and Williams, 2004a):

$$\varepsilon^u_{jk} \equiv \frac{\partial Q_j}{\partial w}\frac{w}{Q_j} = \frac{\gamma_{jk}}{s_j} - \delta_{jk} + \frac{\beta_j}{s_j}\left(s_{Lk} - s_k\right) + s_{Lk} \tag{3.5}$$

for $k = m, f$ (male or female), where $s_{Lk} = t \cdot w_k / y_i$, which is the share of expenditures that is financed from personal wage income. For example, in the case of a one-adult household with zero non-labor income s_L should be 1 and in the two-adult case, where both adults face the same wage, then $s_{Lm} = s_{Lf} = 0.5$.

Further issues concerning the derivation of the net wage per hour and the practical application of leisure demand in the estimation are discussed in the next section.

While many studies of demand systems assume weak separability between the commodity demand and leisure (see e.g. Blundell, Parshades, and Weber, 1993), which is rejected in several papers (see e.g. Blundell and Walker, 1982), this assumption is relaxed here. However, as the present system involves only non-durable goods and leisure time, the assumptions of intertemporal separability and separability between the demand of non-durables and durables have to be made. This does not imply no substitution effect over time or a cross-price elasticity of zero between durables and non-durables, but it assumes a constant intertemporal rate of substitution.[4] Therefore, all price changes affect the savings with the same elasticity because the intertemporal consumption decision is separated and relegated to a preceding step, which

[4]The relationship between the non-durable goods and the durables can be split off into an intertemporal part, which is covered by the intertemporal rate of substitution and a within-period cross-price effect, which refers to a current utility stream from the durable good and would have to be estimated in the intra-period model. But this effect could also be assumed to be equal to the composite good of non-durables effect if no particular durable good is considered.

is linked to the intra-period model via "Two-stage budgeting". The great advantage of this assumption is that neither price nor wage information from other periods or on durable goods are required to estimate the model. This assumption is also crucial, but necessary to avoid an overloaded framework which is not possible to identify with the existing available data. The data issues are discussed in the next section.

3.3 Data and Empirical Strategy

In the following section, some special issues concerning the application of the demand system estimation will be considered. Firstly, the data and the construction of the commodity prices are presented, then further data manipulation regarding the expenditures for leisure is described and finally, the estimation strategy and specification are discussed.

3.3.1 Lewbel Prices

The demand system will be estimated on three pooled repeated cross-sections from household consumption survey data for Germany, which are the survey waves 1998, 2003 and 2008 of the EVS (Income and Consumption Survey for Germany, *Einkommens- und Verbrauchsstichprobe*, see Chapter 3.3.2 for a general data description). The households are observed quarterly, which yields in combination with the three years of time variation 12 points in time in the pooled data set. The price variation for the consumer goods over time is therefore quite small. To expand the possibilities of demand system estimation with this data set, the cross-sectional characteristic and the detailed consumption information have to be exploited. Under additional assumptions, household-specific prices can be constructed (see Lewbel, 1989) and used in the demand system estimation, in order to exploit price variation between households within a time period. The idea is to use the consumption structure in an aggregated commodity group (e.g. "Mobility") by holding the expenditure shares of the commodities in this group constant and constructing household-specific commodity group prices (as already denoted in Eq. (3.1)). This is done by weighting the prices of the commodities within a commodity group with the expenditure shares within the group. The underlying assumption has to be *Cobb-Douglas* preferences within the commodity group (because of the constant shares). The aggregate price for commodity group j is calculated by:

$$p_{i,j} = \sum_{g}^{Gj} s_{i,gj} \cdot p_g, \quad \forall\, g = 1, ..., Gj \tag{3.6}$$

where p_g is the Consumer Price Index for commodity g and $s_{i,gj}$ is the budget share of commodity g in commodity group j for household i. These prices are calculated for the commodity groups "Mobility", "Heating" and the other non-durable goods. "Electricity" consists only of one commodity, so all the price variation comes from time, here.

3.3.2 Data Issues and the Constructing of the Commodity "Leisure"

The data set, the EVS, contains detailed information on income and expenditures of German households. While consumption expenditures are only reported at the household level, income information is available for every household member. Including "Leisure" in the demand system requires information on the gross wage income, the marginal income tax and on the worked hours of the relevant persons. Given the information on the gross wage income, it is possible to derive the net wage income using an income-tax simulation module. In Ochmann (2010a), a simulation model for the EVS survey years 1998 and 2003 was applied, which exploits all tax relevant information in the data set to simulate a marginal tax rate for every household member.[5] In the study at hand, this income tax simulation module for the EVS is revised and extended to the income taxation law of 2008 to simulate the marginal tax rates plus the solidarity surcharge and the additional marginal burden on labor due to the social security contributions (SSC) for all used EVS survey years.[6]

The second necessary variable for modeling the demand for leisure is the information on the hours worked. In the 2003 and 2008 surveys, the EVS contains information on every household member covering the interval between 10 and 60 hours per week, as well as the information "9 or less hours" and zero hours.[7] Unfortunately, the EVS 1998 contains only ordinal data on the occupational status. There exist five categories, which are "no occupation", "marginally occupied", "part-time occupation", "full-time occupation" and "occupied with no further information". This ordinal variable is used to impute the actually hours worked into the EVS 1998 using information of an external data set, the microcensus 1998 (*Mikrozensus 1998*). The microcensus is a representative and administrative data set, which is maintained by the German Federal Statistical Office (*Statistisches Bundesamt*) and involves 1% of the German households every year (about 390,000). For the purpose of imputation, the scientific use-file is used, which is a 70% subsample of the original microcensus. In the microcensus, the ordinal occupational status, as well as the socio-demographic characterictics can be defined

[5]See Appendix 1.8 for the description of a self-written income tax module for the LWR data, which is based on the one used here.

[6]See Appendix 3.11.1 for histograms that show the distributions of simulated marginal tax rate plus SSC burden (also called "marginal total burden" in the following) for the three survey years.

[7]The EVS survey year 2003 covers the continuous interval zero to 99 hours, but this is transformed in the more restrictive version to harmonize with the 2008 EVS.

very similarly to the EVS. On the individual level, about 500,000 persons are observed, which allows for a detailed mean imputation. The mean imputation of the hours worked is done separately for each occupational category (marginal, part-time, full-time) by age group, gender, household composition, three educational achievement categories and by East and West Germany. For those combinations of characteristics that have less than 20 observations in the microcensus, the differentiation into educational achievement and East versus West Germany is omitted. Missing information on the occupational status in the EVS 1998 and on the hours worked in all survey years is imputed firstly by logical imputation (e.g. if social status is "unemployed" and occupational status is "unknown" then hours worked are set to zero) and then also by within sample mean imputation. Additionally, to increase the variance of the imputed variable on a similar level to the observed ones, a normally distributed error term is drawn with the original variance and added to the imputed mean. This added variance smoothes the distribution of the hours worked compared to the observed distributions, but should not bias the estimated coefficient in a linear model.[8]

Finally, all information is available to construct the net wage per hour, which is $w_i = inc_i(1 - r_i)/h_i$, where inc_i is the gross wage income and r_i is the marginal tax rate including social security contributions.[9]

3.3.3 Estimation

Several issues for the estimation of Eq. (3.1) are addressed in this subsection. The structure of the underlying model will be discussed, where the focus is especially on the treatment of potential selectivity bias. Then, endogeneity problems concerning the variables of interest are considered.

As previously noted, following West and Williams (2004a), the model will be estimated for one-adult households and two-adult households separately. This allows for responses to both wages in a two-adult household to be estimated, consequently yielding two different estimation samples and specifications. Preceding the presented AIDS model, which reflects substitution effects at the intensive margin, the extensive labor supply elasticity is estimated in discrete choice models. The approach finally consists of three stages: Firstly, a Heckman model (see Heckman, 1979, "Heckit") is estimated to obtain selectivity-corrected net wages, secondly, an extensive labor supply model, that includes wages and prices is estimated by probit (singles) or bivariate probit model (couples) and thirdly, wages and selectivity terms from the first and second stage are included in the AIDS to estimated intensive elasticities. This stepwise

[8] See Appendix 3.11.2 for a comparison of the histograms between imputed and observed hours worked.

[9] As a robustness analysis, the model was estimated with the observed survey years only, which yielded very similar wage effects.

approach is now discussed in detail.

A problem in the demand estimation for leisure arises, since a relevant share of individuals in the samples does not work. The wages of these households are not observed. Estimating the system with the persons who work and with the observed wages would induce biased parameter estimates. At the first stage, to get selectivity-corrected net wages, a Heckman model is run separately for one-adult and two-adult households (for the two-adult households, the model is run on individual level for males and females separately). Explanatory variables include age, age squared, education, marital status, federal state, agglomeration level of the residence and time dummies. As exclusion restrictions appear the number of children in the household and cubic and quartic polynoms of age for the singles, and the spouse's socio-demographics and gross wage for the two-adult case.[10] Then, selectivity corrected net wages are derived from the estimated Heckit models by calculating the conditional predictions.[11] The selectivity-corrected wages are used to calculate the expenditures on leisure and enter the model as price for leisure in logs.

At the second stage of the model, the wages and the prices of the commodities are included in a probit, a so called "structural" probit compared to the reduced form probit in the Heckman model from stage one.[12] The commodity prices are weighted by the inverse of the average budget share (without leisure) to control for the magnitude of the relative price change. In the one-adult case, the work participation equation takes the form:

$$\begin{aligned} P_i^* &= \alpha + z_i'\beta + \sum_k \beta_k \ln(p_{i,k}) \cdot (1/\overline{s}_{i,k}) + \beta_w \widehat{\ln(w_i)} + \gamma\, nlinc_i + u_i \\ P_i &= \begin{cases} 1 \; if \; P_i^* > 0 \\ 0 \; otherwise \end{cases} \end{aligned} \tag{3.7}$$

where $\widehat{\ln(w_i)}$ is the selectivity corrected conditional prediction from the Heckit model in stage one and $nlinc_i$ is non-labor income. The parameters β_k and β_w can then be used to calculate the extensive price and wage elasticities of labor supply and γ measures the income effect.[13]

[10]The results of these models can be considered in Appendix 3.12.1. As an additional exclusion restriction, the ratio of consumed alcohol and tobacco to expenditures on food is included, which should control for harmful behavior concerning labor force productivity. The coefficient is significantly negative in all estimated Probit equations, except for the female participation equation in the structural probit for couples.

[11]The formula for the conditional level prediction out of the Heckit model is given by $E(w_i|x, w_i > 0) = exp(x_2'\beta_2 + \sigma_2^2/2)\left\{1 - \Phi(-x_1'\beta_1)\right\}^{-1}\left\{1 - \Phi(-x_1'\beta_1 - \sigma_{12}^2)\right\}$, where 1 refers to the selection equation and 2 to the log wage equation (see Cameron and Trivedi (2010), p. 563).

[12]This approach is often applied in the literature (without commodity prices), see e.g. Mroz (1987) for a review and Bishop, Heim, and Mihaly (2009) for an application.

[13]Note that homogeneity in wages and prices should also hold for the extensive labor supply, but is not imposed here because this is only a partial model and not so robust against theoretical restrictions (because of the neglected opposing equation). For couples, symmetry in the cross-wage effects can not be rejected at least at the 1% level and is imposed.

The index k runs over all commodity prices (without leisure because the wage stands separately in Eq. (3.7)). In the two-adult case, the probit turns into a bivariate discrete choice model, which allows for correlation between the error terms in the participation equations of the man and the woman. It takes the form:

$$\begin{aligned} P^*_{im} &= \alpha_m + z'_{im}\beta + \sum_k \beta_{km} \ln(p_{i,k}) \cdot (1/\overline{s}_{i,k}) + \beta_{wmm} \ln(\widehat{w_{im}}) + \beta_{wmf} \ln(\widehat{w_{if}}) \\ &\quad + \gamma_m \, nlinc_{im} + u_{im} \\ P^*_{if} &= \alpha_f + z'_{if}\beta + \sum_k \beta_{kf} \ln(p_{i,k}) \cdot (1/\overline{s}_{i,k}) + \beta_{wff} \ln(\widehat{w_{if}}) + \beta_{wfm} \ln(\widehat{w_{im}}) \\ &\quad + \gamma_f \, nlinc_{if} + u_{if} \end{aligned} \tag{3.8}$$

$$\begin{aligned} u_{im}, u_{if} &\sim \Phi_2(0,0,1,1,\rho) \\ P_{im} &= \begin{cases} 1 \; if \; P^*_{im} > 0 \\ 0 \; otherwise \end{cases} \\ P_{if} &= \begin{cases} 1 \; if \; P^*_{if} > 0 \\ 0 \; otherwise \end{cases} \end{aligned}$$

where Φ_2 denotes the bivariate normal distribution and ρ is the parameter of correlation between the two equations. The variables in x_{im} do not exactly equal the ones in x_f because the interactions between age and education are only included for the particular person and the spouse's age and education information are included without interaction terms in the equations.[14]

While the extensive elasticities are interesting on their own, the results from stage one and two are included in stage three, the estimation of the demand system. In the AIDS model, which corresponds to the intensive elasticities, estimating the system by OLS (or standard SUR) and including only the working households in the estimation would produce inconsistent estimates anyway. The decision of persons whether to participate in the labor market or not is neglected and if it is correlated with the prices and the wage, then estimated parameters are inconsistent. The classical Heckman estimator (Heckman, 1979) applies here. But in a system of equations, the Heckman solution is not straightforward and the literature on this problem is rare. Heien and Wessells (1990) propose to include Heckman-style correction terms in all equations and estimate the system on all observations. Shonkwiler and Yen (1999)

[14] The estimation of the probit in the one-adult case contains all persons that are younger than the age of 65 and not self-employed. In the two-adult case, all observations with a male younger than the age of 65 or a female younger than the age of 63 are included.

find that this procedure is biased and propose their own estimator, which provides consistent estimation of censored systems of equations. However, this estimator does not fulfill the adding-up condition, which has to be implemented by hand. The Shonkwiler and Yen (1999) estimator multiplies all regressors with the probability of being censored in the particular equation, includes the density term as an additional regressor and estimates the system on all observations. West and Williams (2004a) apply a modified approach by correcting only the wages with the probability of being censored and estimating the system on non-censored observations, where they suggest that this is consistent with the Heckman estimator for one equation. The study at hand is geared by the specification of Shonkwiler and Yen (1999) and West and Williams (2004a). In the one-adult case, only the working population is included in the estimation of the demand system. In the two-adult case, households, where both spouses do not work are excluded from the estimation sample. The wages included as prices for leisure are corrected in the one-adult case as follows:

$$\begin{aligned} E\left[\ln(w_i)\right] \;&=\; E\left[z_i'\beta + \, u_i \,>\, 0\right] \,\cdot\, E\left[\ln(w_i)\,|\,P_i = 1\right] \equiv E\left[\ln(p_{i,leisure})\right] \\ with \;\; E\left[z_i'\beta + \, u_i \,>\, 0\right] \;&=\; \Phi(z_i'\beta) \end{aligned} \tag{3.9}$$

where $E\left[\ln(w_i)\,|\,P_i = 1\right]$ is the conditional prediction from the Heckit model in stage one. $\Phi(z_i'\beta)$ is the probability also from the reduced form model in stage one because the predicted wage is already included in stage two.[15] As additional regressor, which comes from stage two, the density term $\lambda_i = \phi(z_i'\beta)$ enters all equations in the system.

The two-adult case is more complex. Let z_{im} describe the explanatory variables from the male participation equation in Eq. (3.8) and z_{if} from the female one. The correction term in the Heckman case for two correlated selection mechanism would be (according to e.g. Ham, 1982):

$$\begin{aligned} \lambda_{im} \;&=\; \phi(z_{im}'\beta) \,\cdot\, \frac{\Phi\left(\frac{z_{if}'\beta \,-\, \rho\, z_{im}'\beta}{(1-\rho^2)^{0.5}}\right)}{E\left[z_{im}'\beta + \, u_{im} \,>\, 0,\, z_{if},\, \rho\right]} \\ \lambda_{if} \;&=\; \phi(z_{if}'\beta) \,\cdot\, \frac{\Phi\left(\frac{z_{im}'\beta \,-\, \rho\, z_{if}'\beta}{(1-\rho^2)^{0.5}}\right)}{E\left[z_{if}'\beta + \, u_{if} \,>\, 0,\, z_{im},\, \rho\right]} \end{aligned} \tag{3.10}$$

As in Eq. (3.9), the expectational term in the denominator of Eq. (3.10) is again replaced by the predictions from the reduced form model in stage one (i.e. $\Phi(z_{im}'\beta)$ for males and $\Phi(z_{if}'\beta)$ for females), which are then multiplied to the conditional wage predictions from stage one,

[15] The only difference in vector z_i between the selection equation in the Heckman model and the stage two model is that the prices (and of course the wage) are left out in the Heckit.

analogously to the Shonkwiler and Yen (1999) transformation for the single selection equation case. The new terms added as additional regressors to the demand system equations are then:

$$\begin{aligned} \tilde{\lambda}_{im} &\equiv \phi(z'_{im}\beta) \cdot \Phi\left(\frac{z'_{if}\beta - \rho\, z'_{im}\beta}{(1-\rho^2)^{0.5}}\right) \\ \tilde{\lambda}_{if} &\equiv \phi(z'_{if}\beta) \cdot \Phi\left(\frac{z'_{im}\beta - \rho\, z'_{if}\beta}{(1-\rho^2)^{0.5}}\right) \end{aligned} \tag{3.11}$$

The next issue addressed is related to the former concerns of "zero consumption" of the commodities. There are of course households, that do not spend amounts on every good included in the demand system. By constructing broad commodity groups like "Mobility", one can minimize the problem. But "zero consumption" households can produce inconsistent estimates, or at least inefficient estimates if the censoring is kind of random. If the censoring is not random, but the share of censored households is small, then the bias in the estimates should also be small. In the demand system at hand, considering only the consumer goods (omitting leisure from the budget for a moment), only households with a share of at least 1% in the categories "Mobility" and "Electricity" are included in the estimation to guarantee enough variation in the shares. In the category "Heating", there are more "zero consumption" cases than in the other ones, but these households are kept in order to avoid losing too many observations. Similar to the introduced procedure with the non-working households, a selection equation is estimated, which explains whether heat expenditures are observed or not. The equation includes in addition to the regressors, which enter all equations (see below), information on social status, expenditures on housing, owner or renter status, the log prices of the commodities, and the consumption budget (without leisure). But the assumption is that every household consumes "Heating" and the selection is only due to seasonal censoring of the expenditures. So, the only relevant results from this selection equation is the predicted probability to consume "Heating" and the density term, which is included in all equations. The selectivity corrected new price for "Heating" is then the probability times the log of the regular price, analogous to the procedure for wages.

In the one-adult sample, the number of observations is thus reduced from 38,128 to 31,885 due to dropping the zero "Mobility" and "Electricity" cases, which make up about 16% of the total sample. The censoring within one equation, which is 10% for "Mobility" and 7% for "Electricity" (see Section 3.4 for detailed descriptives), may cause a systematic bias in the estimation if the dropped censored households differ from the uncensored ones. However, correcting for selectivity in the equations is not undertaken due to the rather small number of cases. In the two-adult sample, the sample is reduced from 77,910 to 72,869 (-6%). The censoring rates are even smaller here for "Mobility" (2%) and "Electricity" (4%).

Obviously, there is a constructed endogeneity problem because net wages depend on labor supply decisions. The marginal tax rate depends mechanically on the functional form of the progressive tax system in Germany. In West and Williams (2004a), the simulated marginal tax rate, as well as measurement errors in the hours worked and the gross income, which appear together with the marginal tax rate on both sides of the equation, are suggested to be sources of endogeneity. However, except for the endogeneity due to the progressive income tax, the problem is resolved by the fact that the wage is a prediction from the Heckit model for all included persons in the regression. In the literature, the endogeneity of the progressive income tax is overcome by instrumental variable technique, where the marginal tax rate is instrumented by a "synthetic" tax rate, which is simulated with a lagged income term (see e.g. Auten and Carroll, 1999). This approach cannot be applied here because no panel data including rich information on consumption is available for Germany. There is also no additional cross-sectional instrument like the mean net wage by profession or branch in the data.

Another endogeneity problem is the dependency of the budget on the allocation of the consumed goods and leisure. In a demand system without leisure, the endogeneity problem is not so serious because the consumer total budget does not depend much on the structure of the consumed non-durables. But in the present study, if leisure is included, then the budget that is allocated for consumption depends on the leisure-work decision and the endogeneity problem becomes more serious. An instrument for the term $\ln(y_i/P_i^*)$ is derived by building an aggregate that includes non-labor income and public as well as private transfer income.[16] These income components are assumed to be exogenous in the model, whereas this assumption can be seen as critical for the public transfers because reducing work may increase these transfers (and the other way around). Despite that fact, the instrument is assumed to be less correlated with the labor/leisure decision, especially at the intensive margin, and therefore a good instrument.

This finally results in a Three-Stage-Least-Squares (3SLS) model with the budget being regressed on the instrument, the additional exogenous variables and year dummies at the first stage. The estimated system of model Eq. (3.1) comprises the following equations:

$$\begin{aligned} s_{i,j} &= \alpha_{0j} + x_i'\beta + \beta_j \ln(y_i/P_i^*) + \sum_k \gamma_{jk} \ln(p_{i,k}) + \sigma_{1j}\lambda_{i,leisure} + \sigma_{2j}\lambda_{i,heating} + \epsilon_{i,j} \\ \ln(y_i/P_i^*) &= x_i'\beta + \gamma_1\, nlinc_i + t'\gamma + \nu_i \end{aligned} \tag{3.12}$$

where $nlinc_i$ is non-labor income and transfers, t is a vector of year dummies, $\lambda_{i,leisure}$ is the density term for leisure, $\lambda_{i,heating}$ is the density term for heating, $\epsilon_{i,i}$ and ν_i are error

[16] Many observations have a value different from zero in the instrumental variable due to its broad definition. In the one-adult sample, less than 15% of the households have a zero and in the two-adult sample, less than 5% have a zero.

terms and x_i' contains the control variables age, age squared, education, social status, federal state dummies, agglomeration level of the residence, quarterly dummies and the number of children in the household. In the two-adult sample, all individual information appears for both spouses, as well as the two density terms for leisure appear instead of the one for the single households. The price for leisure equals the one from Eq. (3.9) and the price for heating is also the selectivity corrected one. The system is estimated by 3SLS to control for cross-equation error term correlation and to set the cross-equation restrictions of homogeneity and symmetry listed in Section 3.2. It includes in the single-adult case, only observations of those who are working but are not self-employed and younger than 65 years old, additional to the conditioning on households that have positive expenditures in the mentioned consumer good groups. In the case of couples, the sample is conditioned on all observations with a male younger than the age of 65 or a female younger than the age of 63, and that at least one spouse is working.

3.3.4 Combining the Extensive and Intensive Elasticities of Leisure

The results from stage two of the model are the extensive elasticities, which refer to labor market participation and the results of stage three are intensive elasticities, which show adjustments of the hours spent on leisure for those who work. These two concepts can be linked to the total elasticity of leisure demand. Following McDonald and Moffitt (1980), the total response of leisure demand with respect to e.g. a change in the net wage can be decomposed into:

$$\frac{\partial E\left[Q_L\right]}{\partial w} = \Phi(z_i'\beta) \cdot \frac{\partial E\left[Q_L^*\right]}{\partial w} + E\left[Q_L^*\right] \cdot \frac{\partial \Phi(z_i'\beta)}{\partial w} \tag{3.13}$$

where Q_L is the demand for leisure and Q_L^* is the demand for leisure conditional on labor market participation (the intensive demand). Simple mathematical rearranging yields:

$$\begin{aligned} \frac{\partial E\left[Q_L\right]}{\partial w} \cdot w &= \Phi(z_i'\beta) E\left[Q_L^*\right] \cdot \frac{\partial E\left[Q_L^*\right]}{\partial w} \cdot \frac{w}{E\left[Q_L^*\right]} + \Phi(z_i'\beta) E\left[Q_L^*\right] \cdot \frac{\partial \Phi(z_i'\beta)}{\partial w} \cdot \frac{w}{\Phi(z_i'\beta)} \\ \frac{\partial E\left[Q_L\right]}{\partial w} \cdot \frac{w}{E\left[Q_L\right]} &= \frac{\Phi(z_i'\beta)}{\Phi(z_i'\beta) + (1-\Phi(z_i'\beta)) \cdot k} \cdot \left(\epsilon^i + \epsilon^e\right) \end{aligned} \tag{3.14}$$

where ϵ^i is the intensive leisure elasticity and ϵ^e is the extensive elasticity. The correction term $k = T/E\left[Q_L^*\right]$ appears, where T is the time endowment. Note that the total elasticity of leisure is not equal to the formula for labor because $E\left[Q_L\right] = \Phi(z_i'\beta)E\left[Q_L^*\right] + (1-\Phi(z_i'\beta)) \cdot T$, where the latter term drops off in the case of labor supply. The labor supply formula is just

$\epsilon^i + \epsilon^e$.[17] The reason is the high level of leisure demand for the unemployed, which makes the total leisure demand more inelastic given the same marginal effect.

3.4 Descriptive Evidence

The focus on energy goods and mobility in the demand system results from the increasing importance of these goods compared to total expenditures. Increasing prices and taxes led to higher expenditure shares of energy goods and also of mobility which are mainly driven by the oil and gasoline prices. The demand system includes the group "Mobility", which consists most importantly of expenditures for fuels (gasoline and diesel) and additionally of expenditures on public transport (local and long-distance travels). The consumer good "Electricity" explains itself by containing all reported expenditures on electricity. And the commodity group "Heating" includes expenditures on natural gas, heating oil, coal, as well as the cost for central heating, which may use one of many different kinds of energy sources, including district heating.

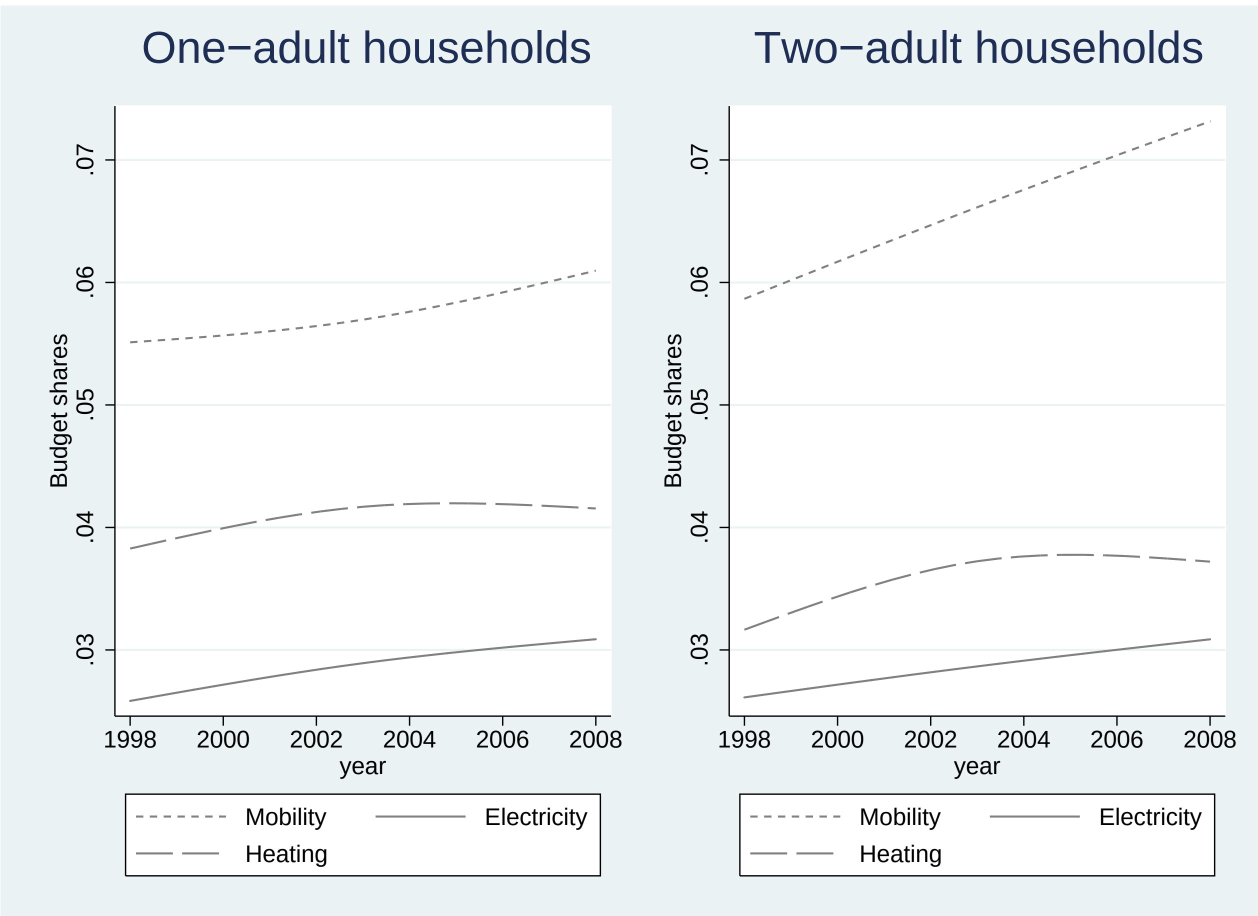
Expenditures for electric heating can be included either as "Electricity" or "Heating", depending on how they are reported by the household. The last consumer good group contains all expenditures that are classed as *non-durable*. This includes consumer goods like housing, food, drinks, tobacco, articles of daily use, health expenditures, spending for leisure activities etc., where housing forms the biggest position within the group. Housing expenditures in the data can be actually paid rents without heating and electricity costs or imputed rents for owner-occupied houses and flats. The imputed rents are calculated by the German Federal Statistical Office (*Statistisches Bundesamt*) and already implemented in the EVS data sets.

In Figure 3.1, the development of the shares for energy goods and mobility in the examined time span can be considered. The shares are defined as expenditures on the respective consumer good group divided by total expenditures on non-durable goods (leisure time is excluded). The left part of the figure shows the shares for one-adult households as median spline plots, which connect the medians at the three observed points in time 1998, 2003 and 2008. In the right part, the same is shown for the two-adult household sample.

The graphs show a clear tendency of increasing expenditure shares for energy goods with the exception of stagnating shares of heating expenditures between 2003 and 2008. For both, the one-adult and two-adult households, the median share of electricity expenditures follows a positive linear trend that ends over 3% in 2008. Heating expenditures are slightly over 4% in one-adult households and about 3.7% in two-adult households.

[17]Note that the intensive labor supply elasticity is not always the same as the intensive leisure demand elasticity, only in the special case if the number of hours worked is equal to the one of leisure time. See Section 3.5 for details and the difference between the two elasticities in this study.

Figure 3.1: Development of the Expenditure Shares over Time



Notes: Median spline plots in the subsamples calculated using the EVS (1998, 2003 and 2008) provided by the German Federal Statistical Office (*Statistisches Bundesamt*). The budget shares are defined as expenditures in the respective consumer good group divided by total expenditures on non-durable goods.

Table 3.1: Descriptive Statistics on One-Adult Households

Without leisure	**Whole sample**			**Conditional sample obs. 31,885**	
	mean	**st. dev.**	**obs. >0**	**mean**	**st. dev.**
Consumption budget	1107.22	523.35	**38,128**	1118.27	523.35
Expenditures					
Mobility	77.80	83.39	34,219	84.62	79.16
Electricity	34.79	27.55	35,633	36.82	27.67
Heating	50.93	69.07	29,515	52.35	68.75
Other non-durables	943.69	471.01	38,128	944.48	419.52
Shares					
Mobility	0.07	0.06	34,219	0.08	0.06
Electricity	0.03	0.02	35,633	0.03	0.02
Heating	0.05	0.05	29,515	0.05	0.05
Other non-durables	0.85	0.07	38,128	0.84	0.07
Including leisure	**Whole sample obs. 38,128**			**Working individuals obs. 21,449**	
Labor/Leisure					
Hours worked	19.50	18.71		34.18	10.95
Gross wage	8.81	10.23		15.50	9.08
Net wage	4.65	5.36		8.16	4.71
Net wage (Heckman)	8.36	2.33		9.14	2.04
Marginal tax rate	0.18	0.16		0.28	0.13
Marginal total burden	0.26	0.23		0.42	0.16
	Whole sample obs. 38,128			**Estimation sample obs. 17,362**	
Shares					
Mobility	0.04	0.03		0.05	0.03
Electricity	0.02	0.01		0.02	0.01
Heating	0.02	0.03		0.02	0.02
Leisure	0.47	0.14		0.46	0.11
Other non-durables	0.45	0.12		0.45	0.10

Notes: The consumption budget and expenditures are in euro per month. The hours worked are hours per week and the wages are in euro per hour.

Source: Own calculations using the scientific use-files of the EVS (1998, 2003 and 2008) provided by the German Federal Statistical Office (*Statistisches Bundesamt*).

Differences between the household types exist for mobility consumption. Although, the positive time trend can be seen in both plots, the median share for two-adult households lies over 7% in 2008 but only around 6% for the singles.

Table 3.1 gives a comprehensive picture of the descriptive evidence for one-adult households. In the upper part, the statistics for the consumer goods are presented, which means that expenditures on leisure are left out. So, the sum of consumer good shares is one. On average, the total budget on non-durables is about 1,100 euro per month and the shares are 7% for mobility, 3% for electricity, 5% for heating and 85% for other non-durables. As mentioned in Section 3.3.3, some observations are excluded because of zero or small consumption in respective categories. From the total one-adult sample of 38,128 households, only 31,885 remain due to missing information about mobility or electricity consumption. The upper right part of the table shows the descriptives for the conditional sample, in which the mobility share is risen by one percentage point due to the censoring.

The lower part of Table 3.1 shows the statistics if leisure time is introduced to the model. Firstly, the statistics on leisure/labor specific information are presented. The descriptives for the whole sample on the right are compared to subsamples in the left part of the table, first the sample of working households (21,449 observations) and below the estimation sample, which consists of all individuals younger than the age of 65 who are working and have mobility and electricity expenditure shares of each with at least 1% (calculated without leisure consumption). The estimation sample comprises 17,362 observations.

For the whole sample the average working time is 19.5 hours per week and 34.2 hours for the working population.[18] The average gross and net wages, as well as the unconditional Heckman wage predictions are listed in the lines below (all in euro per hour).[19] And the marginal tax rates and the marginal burden rates, which include the marginal tax rate and the marginal burden on social security contributions, follow under it.[20] In the demand system, the share of leisure expenditures amounts to about 47% of the new total budget in the whole sample and the share is 46% in the estimation sample. The share of leisure expenditures increases slightly between 1998 and 2008 because of the reduced hours worked over the time span (not in the table).

Table 3.2 presents the same statistics for the two-adult households. The average consumption budget is about 1,900 euro per month and the average consumption structure does not differ much from the one for one-adult households. Accounting for the censoring leaves 72,869

[18]See Appendix 3.11.2 for a comparison of the distributions of hours worked by survey year and household type.

[19]Note that the net wages are wages after tax and social security contributions, which may differ from other net wage definitions in the literature, where it is defined as wage after tax.

[20]See as well Appendix 3.11.1 for histograms that show the simulated marginal burden rates in the three survey years.

Table 3.2: Descriptive Statistics on Two-Adult Households

Without leisure	**Whole sample**			**Conditional sample obs. 72,869**	
	mean	**st. dev.**	**obs. >0**	**mean**	**st. dev.**
Consumption budget	1898.68	757.57	**77,910**	1884.31	757.57
Expenditures					
Mobility	140.05	118.90	76,256	141.13	111.52
Electricity	58.44	39.42	74,495	60.50	38.96
Heating	79.38	102.93	60,055	79.63	101.82
Other non-durables	1620.80	686.80	77,910	1603.06	635.29
Shares					
Mobility	0.07	0.05	76,256	0.08	0.05
Electricity	0.03	0.02	74,495	0.03	0.02
Heating	0.04	0.05	60,055	0.04	0.05
Other non-durables	0.85	0.07	77,910	0.85	0.07
Including leisure	**Whole sample obs. 77,910**			**Working individuals male obs. 49,587 / female obs. 43,571**	
Labor/Leisure					
Hours worked male	24.81	20.02		38.99	8.77
Hours worked female	15.16	16.21		27.11	12.07
Gross wage male	11.94	12.50		18.76	10.83
Gross wage female	7.38	9.34		13.19	8.91
Net wage male	6.81	7.35		10.70	6.58
Net wage female	3.88	4.98		6.93	4.81
Net wage (Heckit) male	10.66	3.73		11.74	3.41
Net wage (Heckit) female	6.75	2.13		7.64	1.58
Marginal tax rate male	0.21	0.15		0.29	0.10
Marginal tax rate female	0.17	0.16		0.25	0.13
Marg. total burden male	0.28	0.21		0.41	0.13
Marg. total burden female	0.25	0.23		0.39	0.19
	Whole sample obs. 77,910			**Estimation sample obs. 53,078**	
Shares					
Mobility	0.04	0.03		0.04	0.02
Electricity	0.02	0.01		0.02	0.01
Heating	0.02	0.03		0.02	0.02
Leisure male	0.24	0.15		0.30	0.10
Leisure female	0.22	0.12		0.23	0.08
Other non-durables	0.46	0.20		0.40	0.10

Notes: The consumption budget and expenditures are in euro per month. The hours worked are hours per week and the wages are in euro per hour.

Source: Own calculations using the scientific use-files of the EVS (1998, 2003 and 2008) provided by the German Federal Statistical Office (*Statistisches Bundesamt*).

out of 77,910 observations in the sample.

In the lower part of Table 3.2, descriptive information on leisure/labor is presented for men and women separately, as they both enter separately the model. The men work more on average than the women and earn higher wages. Note that the estimation sample includes only households, in which the man is younger than 65 or the woman is younger than the age of 63, at least one of them is working and additionally mobility and electricity expenditure shares of each with at least 1% (calculated without leisure consumption). This leaves the estimation sample with 53,078 observations. Separately considered, there are 49,587 households with a working male person and 43,571 households with a working female person. The average net wage for working men is 10.70 euro per hour, while it is 6.93 euro per hour for working women. Interestingly, the marginal burden for women is only a bit smaller on average than for men, which results from joint assessment to the income tax for married couples.

The share for male leisure time is 24% and for female leisure time 22% in the unconditional sample, while it is 30% for males and 23% for females in the demand system estimation sample.

3.5 Results

In this section, the estimation results for the demand elasticities of Eq. (3.12) are presented separately for one-adult and two-adult households. First the extensive reactions to labor supply are discussed, then the unconstrained estimation results from the demand system without implementing the constraints on symmetry and homogeneity (see Section 3.2) are shown. For welfare analyses and tax revenue simulations, the fully consistent demand system with the cross-equation restrictions has to be used, which is then presented and discussed afterwards.

Results for the One-Adult Households

Firstly, the results from the "structural" probit model for the participation decision to work are presented in Table 3.3. These results refer to the elasticities with respect to changes in the commodity prices and the wage. It is differentiated between male and female wage responses by interacting the wage with a dummy indicating the gender. Confidence intervals are calculated using the delta method (see Greene, 2003, p. 913).[21]

Unfortunately, the price for electricity cannot be included in this model, because of the high correlation with the time dummies. It is the only price effect that oscillates heavily if

[21] The estimation results from the probit can be found in Table 3.16 in Appendix 3.12.2.

Table 3.3: Compensated Price and Own Wage and Income **Elasticities of Extensive Leisure** for One-Adult Households[1]

Prices	Mobility	Heating	Own wage (m)	Own wage (f)	Others
	0.031	**-0.000**	**-0.244**	**-0.365**	**0.619**
	[0.025 : 0.037]	[-0.001 : 0.001]	[-0.466 : -0.023]	[-0.583 : -0.146]	[0.422 : 0.816]
Income			Male	Female	
			0.031	**0.056**	
			[0.027 : 0.035]	[0.052 : 0.060]	

Notes: 95%-Confidence intervals of robust standard errors in parentheses.
[1]: All elasticities are evaluated at the respective means of the explanatory variables.
Reading example: A 1% increase in the price of mobility increases the demand for leisure by 0.031%.
Source: Own calculations using the scientific use-files of the EVS (1998, 2003 and 2008) provided by the German Federal Statistical Office (*Statistisches Bundesamt*).

time dummies are included in the probit and is therefore excluded.[22] The extensive compensated demand for leisure increases if the prices for mobility and the other non-durable goods increases. A 1% increase in these prices rises leisure by about 0.03% (mobility) and 0.62% (other goods). The elasticity for the price of heating is not significant. Importantly, the extensive wage elasticity for men is -0.24 and for women -0.37 and both significantly different from zero. The standard errors of the wage effects are quite high, which could be explained by the first stage Heckit. There is maybe too less variation in the predicted wage and no strong exclusion restriction since only single households are in the sample. However, the income elasticities are estimated very precisely and significantly different from zero with 0.03 for men and 0.06 for women. So, the uncompensated wage effect for men is about -0.2 and only significant at the 10% level, while it is -0.3 and still significant at the 5% level for women.

Next, the results for the demand system are considered in Table 3.4. The leisure demand elasticities here correspond to reactions at the intensive margin.[23] These results are also best evaluated by considering the price and budget elasticities of demand. They show the compensated and uncompensated effects of price changes on the quantitative demand (hours in the leisure case). The corresponding parameters of the share equations are reported in Table 3.18 in the Appendix, but the interpretation is not intuitive. They refer to the marginal effects on the expenditure shares and are used to calculate the elasticities. Additionally, the implications of homogeneity and symmetry are tested with the estimated parameters, which

[22]Setting the leisure demand elasticity with respect to the electricity price to zero is justified by the constrained demand system estimation, which can be seen anticipatory in Table 3.5.

[23]Elasticities at the *intensive margin* are always referring to effects conditioned on labor market participation in the following.

Table 3.4: Compensated Price and Budget Elasticities[1] for Commodity Demand and **Intensive Leisure** (Unconstrained Estimation for One-Adult Households)

Compensated	Mobility	Electricity	Heating	Leisure	Others
Mobility price	**-0.90**	**-0.13**	**-0.08**	**0.19**	**-0.09**
	[-1.03 : -0.78]	[-0.25 : -0.01]	[-0.27 : 0.11]	[0.15 : 0.22]	
Electricity price	**0.54**	**-0.55**	**-0.25**	**-0.40**	**0.38**
	[0.28 : 0.80]	[-0.79 : -0.30]	[-0.65 : 0.14]	[-0.46 : -0.33]	
Heating price	**0.11**	**-0.03**	**-0.74**	**0.05**	**-0.02**
	[0.04 : 0.18]	[-0.10 : 0.04]	[-0.85 : -0.64]	[0.03 : 0.07]	
Wage	**0.30**	**0.06**	**0.05**	**-0.13**	**0.09**
	[0.17 : 0.42]	[-0.06 : 0.18]	[-0.14 : 0.23]	[-0.16 : -0.09]	
Others price	**1.02**	**0.85**	**1.48**	**0.88**	**-1.10**
	[0.53 : 1.52]	[0.38 : 1.31]	[0.74 : 2.22]	[0.75 : 1.01]	
Budget elasticities[2]					
	0.92	**0.84**	**1.26**	**0.30**	**1.00**
	[0.81 : 1.04]	[0.73 : 0.96]	[1.08 : 1.44]	[0.24 : 0.36]	

Notes: Confidence intervals in parentheses.
[1]: All elasticities are evaluated at the respective mean expenditures.
[2]: The budget elasticities presented here for the consumer goods refer to changes in the expenditure budget rather than to changes in the virtual budget including leisure consumption. This allows to compare the budget effects with demand systems neglecting leisure consumption.
Reading example: A 1% increase in the price of mobility decreases the demand for mobility by 0.9%.
Source: Own calculations using the scientific use-files of the EVS (1998, 2003 and 2008) provided by the German Federal Statistical Office (*Statistisches Bundesamt*).

are then constrained in a second estimation to impose these conditions.

As the total budget is instrumented by non-labor and transfer income in the 3SLS model, some diagnostics are made to check the validity of the instrumentation. The partial R^2 is 8% and exogeneity has to be rejected by the Hausman-Wu test (Hausman, 1978; Wu, 1973) in all equations, which shows an acceptable correlation between the instrument and the total budget and the need for instrumentation. Also, the included density terms for the selection correction are reported in Table 3.18 in the Appendix. They are included in every equation because of the system dependency of every parameter. The density term for heating is not significant in the heating equation, but highly significant in other equations and can therefore not be neglected. The density term for leisure is not significant in any equation but will be of statistical relevance if the cross-equation restriction are set later on. Furthermore, the insignificance of the density term does not imply that there is no sample selection bias because the price respectively wage variable is also adjusted in the correction procedure.

The elasticities for the unconstrained estimation are shown in Table 3.4. The sample contains 17,333 households, as discussed in the descriptive section. The elasticities are evaluated regarding the formulas of Eq. (3.2)-(3.5) at the mean expenditures of the sample.

Table 3.4 presents the compensated price elasticities on top and the budget elasticities below. The quantities are put in the columns, while the prices are in the lines. The table is read in the following way: A 1% price increase, e.g. in the price of electricity, yields a 0.54% increase in the demand for mobility.

The own-price elasticities are on the main diagonal and they are all negative, which means that the negativity condition is fulfilled. There are inelastic own-price effects found for mobility (-0.9), electricity (-0.55), heating (-0.74) and leisure (-0.13). A reaction of -1 is found for the other non-durable goods. The budget effects for the goods can be found in the bottom row and indicate all goods to be normal goods except for heating, which is a superior good, and the other non-durables, which have a proportional reaction of one according to *Cobb-Douglas* preferences. The budget effects for the commodities refer to changes in the expenditure budget without the expenditures on leisure, which are *virtual* expenditures, to make them comparable with demand systems that exclude leisure. The uncompensated price elasticities have to be calculated indeed with the budget effects including leisure.[24]

The compensated leisure own-wage effect is -0.13 and significant. The respective elasticity on labor supply would be +0.13 in this case, because the time endowment is set to two times the working time (working time equals leisure time at the mean). The corresponding budget elasticity is estimated to about 0.3 and the uncompensated price elasticity of leisure would then be zero. The respective labor supply elasticities, extensive from Table 3.3 and intensive from Table 3.4, are in the range of estimated values in the literature (see Fuchs, Krueger, and Poterba, 1998, for a review), even though a differentiation between male and female labor supply at the intensive margin for single households brought no additional insight in another specification because there were no significant interaction effects found. Furthermore, the estimates of the leisure budget effect are significantly affected by the instrumentation. OLS estimates would give an income elasticity of 0.7.

The unconstrained estimation violates clearly the conditions on homogeneity and symmetry. The χ^2-test with the null of symmetry of the cross-price effects has to be rejected with a value of 169 (6 degrees of freedom) and homogeneity holds only in the electricity and heating equations, but does not hold in the mobility and leisure equations (χ^2-values of 28 respectively 123).

However, the restrictions for symmetry and homogeneity are set in order to estimate a fully consistent demand system. The respective elasticities are presented in Table 3.5, the compensated ones on top, the uncompensated ones below and the budget effects in the bottom row.

[24]The uncompensated price elasticities are left out in Table 3.4 for lack of space but can be seen in Appendix 3.12.3, Table 3.22.

Table 3.5: Compensated and Uncompensated Price and Budget Elasticities[1] for Commodity Demand and **Intensive Leisure**
(Constrained Estimation for One-Adult Households)

Compensated	Mobility	Electricity	Heating	Leisure	Others
Mobility price	**-0.43**	**0.02**	**0.27**	**0.03**	**0.00**
	[-0.51 : -0.35]	[-0.10 : 0.13]	[0.18 : 0.36]	[0.02 : 0.04]	
Electricity price	**0.01**	**-0.66**	**-0.02**	**0.00**	**0.02**
	[-0.03 : 0.05]	[-0.86 : -0.46]	[-0.07 : 0.03]	[0.00 : 0.01]	
Heating price	**0.13**	**-0.03**	**-0.86**	**0.02**	**0.01**
	[0.09 : 0.18]	[-0.11 : 0.04]	[-0.94 : -0.78]	[0.01 : 0.02]	
Wage	**0.29**	**0.07**	**0.33**	**-0.25**	**0.21**
	[0.20 : 0.39]	[-0.04 : 0.17]	[0.20 : 0.47]	[-0.28 : -0.22]	
Others price	**0.00**	**0.60**	**0.27**	**0.20**	**-0.24**
	[-0.13 : 0.13]	[0.44 : 0.76]	[0.09 : 0.45]	[0.17 : 0.23]	
Uncompensated					
Mobility price	**-0.50**	**-0.05**	**0.17**	**0.03**	**-0.09**
	[-0.58 : -0.42]	[-0.17 : 0.06]	[0.08 : 0.26]	[0.02 : 0.04]	
Electricity price	**-0.02**	**-0.68**	**-0.06**	**0.00**	**-0.01**
	[-0.06 : 0.02]	[-0.88 : -0.48]	[-0.10 : -0.01]	[-0.00 : 0.01]	
Heating price	**0.10**	**-0.07**	**-0.91**	**0.02**	**-0.03**
	[0.06 : 0.14]	[-0.14 : 0.00]	[-1.00 : -0.83]	[0.01 : 0.02]	
Wage	**1.03**	**0.84**	**1.45**	**-0.24**	**1.12**
	[0.90 : 1.17]	[0.69 : 0.98]	[1.26 : 1.65]	[-0.28 : -0.20]	
Others price	**-0.69**	**-0.11**	**-0.76**	**0.19**	**-1.08**
	[-0.85 : -0.53]	[-0.29 : 0.07]	[-0.99 : -0.54]	[0.16 : 0.23]	
Budget elasticities[2]					
	0.81	**0.84**	**1.23**	**0.02**	**1.01**
	[0.72 : 0.91]	[0.75 : 0.94]	[1.08 : 1.37]	[-0.03 : 0.07]	

Notes: Confidence intervals in parentheses.
[1]: All elasticities are evaluated at the respective mean expenditures.
[2]: The budget elasticities presented here for the consumer goods refer to changes in the expenditure budget rather than to changes in the virtual budget including leisure consumption. This allows to compare the budget effects with demand systems neglecting leisure consumption.

Source: Own calculations using the scientific use-files of the EVS (1998, 2003 and 2008) provided by the German Federal Statistical Office (*Statistisches Bundesamt*).

While the compensated own-price elasticities for electricity and heating bear similar magnitudes compared to the unconstrained estimation, smaller effects are found for mobility (-0.43) and the other non-durables (-0.24). The wage elasticity of leisure is with -0.25 significantly higher than in the unconstrained model. If the cross-price elasticities are considered, mobility is found to be a substitute for heating and leisure. Electricity is only related to the other non-durables as a substitute, while heating and the composite good are substitutes to each other and to leisure. Considering labor supply (and therefore switching the sign for leisure), the complementary relationship between labor and mobility seems plausible because more labor supply may be accompanied with a longer or more comfortable way to work to compensate for the more exhausting day. This is a side result and interesting for optimal taxation in context of energy goods. Significantly negative cross-price elasticities of labor supply lower the optimal tax on these respective goods in a second-best setting (also see West and Williams, 2004a, who found a positive elasticity of the gasoline price with respect to labor supply). Not so intuitive is the complementary link between heating and labor, which also did not appear in the extensive analysis. The complementary relationship seems to come in over the set cross-equation restrictions because it is not clearly identified in the unconstrained model.

The density term for leisure is now strongly significant in the leisure equation and also relevant in the mobility and heating equations (see Table 3.19 in the Appendix).

Interesting results from the uncompensated elasticities, which reflect the observed demand responses, are the wage elasticity of leisure of -0.24, which is not significantly different from the compensated one due to the small and insignificant income elasticity. Significant cross-price elasticities of leisure are found for mobility, heating and non-durables. Another result is that the own-price effect for other non-durables is close to the elasticity of *Cobb-Douglas* preferences, which is -1. Changes in the wage have big impacts on the consumption of the goods due to the budget effect.

The effects of leisure demand at the intensive and the extensive margin can be combined to total leisure demand elasticities (see Section 3.3.4 for the respective formula in Eq. (3.14)), which are shown in Table 3.6. In the table, the results from the constrained estimates at the intensive margin are combined with the extensive elasticities. The uncompensated own-wage elasticity is estimated to -0.26 for males and -0.32 for females and the other effects show only small differences to the results from the intensive margin.[25]

[25] The effect regarding the electricity price at the extensive margin is set to zero, as no extensive effect could be identified.

Table 3.6: Compensated and Uncompensated Price and Own Wage Elasticities[1] (Extensive and Intensive Elasticities Combined) for One-Adult HH

	Mobility	Electricity[2]	Heating	Own wage (m)	Own wage (f)	Others
Comp.						
	0.035	**0.001**	**0.009**	**-0.287**	**-0.357**	**0.477**
	[0.024 : 0.046]	[-0.002 : 0.004]	[0.002 : 0.016]	[-0.510 : -0.064]	[-0.576 : -0.138]	[0.352 : 0.602]
Uncomp.						
	0.032	**0.001**	**0.008**	**-0.263**	**-0.319**	**0.448**
	[0.021 : 0.043]	[-0.001 : 0.003]	[0.001 : 0.015]	[-0.488 : -0.038]	[-0.540 : -0.098]	[0.290 : 0.606]

Notes: 95%-Confidence intervals in parentheses. Standard errors calculated using the delta method.
[1]: All elasticities are evaluated at the respective means of the explanatory variables.
[2]: The commodity electricity has only estimates for the intensive elasticities, while the extensive ones are set to zero.
Reading example: A 1% increase in the price of mobility increases the compensated demand for leisure by 0.035%.
Source: Own calculations using the scientific use-files of the EVS (1998, 2003 and 2008) provided by the German Federal Statistical Office (*Statistisches Bundesamt*).

Results for the Two-Adult Households

In the sample of two-adult households, there are two leisure/work decisions per household, which are taken into account in the model. The estimated extensive elasticities of leisure from the bivariate probit model are shown in Table 3.7, symmetry in the cross-wage effects is imposed. The between-equation correlation coefficient ρ is estimated to 0.18 and significant (the estimated parameters from the model can be found in Table 3.17 in Appendix 3.12.2). Again, the electricity price elasticity is assumed to be zero because of the same issues noted for one-adult households. The male compensated leisure demand elasticities with respect to the prices are found in a similar magnitude like for singles. The own-wage effect is estimated to be -0.15, while the cross-wage effect to the female net wage is about 0.1. The income elasticity is found to be 0.05, which gives an uncompensated own-wage elasticity of -0.11 following the Slutsky equation.

The female elasticities differ. The effects with respect to the price of mobility and the composite good are smaller, while the negative elasticity with respect to the heating price is more negative. The compensated own-wage effect is large with -0.42, which is also found in the literature according to Fuchs et al. (1998), but for Germany rather the upper bound.[26] The response to a male wage increase is, at 0.16, slightly higher than the cross-wage effect for men. The spouse's wages have in both cases a crowding-out effect. The income elasticity for females is similar to that of males with a small value of 0.05, which gives an uncompensated elasticity of -0.4.

[26] A labor supply elasticity with a similar magnitude for Germany is e.g. found by Haan and Steiner (2005).

Table 3.7: Compensated Price and Own Wage and Income **Elasticities of Extensive Leisure** for Two-Adult Households[1]

	Mobility	Heating	Own wage	Spouse's wage	Others	Income
Male leisure						
	0.022	**-0.003**	**-0.151**	**0.102**	**0.776**	**0.054**
	[0.017 : 0.028]	[-0.003 : -0.002]	[-0.174 : -0.127]	[0.083 : 0.120]	[0.616 : 0.935]	[0.048 : 0.061]
Female leisure						
	0.008	**-0.005**	**-0.416**	**0.161**	**0.689**	**0.048**
	[-0.000 : 0.016]	[-0.006 : -0.004]	[-0.458 : -0.374]	[0.132 : 0.190]	[0.456 : 0.923]	[0.039 : 0.058]

Notes: 95%-Confidence intervals in parentheses.
[1]: All elasticities are evaluated at the respective means of the explanatory variables.
Reading example: A 1% increase in the price of mobility increases the demand for male leisure by 0.022%.
Source: Own calculations using the scientific use-files of the EVS (1998, 2003 and 2008) provided by the German Federal Statistical Office (*Statistisches Bundesamt*).

Next, Table 3.8 presents the intensive model for the unconstrained elasticities.[27]

The partial R^2 for the instrument of total budget is about 6% and the Hausman-Wu test clearly rejects exogeneity in all equations. The three included density terms for selectivity correction (heating, male leisure and female leisure) have a differing relevance in the system of equations. The two leisure correction terms are not significant at all in the unconstrained estimation, while the heating term is significant in all equations in contrast to the one-adult model. But when the parameter results for the constrained estimation are considered (see Table 3.21 in Appendix 3.12.2), the female leisure correction term is at least at the 10% level significant in its own equation and the male leisure term is also significant in its equation. Therefore, it is important to control for selectivity since one significant term in an equation effects the results of all other equations via adding-up restriction.

The compensated own-price elasticities are in range of the ones found for single households. For mobility, the elasticity is estimated to -0.54 and for electricity and heating it is slightly below one (-0.89 respectively -0.84). The response for other non-durables is very elastic and higher than the effect for singles. The own-wage effects for male and female leisure are also negative, which is consistent with the theory. Both effects lie around -0.1, with the female point estimate lying a bit under the one found for men.

The cross-wage effect on female leisure is significant and found to be positive, but quite small with 0.04. For male leisure, the cross-wage effect is insignificant.

The budget effects for the consumer goods are also similar to those found for singles but

[27]See Table 3.20 in Appendix 3.12.2 for the estimated parameters and Appendix 3.12.3 for the results of the uncompensated elasticities in the unconstrained estimation.

Table 3.8: Compensated Price and Budget Elasticities[1] for Commodity Demand and **Intensive Leisure** (Unconstrained Estimation for Two-Adult Households)

Compensated	Mobility	Electricity	Heating	Male leisure	Female leisure	Others
Mobility price	**-0.54**	**0.10**	**0.10**	**0.07**	**0.04**	**-0.03**
	[-0.61 : -0.48]	[0.02 : 0.17]	[-0.04 : 0.23]	[0.04 : 0.10]	[0.01 : 0.06]	
Electricity price	**-0.19**	**-0.89**	**0.03**	**-0.19**	**-0.26**	**0.33**
	[-0.34 : -0.05]	[-1.05 : -0.73]	[-0.28 : 0.34]	[-0.25 : -0.13]	[-0.31 : -0.20]	
Heating price	**0.21**	**0.05**	**-0.84**	**-0.05**	**-0.01**	**0.06**
	[0.17 : 0.24]	[0.01 : 0.09]	[-0.91 : -0.78]	[-0.06 : -0.03]	[-0.02 : 0.00]	
Male wage	**0.08**	**0.06**	**0.14**	**-0.13**	**0.04**	**0.06**
	[0.05 : 0.11]	[0.03 : 0.10]	[0.07 : 0.20]	[-0.15 : -0.12]	[0.03 : 0.06]	
Female wage	**0.07**	**0.08**	**0.00**	**0.00**	**-0.12**	**0.06**
	[0.04 : 0.11]	[0.04 : 0.12]	[-0.08 : 0.07]	[-0.01 : 0.01]	[-0.13 : -0.10]	
Others price	**0.62**	**0.89**	**2.04**	**1.37**	**0.78**	**-1.63**
	[0.33 : 0.92]	[0.57 : 1.21]	[1.44 : 2.63]	[1.25 : 1.49]	[0.67 : 0.89]	
Budget elasticities[2]						
	0.81	**0.72**	**1.40**	**0.04**	**0.02**	**1.01**
	[0.76 : 0.87]	[0.66 : 0.78]	[1.29 : 1.51]	[-0.01 : 0.09]	[-0.02 : 0.07]	

Notes: Confidence intervals in parentheses.
[1]: All elasticities are evaluated at the respective mean expenditures.
[2]: The budget elasticities presented here for the consumer goods refer to changes in the expenditure budget rather than to changes in the virtual budget including leisure consumption. This allows to compare the budget effects with demand systems neglecting leisure consumption.
Source: Own calculations using the scientific use-files of the EVS (1998, 2003 and 2008) provided by the German Federal Statistical Office (*Statistisches Bundesamt*).

a bit smaller for mobility and electricity. For both leisure categories, the budget effect is insignificant and much smaller than the one for singles, which had a value of 0.3.

If one converts the intensive leisure elasticities, which are all elasticities in the columns "Male leisure" and "Female leisure", into intensive labor supply elasticities, they will not only differ in the sign anymore, but also in the magnitude. The reason is that the time endowment is not normalized in the two-adult sample. The time endowment is 70 hours and the leisure demand elasticity equals the labor supply elasticity only in the case if the hours worked are 35 and the hours for leisure are also 35. The elasticity stands for a percentage effect of hours, which refer to different bases whether one considers leisure or labor. For example, a 10% increase in the wage for men reduces male leisure by 1.3%, which are 0.4 hours at the mean. But these 0.4 hours are only 1% of hours worked because men work more than 35 hours at the mean and therefore they consume less than 35 hours leisure. So, the labor supply elasticities for males are -0.78 times the leisure demand elasticities and for females, they are about -1.6 as high as leisure demand because the female labor time share of the time endowment is only 38.5%. Thus, the compensated own-wage elasticity for female labor supply is about 0.2.

The hypotheses on homogeneity and symmetry are also broadly rejected in the two-adult case. The only two equations in which homogeneity cannot be rejected at least at the 1% level are the mobility and electricity equations (χ^2-value of 5.23 respectively 6.18). The condition is rejected in the other equations with χ^2-values between 47 (heating) and 601 (male leisure). The null hypothesis on symmetry in the system is clearly rejected (χ^2-value of 420 with 10 degrees of freedom). However, the demand system is restricted on these conditions, and the results can be seen in Table 3.9.

Table 3.9: Compensated and Uncompensated Price and Budget Elasticities[1] for Commodity Demand and **Intensive Leisure**
(Constrained Estimation for Two-Adult Households)

Compensated	Mobility	Electricity	Heating	Male leisure	Female leisure	Others
Mobility price	**-0.54**	**0.10**	**0.43**	**0.02**	**0.01**	**0.01**
	[-0.58 : -0.50]	[0.03 : 0.17]	[0.38 : 0.48]	[0.02 : 0.03]	[0.00 : 0.01]	
Electricity price	**0.04**	**-0.67**	**0.04**	**0.00**	**0.00**	**0.01**
	[0.01 : 0.06]	[-0.81 : -0.55]	[0.01 : 0.07]	[0.00 : 0.01]	[0.00 : 0.01]	
Heating price	**0.20**	**0.06**	**-0.76**	**0.01**	**-0.01**	**0.01**
	[0.17 : 0.22]	[0.01 : 0.10]	[-0.82 : -0.71]	[0.01 : 0.02]	[-0.01 : 0.00]	
Male wage	**0.18**	**0.10**	**0.23**	**-0.18**	**0.01**	**0.09**
	[0.15 : 0.21]	[0.06 : 0.13]	[0.17 : 0.28]	[-0.19 : -0.17]	[0.00 : 0.02]	
Female wage	**0.04**	**0.05**	**-0.10**	**0.01**	**-0.14**	**0.07**
	[0.01 : 0.07]	[0.01 : 0.10]	[-0.16 : -0.04]	[0.01 : 0.02]	[-0.15 : -0.12]	
Others price	**0.08**	**0.37**	**0.17**	**0.13**	**0.12**	**-0.19**
	[0.04 : 0.13]	[0.29 : 0.46]	[0.08 : 0.26]	[0.11 : 0.14]	[0.10 : 0.13]	
Uncompensated						
Mobility price	**-0.61**	**0.04**	**0.32**	**0.02**	**0.00**	**-0.08**
	[-0.65 : -0.57]	[-0.03 : 0.12]	[0.27 : 0.37]	[0.02 : 0.03]	[-0.00 : 0.01]	
Electricity price	**0.01**	**-0.69**	**0.00**	**0.00**	**0.00**	**-0.02**
	[-0.01 : 0.04]	[-0.82 : -0.57]	[-0.02 : 0.03]	[0.00 : 0.01]	[0.00 : 0.00]	
Heating price	**0.17**	**0.03**	**-0.82**	**0.01**	**-0.01**	**-0.03**
	[0.14 : 0.19]	[-0.01 : 0.07]	[-0.87 : -0.77]	[0.01 : 0.02]	[-0.02 : -0.01]	
Male wage	**0.84**	**0.66**	**1.31**	**-0.18**	**0.05**	**0.09**
	[0.80 : 0.89]	[0.61 : 0.71]	[1.23 : 1.40]	[-0.19 : -0.16]	[0.04 : 0.06]	
Female wage	**0.28**	**0.26**	**0.30**	**0.01**	**-0.09**	**0.06**
	[0.25 : 0.32]	[0.22 : 0.30]	[0.23 : 0.36]	[0.00 : 0.03]	[-0.11 : -0.08]	
Others price	**-0.59**	**-0.20**	**-0.93**	**0.12**	**0.08**	**-1.03**
	[-0.65 : -0.53]	[-0.28 : -0.11]	[-1.04 : -0.82]	[0.11 : 0.14]	[0.06 : 0.10]	
Budget elasticities[2]						
	0.79	**0.68**	**1.30**	**0.01**	**0.09**	**1.01**
	[0.75 : 0.83]	[0.63 : 0.72]	[1.22 : 1.38]	[-0.01 : 0.03]	[0.06 : 0.12]	

Notes: Confidence intervals in parentheses.
[1]: All elasticities are evaluated at the respective mean expenditures.
[2]: The budget elasticities presented here for the consumer goods refer to changes in the expenditure budget rather than to changes in the virtual budget including leisure consumption. This allows to compare the budget effects with demand systems neglecting leisure consumption.
Source: Own calculations using the scientific use-files of the EVS (1998, 2003 and 2008) provided by the German Federal Statistical Office (*Statistisches Bundesamt*).

Unfortunately, the constraints on homogeneity and symmetry of the price effects affect the estimated budget effects. While the budget effects are normally estimated well in micro-econometric analyses and cross-equation restrictions on the prices should not alter this fact, the instrumentation of the budget in combination with the binding restrictions lowers the robustness of the estimated budget effects. For this reason, one additional restriction is imposed, which fixes the estimated budget effect for the composite good to the one of the unconstrained model. This single restriction suffices to avoid a significant bias of all estimated budget effects compared to the unconstrained estimation via adding-up.

The estimation gives inelastic compensated own-price effects for all goods, which lie close to the unconstrained ones. Mobility has an effect of -0.5, electricity of around -0.7, heating of around -0.8 and for the composite good of -0.2, where all are also similar to the ones in the constrained estimation for singles. The compensated own-wage elasticities for leisure are -0.18 for males and -0.14 for females, which relates to intensive labor supply elasticities of 0.14 for males and 0.22 for females.

Table 3.10: Compensated and Uncompensated Price and Own Wage Elasticities[1] (Extensive and Intensive Elasticities Combined)

Prices	**Two-Adult Households**			
	Male Leisure		Female Leisure	
	Comp.	Uncomp.	Comp.	Uncomp.
Mobility	**0.033**	**0.025**	**0.007**	**0.003**
	[0.026 : 0.040]	[0.019 : 0.031]	[0.000 : 0.014]	[-0.004 : 0.009]
Electricity[2]	**0.003**	**0.003**	**0.002**	**0.001**
	[0.002 : 0.004]	[0.002 : 0.004]	[0.000 : 0.003]	[-0.000 : 0.002]
Heating	**0.007**	**0.003**	**-0.007**	**-0.009**
	[0.003 : 0.011]	[-0.001 : 0.007]	[-0.012 : -0.002]	[-0.012 : -0.006]
Male wage	**-0.223**	**-0.195**	**0.094**	**0.125**
	[-0.252 : -0.194]	[-0.226 : -0.164]	[0.075 : 0.113]	[0.101 : 0.149]
Female wage	**0.076**	**0.090**	**-0.296**	**-0.265**
	[0.051 : 0.101]	[0.065 : 0.115]	[-0.324 : -0.268]	[-0.299 : -0.231]
Others	**0.608**	**0.570**	**0.434**	**0.398**
	[0.437 : 0.779]	[0.398 : 0.742]	[0.201 : 0.667]	[0.304 : 0.492]

Notes: 95%-Confidence intervals in parentheses. Standard errors calculated using the delta method.
[1]: All elasticities are evaluated at the respective means of the explanatory variables.
[2]: The commodity electricity has only estimates for the intensive elasticities, while the extensive ones are set to zero.
Reading example: A 1% increase in the price of mobility increases the compensated demand for male leisure by 0.033%.
Source: Own calculations using the scientific use-files of the EVS (1998, 2003 and 2008) provided by the German Federal Statistical Office (*Statistisches Bundesamt*).

The cross-price effects are again similar to those found for singles. Mobility has all other goods and both leisure categories as substitutes. Electricity has only small, but significant substitutional relationships to the other categories except for the higher effect of the price of other non-durables. Interestingly, heating is complementary to female leisure, as intuition would tell, but substitutional to male leisure. The cross-wage relationship between male and female leisure is substitutional, but with small magnitude.

Considering the uncompensated leisure elasticities reveals nearly the same magnitude as for the compensated ones because the budget effects are only small. A price increase in the composite good reduces the uncompensated demand for all commodities, as it has nearly the power of the inflation rate, but increases leisure.

Table 3.10 summarizes the results at extensive and intensive margin to combined elasticities of leisure. The compensated own-wage elasticity is about -0.2 for males and -0.3 for females in couple households, which is more inelastic for both than the effects found for singles. Higher prices of the commodities increase the demand for leisure, except for the heating price, which lowers female leisure.

3.6 Interim Conclusion

In the first part of this chapter, a demand system on energy goods involving the demand for leisure is estimated on German consumption cross-sectional data. For the purpose of evaluating policy reforms of the so called *green taxes*, three survey waves of the Income and Consumption Survey for Germany (*Einkommens- und Verbrauchsstichprobe*) are used to estimate a demand system that includes the demand for mobility, electricity, heating and other non-durables as well as leisure. The model allows for a reaction of leisure demand at the *extensive*, as well as at the *intensive* margin, to changes in prices and wages and combines both elasticities to a total response elasticity. It is estimated separately for single and couple households to allow for two different types of leisure demand in couple households. Selectivity corrections for heating demand and the leisure/labor choice are introduced to the model and found to be important for the results due to relevant shares of censored observations. To control for endogeneity of the total consumption budget, 3SLS estimation is applied, which instruments the budget with non-labor and transfer income. Exogeneity is strongly rejected and the income effects, especially for the leisure categories change significantly due to the instrumentation from highly positive to small in the single case (0.3) and insignificant in the couples case, and are in line with the literature.

The theoretical implications of symmetry and homogeneity are rejected, however they are imposed to estimate a fully consistent demand system. The estimated compensated own-price elasticities are all negative and in a plausible range for all goods. Mobility, electricity, heating and the other non-durables are estimated to be inelastic goods with elasticities significantly smaller than one.

Importantly, the compensated own-wage elasticity of leisure demand (intensive and extensive margins combined) is estimated to be -0.29 for single men and -0.36 for single women, while for couple households the elasticity for males is -0.22 and -0.3 for females. The respective uncompensated elasticities are a bit smaller for the singles with -0.26 for men and -0.32 for women, but not significantly different from the compensated ones because of high standard errors. For couples, they bear the same magnitudes because of the small (but significant) income effects. Comparing intensive and extensive elasticities for single women reveals a higher reaction at the extensive margin, while they are nearly equal at both margins for single males. For females in couple households the extensive reaction is significantly higher than the intensive one, while for males, they are nearly equal.

Interesting cross-price elasticities are found that, amongst others, confirm the intuitive view of the substitutional character between mobility and heating and between mobility and leisure. The latter is an important side result, because it lowers the tax on polluting goods that provide mobility in a second-best tax setting. Another result is that there are only small cross-price effects between heating and leisure and between electricity and leisure. They have all a substitutional character except for the relationship between heating and female leisure, which is found to be complementary. In summary, women's labor/leisure decision in couple households seems to depend less on other prices and consumption of the goods that are modeled here than men's decision.

The estimated consistent demand systems are used in a second step to evaluate the incidence of the green taxes on gasoline and diesel in Germany.

3.7 The Incidence of the Green Taxes on Gasoline and Diesel in Germany

Taxes on polluting goods, like gasoline or other fossil fuels, are gaining in importance. Since market prices do not incorporate the external costs of the consumption of these goods, economists propose taxing them in order to internalize these costs.[28] Increasing the price for e.g. gasoline to the efficient optimum, in which all external costs are internalized, would decrease the total amount of consumption of the good and reduce the emitted harmful substances that pollute the air. In the case of gasoline other external effects like the costs of noise and congestion are also addressed by the tax. Another positive aspect of these so-called *green taxes* is that one might use the generated tax revenue from it and reduce taxes that distort the efficient allocation of the markets like the tax on labor. The double-dividend hypothesis of *green taxes* (see e.g. Lee and Misiolek, 1986) is often discussed in the literature and the taxes are widely seen as an efficient instrument to increase the fiscal budget. However, several studies find that a tax on gasoline would have a regressive effect relative to the net income in a distributional analysis (see e.g. Poterba, 1991), which therefore has to be taken into account by policymakers because it reduces the popularity of the tax.

[28] First analyzed by Pigou (1920).

Between 1998 and 2005, in Germany, the governing coalition of the Social Democratic Party and the Green Party forced a more intense taxation of polluting goods. In the course of the green tax reform from 1998 to 2003 (*Ökosteuerreform*), a tax on electricity was introduced and the existing taxes on fossil fuels were increased. The taxes on gasoline and diesel were increased from 50 cents to 65 cents per liter for gasoline and for diesel from 32 cents to 47 cents. The study at hand considers a hypothetical reform of the taxes on gasoline and diesel, that cuts the taxes to the pre-green-tax-reform level from 1998. But the results are also valid with different sign for another increase in the taxes by 15 cents.

Using the EVS 2008 data for the microsimulation, the consumption of gasoline and diesel is initially derived from expenditures on fuel with imputation methods, and household specific price changes are calculated. In a second step, the price changes are inserted into the estimated demand system from Section 3.5 and used to calculate the distributional and welfare effects of such a reform.

3.8 Data for the Microsimulation

The EVS data 2008 is the latest available survey year of this cross-sectional series and contains the necessary detailed information on income and expenditures. As described in Section 3.3.2, the data set was also used in the demand system estimation. Although the expenditures on fuel are reported by the households, the differentiation between gasoline and diesel is not possible. The tax is a quantity tax and due to different prices between the two types of fuel, the households face different percentage effects on the prices depending on whether gasoline or diesel is consumed. It is therefore necessary to divide the expenditures into a gasoline part and a diesel part.[29] There are not many data sets available that report the type of fuel that households use. The data set "Mobility in Germany 2002" (MiD 2002), provided by the *German Institute for Economic Research* (DIW Berlin), is a representative survey that reports information on the first three cars in a household. Using socio-demographics that are available in both data sets, the type of fuel is imputed from the MiD 2002 to the EVS 2008. A multinomial logit is estimated separately for households with one, two or three cars with any combination between gasoline and diesel as an alternative in the MiD 2002. Information on the number of cars in the household is also available in the EVS, where the estimated models are then used to predict the combination of types. The crucial choice probabilities are calibrated in a way to fit the aggregate share of cars with diesel motors, which is published regularly by the Federal Office for Motor Traffic (*Kraftfahrt Bundesamt*). If there are gasoline and diesel

[29]Note that the price differential between gasoline and diesel was not very large in 2008, but the procedure of splitting the expenditures into a gasoline part and a diesel part is undertaken regardless.

vehicles predicted for a household, *Cobb-Douglas* preferences are assumed, which yield equally split expenditures between the vehicles. Additionally, quarterly averaged prices for 2008 are added to the data and used to derive the quantities of gasoline and diesel consumption for each household.[30]

The data base was not updated to 2013 because the changes in expenditures and the income distribution were probably not so large since 2008. In principle, the demand system could be used to update the consumption structure by inserting a new price vector and a new budget (income). In the next section, the results from the microsimulation are presented.

3.9 Results from the Distributional and Welfare Analysis

Firstly, the static effects of a tax relief on gasoline and diesel are simulated. As the commodity group "Mobility" consists of fuel and public transportation, a direct price effect for the latter has to be assumed. Although, substitution between fuel and public transportation is not modeled, the average price decline for fuel was assumed as a price shock on the input factor fuel in public transportation. The total price effect on mobility consumption sums over the price effect on fuel times the expenditures on fuel and the price effect times the expenditures on public transportation multiplied with the share of fuel input in this industrial sector. According to the input-output table 2007 provided by the Statistisches Bundesamt (2010), the average share of fuel costs in total production value of public transportation is about 4%.

Additionally to the static analysis, the demand system is used to calculate some interesting behavioral responses. The compensated elasticities are used to calculate the compensating variations (CV), which are then aggregated assuming an *Utilitarian* social welfare function, meaning all households get the same weight. To calculate the CVs, a second-order approximation is used from Weitzman (1988). Afterwards, the uncompensated demand responses are considered for the revenue effects and the excess burden of taxation. Note that the estimated elasticities correspond to marginal effects, which have to be assumed as constant if a reform is simulated that is not marginal.

In Table 3.11, the households are sorted by the net equivalent income, with the poorest households in the first decile.[31] The first three columns refer to the static analysis of just plotting the tax relief by holding the consumed quantities constant. The average relief is 10.70 euro per month. The continuous increase in the monthly amount over the deciles means that

[30] The price information was collected from the internet and several sources were compared (e.g. http://www.benzinpreis.de).

[31] The need-weighted concept of equivalent income is applied here, which means that the equivalent income is weighted by the equivalent scale of the households instead of its number of persons (see e.g. Bönke and Schröder, 2010).

Table 3.11: Distributional Effects of a Tax Relief on Gasoline and Diesel

Net equivalent income	average class income	highest class income	**Static tax relief** Euro	(1) %	(2) %	**Compensating variation** Euro	(1) %	(2) %	Compensating variation to static burden ratio
Bottom 5 %	591	735	- 2.78	- 0.39	- 0.34	- 1.04	- 0.14	- 0.13	0.37
1. decile	693	876	- 3.09	- 0.35	- 0.36	- 1.31	- 0.15	- 0.15	0.42
2. decile	999	1 120	- 5.75	- 0.42	- 0.53	- 3.39	- 0.25	- 0.31	0.59
3. decile	1 230	1 336	- 8.10	- 0.46	- 0.64	- 5.61	- 0.32	- 0.44	0.69
4. decile	1 436	1 538	- 9.64	- 0.44	- 0.67	- 6.91	- 0.32	- 0.48	0.72
5. decile	1 638	1 738	- 11.03	- 0.44	- 0.71	- 8.20	- 0.33	- 0.53	0.74
6. decile	1 851	1 967	- 12.17	- 0.43	- 0.73	- 9.12	- 0.32	- 0.55	0.75
7. decile	2 098	2 246	- 13.41	- 0.41	- 0.75	- 10.13	- 0.31	- 0.56	0.76
8. decile	2 430	2 649	- 14.43	- 0.37	- 0.73	- 10.94	- 0.28	- 0.56	0.76
9. decile	2 967	3 369	- 15.74	- 0.33	- 0.70	- 12.00	- 0.25	- 0.53	0.76
10. decile	4 690	.	- 16.38	- 0.23	- 0.60	- 12.43	- 0.18	- 0.46	0.76
Average	1 957	.	- 10.70	- 0.36	- 0.66	- 7.77	- 0.26	- 0.48	0.73

Notes: Sorted by the distribution of net equivalent income (new OECD scale). Euro per month.
(1): The column displays the monetary effect as a percentage of net income.
(2): The column displays the monetary effect as a percentage of non-durable consumption expenditures.
Source: Own calculations using the scientific use-files of the EVS 2008 provided by the German Federal Statistical Office (*Statistisches Bundesamt*).

the consumed quantities of fuel are increasing with the equivalent income. The next column shows the relative relief compared to the net income. There is a slight progressivity up to the third decile and then a clear regressive effect, as usually found for indirect tax incidence (see e.g. Ochmann et al., 2012, for distributional effects of the value-added tax in Germany). The slight progressivity part in the bottom of the distribution suggest underproportional low fuel consumption for poor households. Therefore, the regressivity of the gasoline tax appears overall less compared to other indirect taxes, even compared to taxes on other energy goods like electricity (see e.g. Beznoska, Cludius, and Steiner, 2012, who analyze the effects of the European Union Emissions Trading System for CO_2, which can be converted into a tax on electricity). When the next column is considered, where the relative relief compared to non-durable consumption is shown, the progressivity holds up to the seventh decile and the top decile still receives more than the bottom 20%. Similar results for the distribution of gasoline consumption were found by Poterba (1991) for the United States. The distributions of income and consumption differ in the amount of savings and additionally in this analysis of consumption on durables too. If only one point in time is considered in a distributional analysis, then the question arises as to which measure is the best to show the relative relief compared to the true economic welfare position. The income can be seen as the true economic potential but it contains savings and therefore the true welfare position can be distorted because savings may be consumed at a different point in time, when no or only low earnings are expected. So, income is more volatile over the life-cycle, whereas consumption does not vary as much. Consumption, or more precisely non-durable consumption, reflects a stream of utility that a household actually gets, which can be seen as a better indicator of the wealth position over the life-cycle because it can be smoothed by savings and dissavings (see e.g. Caspersen and Metcalf, 1994, for a discussion).

The compensating variations are plotted in the right part of Table 3.11. They are on average about 27% smaller than the static relief (speaking of the absolute value). Decomposing this deviation reveals that about half of the effect comes from the substitution within the demand system of commodities and intensive leisure demand while the other half from the extensive leisure demand. Relevant distributional differences between the static results and the CVs are found for the bottom 20% of households. The interesting result is the small relative relief compared to the net income, which can be seen especially for the bottom 5%. The relative relief lies with -0.14% considerably under the average of -0.26%, whereas it is above average in the static analysis. There are big substitution effects in the bottom decile, as the own-price elasticity is negatively correlated with the share of mobility expenditures, which diminishes at the bottom of the distribution. Another factor is the high relevance of the extensive margin of leisure for the poorest. The substitution effect from the extensive part of the model is about 17% higher than the one from the demand system for the bottom 20% households and shrinks for the richer deciles.

Table 3.12: Changes in Labor Force Participation and Commodity Demand

Net equivalent income	**Change in labor force participation**				**Share of single households**	**Change in expenditures**				**Mobility price change**
	Singles		**Couples**							
	M	F	M	F		Mobility	Electr.	Heating	Others	
	%				%	%				%
Bottom 5 %	0.44	0.00	0.00	0.00	79.62	- 2.78	0.07	- 0.61	0.37	- 3.75
1. decile	0.28	0.00	0.00	0.00	78.23	- 2.94	0.07	- 0.67	0.38	- 4.03
2. decile	0.59	0.00	0.38	0.00	67.86	- 2.78	0.07	- 0.61	0.37	- 3.75
3. decile	0.00	0.45	0.17	0.00	61.66	- 3.11	0.07	- 0.72	0.39	- 4.32
4. decile	0.04	0.52	0.00	0.47	54.51	- 4.07	0.04	- 1.07	0.53	- 6.04
5. decile	0.01	0.13	0.17	0.03	53.42	- 4.58	0.03	- 1.18	0.61	- 7.22
6. decile	0.17	0.12	0.03	0.17	52.46	- 4.85	- 0.04	- 1.35	0.63	- 7.86
7. decile	0.29	0.27	0.03	0.14	49.61	- 4.75	- 0.03	- 1.42	0.65	- 8.12
8. decile	0.15	0.21	0.18	0.26	48.43	- 4.92	- 0.02	- 1.73	0.68	- 8.39
9. decile	0.31	0.00	0.17	0.04	43.18	- 5.04	- 0.04	- 1.72	0.69	- 8.65
10. decile	0.26	0.00	0.47	0.00	41.22	- 4.97	- 0.06	- 1.68	0.69	- 8.57
Average	0.22	0.16	0.17	0.11	55.78	- 4.47	0.00	- 1.33	0.60	- 7.25

Notes: Sorted by the distribution of net equivalent income (new OECD scale).
Source: Own calculations using the scientific use-files of the EVS 2008 provided by the German Federal Statistical Office (*Statistisches Bundesamt*).

Importantly, the decrease in the price of mobility affects the labor force participation and the consumption pattern of the households. Table 3.12 shows the changes in labor force participation separately for singles and couples in the left hand part, as well as spending changes on the commodities in the right hand part. The average participation effect for single men is 0.22%, which relates to more than 15,000 people, and for single women it is 0.16%, which is about 9,500 persons. The male labor force participation of couples increases by 0.17%, corresponding to about 16,000 persons, and the female participation rises by 0.11%, which is slightly less than 9,000 people. So, the total labor force participation effect sums up to roughly 50,000 people who choose to work, assuming that the lost tax revenue does not affect the labor market. An additional assumption has to be made that there is no involuntary unemployment.[32] The distributional consideration shows ambiguous effects. Firstly, the average effect for men is bigger than the one for women, which applies for single, as well as for couple households. For single men, who face the biggest effects overall, the most noticeable effects appear at the bottom and at the top of the distribution. While the richer households are more affected by the price change, they have already high participation rates and have therefore fewer changes into participation. So, there are two opposing trends here along the distribution. For single women, the effects are even less clear. The middle of the distribution seems to be the only affected bracket between the third and eighth decile. The effects for couples are smaller than for singles, while men face no clear trend and the effects are more or less evenly distributed from the third decile upwards. Women in couple households are least affected by the price effect with only moderate effects between the fourth and eighth decile. The conclusion, which was already drawn from the elasticities, is that women's work participation does not depend as much on the price for gasoline as does men's participation. A reason for this result could be the fact that only about 20% of female commuters have a distance of at least 25 km to their workplace whereas over 30% of men face these distances (results from microcensus 2008 by Statistisches Bundesamt, 2009a). So there could exist a women's preference for shorter distances to the workplace and fewer dependency on mobility.

In the right part of the table, the demand responses for the commodities are presented. The expenditures on mobility shrink by 4.47% on average with higher responses at the top. Average price decline is 7.25%, which means the demand increases by about 2.8%. The decline in mobility expenditure is progressive because richer households face higher reliefs. Further interesting results from the demand system are the substitution effects. The rich households have higher percental quantity adjustments of the other commodities than the poor ones. They reduce electricity and heating consumption and increase the consumption of other non-durables.

[32]Most studies that account for demand sided restrictions in the labor market find significantly lower effects than without these restrictions, see e.g. Bargain, Caliendo, Haan, and Orsini (2010).

Due to the uncompensated substitution effects, the total tax revenue does not decline by the full 10.70 euro per household and month (about 5.1 bn euro per year), but only by 6.60 euro (3.1 bn euro per year). The efficiency benefit for the economy would be about 18% of the tax relief or 0.57 bn euro. Note that the calculated efficiency gains for the economy are described without knowing anything about the external costs of fuel consumption, which counteract the benefit. It is likely that the external costs exceed the welfare gain from cutting the tax on gasoline. The analysis should be interpreted as positive and not normative because its results appear with the opposite sign for a raise in the tax by the same amount.

3.10 Conclusion

In the course of the increasing importance of indirect taxation in the last decade in Germany for the treasury, as well as for the tax burden of private households, a framework was developed in this chapter that allows for a conclusive evaluation of reforms that changes the relative prices of certain commodities. In a second step, a hypothetical reform of the taxes on gasoline and diesel was considered, that cuts the taxes by 15 cents per liter to the pre-green-tax-reform level from 1998.

The incidence of indirect taxes is suggested to be regressive in the literature, which makes the evaluation important for questions of inequality and poverty. However, the welfare costs of indirect taxation could be systematically biased without knowledge of the substitution effects (see e.g. Banks et al., 1996). So, in the first part of this chapter, a demand system was estimated that includes the demand for mobility, electricity, heating and other non-durables as well as leisure. It allows for a reaction of leisure demand at the *extensive* as well as at the *intensive* margin on changes in prices and wages; combining both elasticities to a total response elasticity. In the estimation, it is accounted for a potential selection bias and the endogeneity of the consumption budget. See Section 3.6 for the most important results of the price and cross-price elasticities.

In the second part of this chapter, the model is used to simulate a hypothetical tax reform of the quantity tax on gasoline and diesel for Germany. Using the EVS 2008, the static tax relief and the compensating variation of a tax cut by 15 cents per liter are simulated. The static results of the relative tax relief compared to the net income show a progressive effect up to the third decile, followed by a regressive effect and an average relief of 0.36%. Compared to the expenditures on non-durable consumption, a progressive effect is found up to the seventh decile and a still high relief for the top decile, while the average relief is 0.66%. The comparison between these two distributions confirms the suggestion that the choice of the economic welfare measure is important for an interpretation of results on the tax incidence. Similar results for the distribution of gasoline consumption were found by Poterba (1991) for the United States. The compensating variations are about 30% lower than the static reliefs and about one half of the substitution comes from within the demand system while the other half from the extensive responses. An important result is the relevance of the extensive leisure demand reactions on price changes, which is mostly not explicitly handled in the literature. Another result from the CVs are the high substitution effects for the poorest 20% of the population, which lower the relative relief for this group more than average.

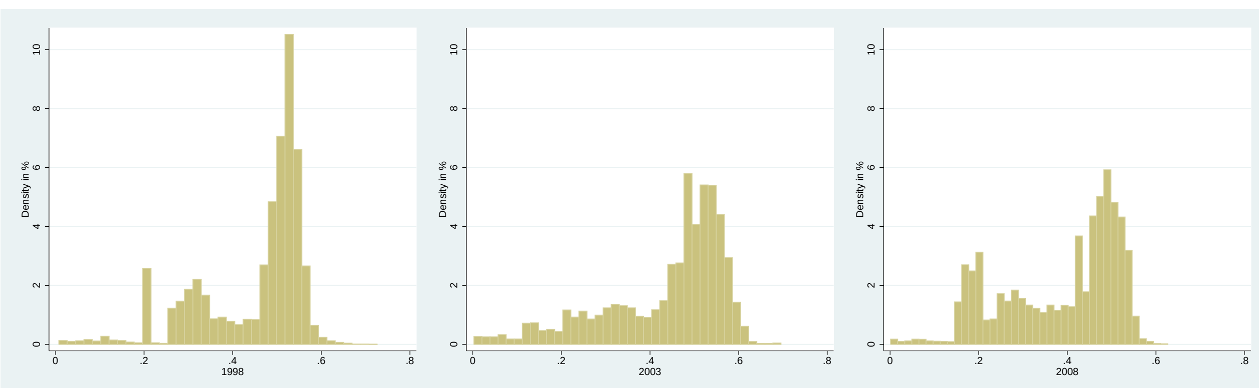
The uncompensated effects suggest an increase in the labor force participation on average by roughly 50,000 persons (0.16% of the working population), where men face stronger relative effects than women. Due to substitution the decline in tax revenue is lowered from 5.1 bn euro per year to 3.1 bn.

3.11 Appendix - Descriptives

3.11.1 Distribution of the Simulated Marginal Tax Rates

The calculation of the net wages requires the information on the marginal burden rate. In an income tax simulation module, the marginal burden rates, which include the marginal income tax rate, the solidarity surcharge and the marginal burden on social security contributions, are derived for all used EVS survey years (see Appendix 1.8 for the description of the structure of such an income tax simulation module for the EVS/LWR data). Figure 3.2 presents the histograms of the conditional distribution of the marginal burden rates (tax rate plus SSC) among one-adult households. In 1998, the distribution starts (neglecting small burdens for e.g. marginally employed people) at a rate of about 20% and has its biggest concentration slightly over 50%. The mass at this concentration point shrinks if the years 2003 and 2008 are considered, where more density mass is spread left to this point. This has to do with implemented tax cuts from 2001 to 2007 due to the tax reform from 2000. The starting tax rate in the tariff also shrunk below 20% which can be seen in the histograms.

Figure 3.2: Conditional Distributions of the Marginal Burden Rates for One-Adult Households

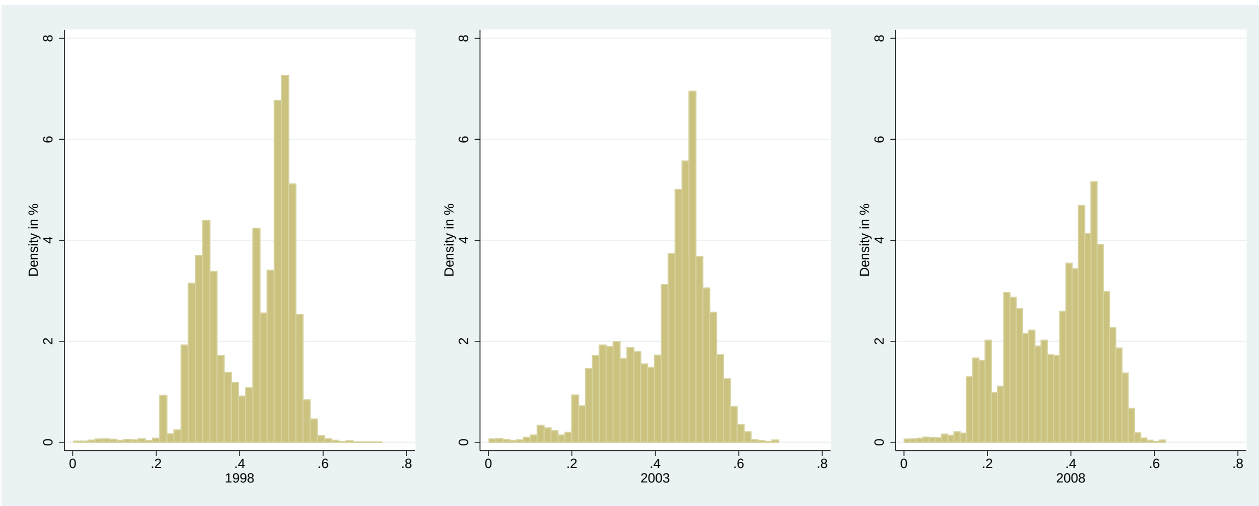


Source: Own calculations using the EVS (1998, 2003 and 2008) provided by the German Federal Statistical Office (*Statistisches Bundesamt*).

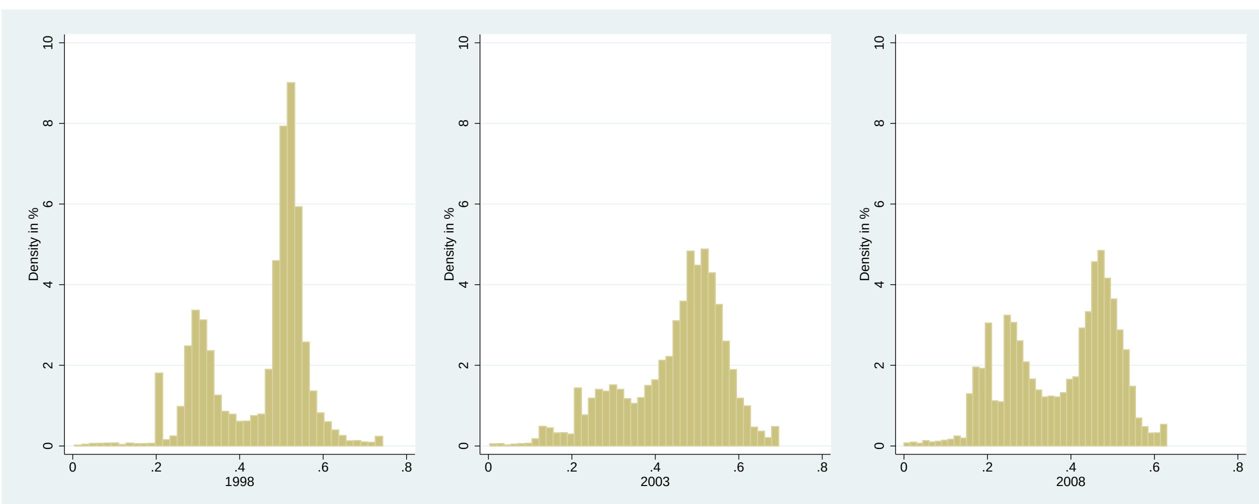
Figure 3.3 shows the distributions for the two-adult households separated by men and women. The upper part of the figure plots the histograms for men and below is the distribution for women. The findings from the single households are confirmed here. Huge differences do not appear between the marginal burden of men and women because of joint assessment to the income tax for married couples. However, a bit more mass right to the distribution of the men at the top rates can be seen for the women. Men often have a higher income than their spouses, which raises the tax rate for the women automatically due to joint assessment, independent from their income. Additionally, the social security contributions come on top to the high income tax rate for the women.

Figure 3.3: Conditional Distributions of the Marginal Burden Rates for Two-Adult Households

(a) Men



(b) Women

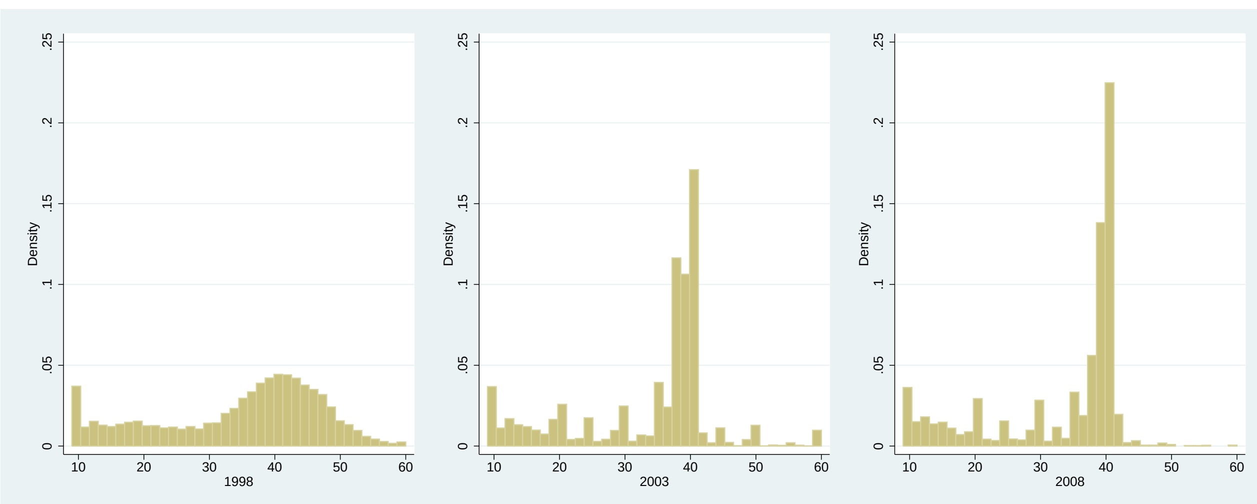


Source: Own calculations using the EVS (1998, 2003 and 2008) provided by the German Federal Statistical Office (*Statistisches Bundesamt*).

3.11.2 Distributions of the Hours Worked by Year and Subsample

While there is continuous information about the hours worked only for the EVS survey years 2003 and 2008, the information for 1998 has to be imputed. The EVS 1998 contains only discrete information on the occupational status. There exist five categories, which are "no occupation", "marginally occupied", "part-time occupation", "full-time occupation" and "occupied with no further information". This variable is taken to impute the hours worked using information of an external data set, the microcensus 1998 (*Mikrozensus 1998*). The hours worked are imputed with mean imputation by occupational status and other socio-demographic characteristics like gender and age group. Additionally, a normal distributed error term is added from the original distribution to maintain the variance of hours worked. In Figure 3.4, the conditional distribution of hours worked for the working one-adult household population are shown in histograms. Clearly, the artificial distribution for the survey year 1998 differs from the actually observed distributions in 2003 and 2008. It is much smoother due to the drawn error terms, but these have expected values of zero, therefore there should be no bias.

Figure 3.4: Conditional Distributions of Hours Worked for One-Adult Households

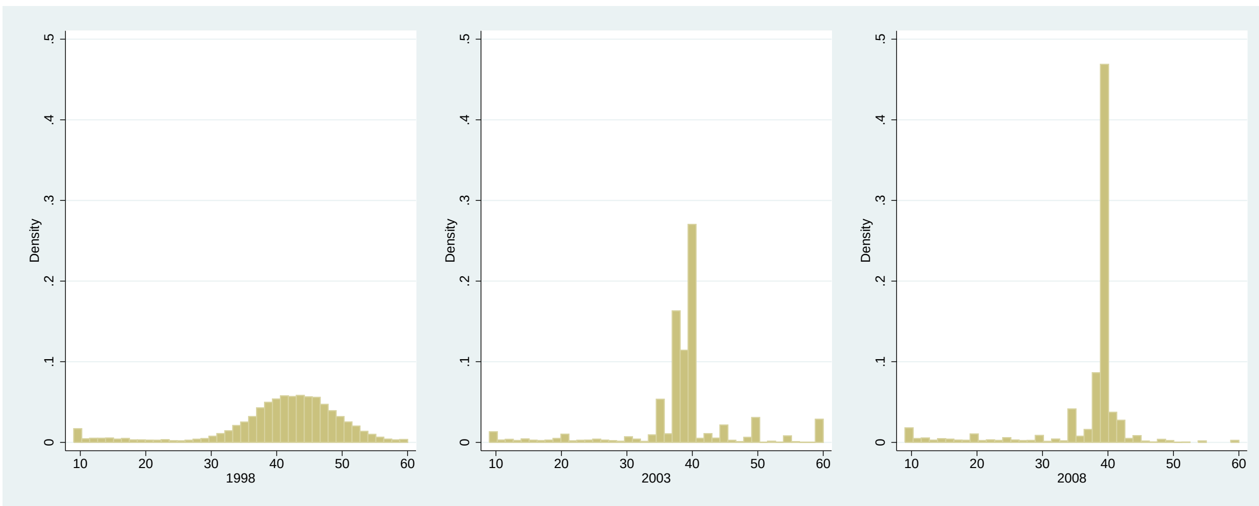


Source: Own calculations using the EVS (1998, 2003 and 2008) provided by the German Federal Statistical Office (*Statistisches Bundesamt*).

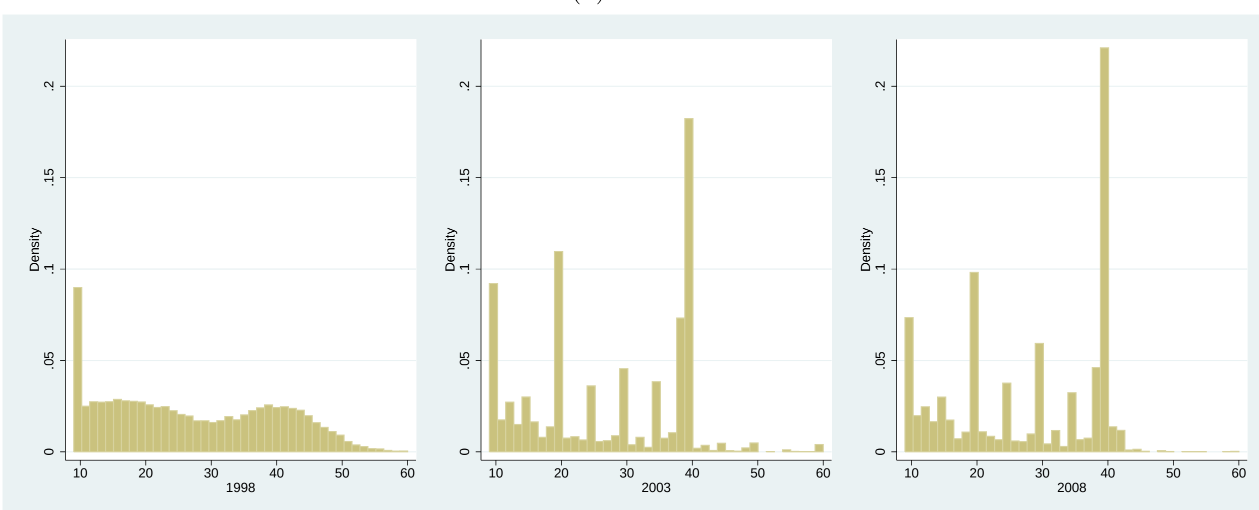
In Figure 3.5, the conditional distributions for two-adult households are presented. The upper part of the figure plots the histograms for men and below is the distribution for women. While the excessive smoothness of the distributions in 1998 can be seen for men and women, a clear difference appear compared to Figure 3.4. The distribution for men is more concentrated around 40 hours which refers to full-time employment, whereas the distribution for women has two humps, one around 17 hours and one around 40 hours. This fits to the observed distributions which have also more mass in the part-time area around 20 hours working time.

Figure 3.5: Conditional Distributions of Hours Worked for Two-Adult Households

(a) Men



(b) Women



Source: Own calculations using the EVS (1998, 2003 and 2008) provided by the German Federal Statistical Office (*Statistisches Bundesamt*).

3.12 Appendix - Results

3.12.1 Heckman Wage Equations

Table 3.13: Heckman Wage Equation for One-Adult Households

	Log Wage		Working =1	
	Coeff	(SE)	Coeff	(SE)
Age	0.078	(0.005)***	0.862	(0.179)***
Age squared	-0.001	(0.000)***	-0.033	(0.007)***
Female	-0.075	(0.007)***	0.156	(0.024)***
Medium skill	0.316	(0.113)***	-0.320	(0.026)***
Low skill	0.378	(0.183)**	-1.109	(0.047)***
Age*Medium skill	-0.025	(0.005)***		
Age^2 * Medium skill	0.000	(0.000)***		
Age*Low skill	-0.044	(0.010)***		
Age^2 * Low skill	0.001	(0.000)***		
East Germany	-0.132	(0.035)***	0.055	(0.105)
Medium agglom.	-0.038	(0.012)***	0.013	(0.041)
Low agglom.	-0.083	(0.014)***	-0.089	(0.046)*
Alc. and tobacco			-0.040	(0.021)*
1 child			-0.330	(0.039)***
2 children			-0.450	(0.053)***
3 children			-0.903	(0.115)***
4 children			-1.183	(0.229)***
Constant	0.581	(0.112)***	-7.136	(1.726)***
Year dum.	Yes		Yes	
Quarterly dum.	Yes		Yes	
Federal States	Yes		Yes	
Observations	17,726			
Uncensored	12,908			
Censored	4,818			
Lambda	-0.145	(0.035)***		

Notes: Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
Log wage equation in the left column and Probit whether to work or not in the right column. Alcohol and tabacco are defined as expenditures for these goods divided by the consumer budget.

Source: Own calculations using the scientific use-files of the EVS (2003 and 2008) provided by the German Federal Statistical Office (*Statistisches Bundesamt*).

Table 3.14: Heckman Wage Equation for Two-Adult Households (Males)

	Log Wage		Work =1	
	Coeff	(SE)	Coeff	(SE)
Age	0.082	(0.006)***	0.775	(0.194)***
Age squared	-0.001	(0.000)***	-0.027	(0.007)***
Age cubic			0.000	(0.000)***
Age quadratic			-0.000	(0.000)***
Medium skill	0.580	(0.109)***	-0.330	(0.023)***
Low skill	0.228	(0.227)	-1.043	(0.053)***
Age*Medium skill	-0.040	(0.005)***		
Age^2 * Medium skill	0.000	(0.000)***		
Age*Low skill	-0.039	(0.012)***		
Age^2 * Low skill	0.000	(0.000)***		
East Germany	-0.292	(0.039)***	-0.119	(0.065)
Medium agglom.	-0.061	(0.008)***	-0.010	(0.025)
Low agglom.	-0.103	(0.010)***	-0.071	(0.030)**
Alc. and tobacco			-0.099	(0.033)***
Age partner			0.010	(0.010)
Age^2 partner			-0.000	(0.000)
Gross wage partner			0.008	(0.001)***
1 child	0.041	(0.007)***	0.006	(0.031)
2 children	0.094	(0.007)***	0.080	(0.034)**
3 children	0.121	(0.011)***	0.056	(0.052)
4 children	0.124	(0.021)***	-0.219	(0.085)**
Constant	0.471	(0.121)***	-7.752	(1.973)***
Year dum.	Yes		Yes	
Quarterly dum.	Yes		Yes	
Partner's Educ.	No		Yes	
Region dum.	No		Yes	
Region * Quarter	No		Yes	
Federal States	Yes		No	
Observations	33,081			
Uncensored	26,907			
Censored	6,174			
Lambda	-0.088	(0.029)***		

Notes: Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
Log wage equation in the left column and Probit whether to work or not in the right column. Alcohol and tabacco are defined as expenditures for these goods divided by the consumer budget.

Source: Own calculations using the scientific use-files of the EVS (2003 and 2008) provided by the German Federal Statistical Office (*Statistisches Bundesamt*).

Table 3.15: Heckman Wage Equation for Two-Adult Households (Females)

	Log Wage		Work =1	
	Coeff	(SE)	Coeff	(SE)
Age	0.109	(0.007)***	-0.543	(0.135)***
Age squared	-0.001	(0.000)***	0.022	(0.005)***
Age cubic			-0.000	(0.000)***
Age quadratic			0.000	(0.000)***
Medium skill	0.404	(0.110)***	-0.258	(0.019)***
Low skill	0.308	(0.181)*	-0.783	(0.038)***
Age*Medium skill	-0.031	(0.005)***		
Age^2 * Medium skill	0.000	(0.000)***		
Age*Low skill	-0.043	(0.010)***		
Age^2 * Low skill	0.000	(0.000)***		
East Germany	-0.063	(0.039)	0.142	(0.052)***
Medium agglom.	-0.023	(0.009)***	0.007	(0.019)
Low agglom.	-0.050	(0.010)***	0.001	(0.023)
Alc. and tobacco			0.066	(0.030)**
Age partner			0.027	(0.007)***
Age^2 partner			-0.000	(0.000)***
Gross wage partner			0.001	(0.001)*
1 child	-0.093	(0.012)***	-0.587	(0.024)***
2 children	-0.164	(0.014)***	-0.726	(0.025)***
3 children	-0.254	(0.023)***	-1.127	(0.034)***
4 children	-0.340	(0.036)***	-1.340	(0.060)***
Constant	-0.150	(0.149)	4.272	(1.336)***
Year dum.	Yes		Yes	
Quarterly dum.	Yes		Yes	
Partner's Educ.	No		Yes	
Region dum.	No		Yes	
Region * Quarter	No		Yes	
Federal States	Yes		No	
Observations	37,760			
Uncensored	24,080			
Censored	13,680			
Lambda	0.133	(0.032)***		

Notes: Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
Log wage equation in the left column and Probit whether to work or not in the right column. Alcohol and tabacco are defined as expenditures for these goods divided by the consumer budget.

Source: Own calculations using the scientific use-files of the EVS (2003 and 2008) provided by the German Federal Statistical Office (*Statistisches Bundesamt*).

3.12.2 Discrete Choice Participation Model and Demand System Estimation - Parameters

Table 3.16: Probit Participation Equation for One-Adult Households

	Working =1	
	Coeff	(SE)
Wage	0.688	(0.319)**
Wage * Female	0.355	(0.085)***
Mobility price	-0.087	(0.009)***
Heating price	0.001	(0.001)
Others price	-1.761	(0.286)***
Female	-0.157	(0.180)
Non-labor inc.	-0.087	(0.006)***
Non-labor inc. * Female	-0.072	(0.008)***
Age	0.080	(0.020)***
Age squared	-0.001	(0.000)***
Medium skill	-0.105	(0.093)
Low skill	-0.522	(0.146)***
East Germany	0.019	(0.092)
Medium agglom.	0.037	(0.037)
Low agglom.	0.022	(0.050)
Alc. and tobacco	-0.075	(0.021)***
1 child	-0.093	(0.032)***
2 children	-0.209	(0.043)***
3 children	-0.545	(0.085)***
4 children	-0.765	(0.183)***
Constant	12.980	(1.681)***
Year dum.	Yes	
Quarterly dum.	Yes	
Federal States	Yes	
Observations	26,991	
Pseudo R^2	0.21	

Notes: Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The prices and the wage are defined in logs. Alcohol and tabacco are defined as expenditures for these goods divided by the consumer budget.

Source: Own calculations using the scientific use-files of the EVS (1998, 2003 and 2008) provided by the German Federal Statistical Office (*Statistisches Bundesamt*).

Table 3.17: Bivariate Probit Participation Equations for Two-Adult Households

	Man Working		Woman Working	
	Coeff	(SE)	Coeff	(SE)
Male wage	0.414	(0.033)***	-0.279	(0.026)***
Female wage	-0.279	(0.026)***	0.723	(0.037)***
Mobility price	-0.062	(0.008)***	-0.013	(0.007)*
Heating price	0.007	(0.001)***	0.008	(0.001)***
Others price	-2.134	(0.224)***	-1.198	(0.207)***
Non-labor and partner's inc.	-0.150	(0.009)***	-0.084	(0.008)***
Age male	0.161	(0.008)***	0.065	(0.006)***
Age squared male	-0.002	(0.000)***	-0.001	(0.000)***
Age female	0.058	(0.008)***	0.192	(0.007)***
Age squared female	-0.001	(0.000)***	-0.003	(0.000)***
East Germany	0.072	(0.080)	0.120	(0.074)
Medium agglom.	0.062	(0.022)***	0.035	(0.019)*
Low agglom.	0.060	(0.028)**	0.090	(0.025)***
Alc. and tobacco	-0.117	(0.031)***	-0.016	(0.030)
1 child	-0.127	(0.019)***	-0.585	(0.018)***
2 children	-0.137	(0.020)***	-0.680	(0.019)***
3 children	-0.300	(0.029)***	-0.981	(0.026)***
4 children	-0.476	(0.047)***	-1.167	(0.044)***
Constant	12.038	(1.306)***	2.034	(1.198)*
Year dum.	Yes		Yes	
Quarterly dum.	Yes		Yes	
Federal States	Yes		Yes	
Observations	62,616			
Rho	0.181	(0.010)***		

Notes: Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
The prices and the wages are defined in logs. Alcohol and tabacco are defined as expenditures for these goods divided by the consumer budget.

Source: Own calculations using the scientific use-files of the EVS (1998, 2003 and 2008) provided by the German Federal Statistical Office (*Statistisches Bundesamt*).

Table 3.18: Estimated Parameters of 3SLS for One-Adult Households (Unconstrained Estimation)

	Log Budget		Mobility		Electricity		Heating		Leisure	
	Coeff	(SE)	Coeff	(SE)	Coeff	(SE)	Coeff	(SE)	Coeff	(SE)
Non-labor inc.	0.082	(0.002)***								
Mobility price			0.002	(0.003)	-0.003	(0.001)**	-0.003	(0.002)	0.065	(0.008)***
Electricity price			0.024	(0.006)***	0.007	(0.002)***	-0.006	(0.004)	-0.189	(0.016)***
Heating price			0.004	(0.002)*	-0.001	(0.001)	0.005	(0.001)***	0.013	(0.004)**
Wage			-0.008	(0.003)*	-0.007	(0.001)***	-0.009	(0.002)***	0.190	(0.008)***
Others price			0.026	(0.012)*	0.006	(0.004)	0.023	(0.009)**	0.196	(0.031)***
Log Budget			0.033	(0.005)***	0.009	(0.002)***	0.030	(0.004)***	-0.321	(0.014)***
Age	0.006	(0.001)***	-0.003	(0.000)***	-0.000	(0.000)	0.000	(0.000)	0.001	(0.001)
Age squared	-0.000	(0.000)	0.000	(0.000)***	0.000	(0.000)	-0.000	(0.000)	-0.000	(0.000)
Medium skill	-0.043	(0.003)***	0.001	(0.001)	0.002	(0.000)***	0.003	(0.001)**	-0.007	(0.004)
Low skill	-0.054	(0.008)***	0.006	(0.003)	0.004	(0.001)**	0.000	(0.002)	-0.010	(0.009)
East Germany	-0.080	(0.013)***	-0.001	(0.003)	-0.001	(0.001)	0.004	(0.002)*	0.002	(0.007)
Medium agglom.	-0.006	(0.005)	0.001	(0.001)	-0.000	(0.000)	0.001	(0.001)*	0.008	(0.003)**
Low agglom.	-0.020	(0.006)***	0.008	(0.001)***	0.001	(0.000)***	0.003	(0.001)***	-0.003	(0.003)
Correction term leisure			-0.008	(0.005)	-0.001	(0.002)	-0.006	(0.004)	0.014	(0.013)
Correction term heat			-0.125	(0.012)***	0.003	(0.004)	0.010	(0.009)	0.434	(0.032)***
Constant	7.281	(0.026)***	-0.319	(0.066)***	-0.088	(0.022)***	-0.284	(0.048)***	1.939	(0.180)***
Quarterly dum.	Yes		Yes		Yes		Yes		Yes	
Federal States	Yes		Yes		Yes		Yes		Yes	
Social status	Yes		Yes		Yes		Yes		Yes	
Observations	17,333									
R^2	0.421		0.108		0.062		0.033		0.370	

Notes: Significance levels: $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$. The dependent variables of the demand system are defined in shares of the budget. The prices and the wage are defined in logs. The non-labor income is defined in 1000 Euro units. Reading example: 1000 Euro more non-labor income increases the budget by 8.2%.
Source: Own calculations using the scientific use-files of the EVS (1998, 2003 and 2008) provided by the German Federal Statistical Office (*Statistisches Bundesamt*).

Table 3.19: Estimated Parameters of 3SLS for One-Adult Households (Constrained Estimation)

	Log Budget		Mobility		Electricity		Heating		Leisure	
	Coeff	(SE)	Coeff	(SE)	Coeff	(SE)	Coeff	(SE)	Coeff	(SE)
Non-labor inc.	0.076	(0.002)***								
Mobility price			0.024	(0.002)***	-0.000	(0.001)	0.005	(0.001)***	-0.008	(0.002)***
Electricity price			-0.000	(0.001)	0.005	(0.002)**	-0.001	(0.001)	-0.006	(0.001)***
Heating price			0.005	(0.001)***	-0.001	(0.001)	0.003	(0.001)**	-0.003	(0.002)
Wage			-0.008	(0.002)***	-0.006	(0.001)***	-0.003	(0.002)	0.133	(0.006)***
Others price			-0.021	(0.003)***	0.002	(0.001)	-0.004	(0.002)*	-0.116	(0.007)***
Log Budget			0.023	(0.004)***	0.009	(0.001)***	0.029	(0.003)***	-0.450	(0.012)***
Age	0.006	(0.001)***	-0.003	(0.000)***	-0.000	(0.000)	-0.001	(0.000)*	0.010	(0.001)***
Age squared	-0.000	(0.000)	0.000	(0.000)***	0.000	(0.000)	0.000	(0.000)*	-0.000	(0.000)***
Medium skill	-0.043	(0.003)***	0.000	(0.001)	0.002	(0.000)***	0.005	(0.001)***	-0.038	(0.003)***
Low skill	-0.055	(0.008)***	0.005	(0.003)*	0.004	(0.001)***	0.006	(0.002)***	-0.080	(0.007)***
East Germany	-0.081	(0.013)***	-0.001	(0.002)	-0.000	(0.001)	0.004	(0.002)*	-0.021	(0.007)**
Medium agglom.	-0.006	(0.005)	0.001	(0.001)	-0.000	(0.000)	0.002	(0.001)*	0.005	(0.003)*
Low agglom.	-0.020	(0.006)***	0.007	(0.001)***	0.001	(0.000)***	0.004	(0.001)***	-0.011	(0.003)***
Correction term leisure			-0.004	(0.004)	-0.001	(0.002)	-0.003	(0.003)	-0.073	(0.011)***
Correction term heat			-0.097	(0.008)***	0.005	(0.004)	-0.004	(0.007)	0.277	(0.019)***
Constant	7.282	(0.026)***	-0.033	(0.033)	-0.072	(0.011)***	-0.190	(0.024)***	3.862	(0.093)***
Quarterly dum.	Yes		Yes		Yes		Yes		Yes	
Federal States	Yes		Yes		Yes		Yes		Yes	
Social status	Yes		Yes		Yes		Yes		Yes	
Observations	17,333									
R^2	0.421		0.112		0.062		0.034		0.213	

Notes: Significance levels: $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$. The dependent variables of the demand system are defined in shares of the budget. The prices and the wage are defined in logs. The non-labor income is defined in 1000 Euro units. Reading example: 1000 Euro more non-labor income increases the budget by 7.6%.

Source: Own calculations using the scientific use-files of the EVS (1998, 2003 and 2008) provided by the German Federal Statistical Office (*Statistisches Bundesamt*).

Table 3.20: Estimated Parameters of 3SLS for Two-Adult Households (Unconstrained Estimation)

	Log Budget		Mobility		Electricity		Heating		Male leisure		Female leisure	
	Coeff	(SE)	Coeff	(SE)	Coeff	(SE)	Coeff	(SE)	Coeff	(SE)	Coeff	(SE)
Non-labor inc.	0.037	(0.001)***										
Mobility price			0.017	(0.001)***	0.001	(0.001)	0.001	(0.001)	0.009	(0.004)*	-0.000	(0.003)
Electricity price			-0.008	(0.003)**	0.001	(0.001)	0.000	(0.003)	-0.061	(0.009)***	-0.061	(0.006)***
Heating price			0.008	(0.001)***	0.000	(0.000)	0.003	(0.001)***	-0.019	(0.002)***	-0.007	(0.001)***
Male wage			-0.009	(0.001)***	-0.003	(0.000)***	-0.003	(0.001)***	0.170	(0.002)***	-0.057	(0.001)***
Female wage			-0.006	(0.001)***	-0.002	(0.000)***	-0.004	(0.001)***	-0.068	(0.002)***	0.147	(0.002)***
Others price			0.009	(0.006)	0.007	(0.002)**	0.031	(0.006)***	0.289	(0.018)***	0.085	(0.013)***
Log Budget			0.029	(0.002)***	0.007	(0.001)***	0.036	(0.002)***	-0.288	(0.008)***	-0.218	(0.005)***
Age male	0.003	(0.001)**	-0.000	(0.000)*	0.000	(0.000)	-0.000	(0.000)**	0.002	(0.000)***	-0.001	(0.000)*
Age squared male	-0.000	(0.000)	0.000	(0.000)	-0.000	(0.000)	0.000	(0.000)**	-0.000	(0.000)**	0.000	(0.000)**
Age female	0.014	(0.001)***	-0.001	(0.000)***	-0.000	(0.000)***	-0.000	(0.000)*	0.002	(0.001)**	0.005	(0.000)***
Age squared female	-0.000	(0.000)***	0.000	(0.000)***	0.000	(0.000)***	0.000	(0.000)*	-0.000	(0.000)**	-0.000	(0.000)***
East Germany	-0.085	(0.009)***	0.003	(0.001)	-0.001	(0.001)	0.002	(0.001)	-0.010	(0.005)*	-0.011	(0.003)***
Medium agglom.	-0.003	(0.002)	0.003	(0.000)***	-0.000	(0.000)	0.003	(0.000)***	-0.007	(0.001)***	-0.001	(0.001)
Low agglom.	-0.003	(0.003)	0.007	(0.000)***	0.001	(0.000)***	0.005	(0.000)***	-0.014	(0.002)***	-0.004	(0.001)***
Correction term male			0.000	(0.003)	-0.003	(0.001)*	0.005	(0.003)	-0.014	(0.010)	-0.005	(0.007)
Correction term female			-0.001	(0.001)	0.000	(0.001)	0.000	(0.001)	0.006	(0.004)	-0.005	(0.003)
Correction term heat			-0.060	(0.004)***	0.005	(0.002)**	-0.026	(0.004)***	0.137	(0.013)***	0.103	(0.009)***
Constant	7.690	(0.015)***	-0.217	(0.034)***	-0.077	(0.013)***	-0.397	(0.032)***	1.262	(0.110)***	1.699	(0.073)***
Quarterly dum.	Yes		Yes		Yes		Yes		Yes		Yes	
Federal States	Yes		Yes		Yes		Yes		Yes		Yes	
Social status m/f	Yes		Yes		Yes		Yes		Yes		Yes	
Skill m/f	Yes		Yes		Yes		Yes		Yes		Yes	
Observations	53,078											
R^2	0.478		0.129		0.079		0.013		0.422		0.642	

Notes: Significance levels: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. The dependent variables of the demand system are defined in shares of the budget. The prices and the wages are defined in logs. The non-labor income is defined in 1000 Euro units. Reading example: 1000 Euro more non-labor income increases the budget by 3.7%.

Source: Own calculations using the scientific use-files of the EVS (1998, 2003 and 2008) provided by the German Federal Statistical Office (*Statistisches Bundesamt*).

Table 3.21: Estimated Parameters of 3SLS for Two-Adult Households (Constrained Estimation)

	Log Budget		Mobility		Electricity		Heating		Male leisure		Female leisure	
	Coeff	(SE)	Coeff	(SE)	Coeff	(SE)	Coeff	(SE)	Coeff	(SE)	Coeff	(SE)
Non-labor inc.	0.038	(0.001)***										
Mobility price			0.017	(0.001)***	0.001	(0.001)	0.007	(0.000)***	-0.005	(0.001)***	-0.007	(0.001)***
Electricity price			0.001	(0.001)	0.005	(0.001)***	0.000	(0.000)	-0.003	(0.000)***	-0.002	(0.000)***
Heating price			0.007	(0.000)***	0.000	(0.000)	0.004	(0.000)***	-0.001	(0.001)*	-0.006	(0.001)***
Male wage			-0.005	(0.001)***	-0.003	(0.000)***	-0.001	(0.001)*	0.156	(0.002)***	-0.063	(0.001)***
Female wage			-0.007	(0.001)***	-0.002	(0.000)***	-0.006	(0.001)***	-0.063	(0.001)***	0.143	(0.002)***
Others price			-0.013	(0.001)***	-0.000	(0.001)	-0.004	(0.001)***	-0.083	(0.002)***	-0.064	(0.002)***
Log Budget			0.027	(0.002)***	0.006	(0.001)***	0.032	(0.002)***	-0.297	(0.003)***	-0.203	(0.003)***
Age male	0.003	(0.001)***	-0.001	(0.000)***	0.000	(0.000)	-0.001	(0.000)***	0.004	(0.000)***	0.000	(0.000)
Age squared male	-0.000	(0.000)	0.000	(0.000)***	0.000	(0.000)	0.000	(0.000)***	-0.000	(0.000)***	-0.000	(0.000)
Age female	0.015	(0.001)***	-0.001	(0.000)***	-0.000	(0.000)**	-0.000	(0.000)	0.002	(0.000)***	0.006	(0.000)***
Age squared female	-0.000	(0.000)***	0.000	(0.000)**	0.000	(0.000)***	0.000	(0.000)	-0.000	(0.000)***	-0.000	(0.000)***
East Germany	-0.085	(0.009)***	0.004	(0.001)**	-0.001	(0.001)	0.002	(0.001)	-0.013	(0.005)**	-0.011	(0.003)***
Medium agglom.	-0.003	(0.002)	0.003	(0.000)***	0.000	(0.000)	0.003	(0.000)***	-0.007	(0.001)***	-0.001	(0.001)
Low agglom.	-0.003	(0.003)	0.007	(0.000)***	0.001	(0.000)***	0.005	(0.000)***	-0.014	(0.001)***	-0.005	(0.001)***
Correction term male			-0.000	(0.003)	-0.003	(0.001)*	0.004	(0.003)	-0.027	(0.010)**	-0.011	(0.007)
Correction term female			-0.001	(0.001)	0.000	(0.001)	0.000	(0.001)	0.008	(0.004)	-0.006	(0.003)*
Correction term heat			-0.062	(0.003)***	0.004	(0.002)*	-0.014	(0.003)***	0.228	(0.007)***	0.100	(0.005)***
Constant	7.693	(0.015)***	-0.139	(0.015)***	-0.047	(0.006)***	-0.244	(0.014)***	2.719	(0.031)***	2.008	(0.028)***
Quarterly dum.	Yes		Yes		Yes		Yes		Yes		Yes	
Federal States	Yes		Yes		Yes		Yes		Yes		Yes	
Social status m/f	Yes		Yes		Yes		Yes		Yes		Yes	
Skill m/f	Yes		Yes		Yes		Yes		Yes		Yes	
Observations	53,078											
R^2	0.476		0.131		0.086		0.021		0.409		0.654	

Notes: Significance levels: $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$. The dependent variables of the demand system are defined in shares of the budget. The prices and the wages are defined in logs. The non-labor income is defined in 1000 Euro units. Reading example: 1000 Euro more non-labor income increases the budget by 3.8%.

Source: Own calculations using the scientific use-files of the EVS (1998, 2003 and 2008) provided by the German Federal Statistical Office (*Statistisches Bundesamt*).

3.12.3 Demand System Estimation - Uncompensated Elasticities

Table 3.22: Uncompensated Price Elasticities[1] for Commodity Demand and **Intensive Leisure** (Unconstrained Estimation for One-Adult Households)

Uncompensated	Mobility	Electricity	Heating	Leisure	Others
Mobility price	**-0.98**	**-0.20**	**-0.19**	**0.17**	**-0.16**
	[-1.11 : -0.86]	[-0.32 : -0.08]	[-0.37 : 0.00]	[0.14 : 0.21]	
Electricity price	**0.51**	**-0.57**	**-0.29**	**-0.40**	**0.35**
	[0.25 : 0.77]	[-0.82 : -0.33]	[-0.68 : 0.11]	[-0.47 : -0.33]	
Heating price	**0.07**	**-0.07**	**-0.80**	**0.04**	**-0.06**
	[0.00 : 0.14]	[-0.14 : 0.01]	[-0.90 : -0.69]	[0.03 : 0.06]	
Wage	**1.14**	**0.83**	**1.20**	**0.02**	**0.86**
	[0.95 : 1.33]	[0.65 : 1.01]	[0.92 : 1.48]	[-0.03 : 0.07]	
Others price	**0.25**	**0.14**	**0.42**	**0.74**	**-1.80**
	[-0.21 : 0.70]	[-0.29 : 0.56]	[-0.26 : 1.09]	[0.62 : 0.86]	

Notes: Confidence intervals in parentheses.
[1]: All elasticities are evaluated at the respective mean expenditures.
Source: Own calculations using the scientific use-files of the EVS (1998, 2003 and 2008) provided by the German Federal Statistical Office (*Statistisches Bundesamt*).

Table 3.23: Uncompensated Price Elasticities[1] for Commodity Demand and **Intensive Leisure** (Unconstrained Estimation for Two-Adult Households)

Uncompensated	Mobility	Electricity	Heating	Male leisure	Female leisure	Others
Mobility price	**-0.61**	**0.04**	**-0.02**	**0.07**	**0.04**	**-0.11**
	[-0.68 : -0.55]	[-0.04 : 0.11]	[-0.16 : 0.11]	[0.04 : 0.10]	[0.01 : 0.06]	
Electricity price	**-0.22**	**-0.91**	**-0.01**	**-0.19**	**-0.26**	**0.30**
	[-0.37 : -0.07]	[-1.07 : -0.75]	[-0.32 : 0.30]	[-0.25 : -0.13]	[-0.32 : -0.20]	
Heating price	**0.17**	**0.02**	**-0.90**	**-0.05**	**-0.01**	**0.02**
	[0.14 : 0.21]	[-0.02 : 0.06]	[-0.96 : -0.84]	[-0.06 : -0.03]	[-0.02 : 0.00]	
Male wage	**0.76**	**0.67**	**1.30**	**-0.12**	**0.05**	**0.20**
	[0.70 : 0.81]	[0.60 : 0.73]	[1.19 : 1.42]	[-0.14 : -0.10]	[0.03 : 0.07]	
Female wage	**0.32**	**0.31**	**0.42**	**0.01**	**-0.11**	**0.36**
	[0.28 : 0.36]	[0.26 : 0.35]	[0.34 : 0.51]	[-0.01 : 0.04]	[-0.13 : -0.08]	
Others price	**-0.07**	**0.28**	**0.86**	**1.36**	**0.77**	**-2.47**
	[-0.33 : 0.20]	[-0.01 : 0.57]	[0.32 : 1.39]	[1.25 : 1.46]	[0.67 : 0.88]	

Notes: Confidence intervals in parentheses.
[1]: All elasticities are evaluated at the respective mean expenditures.
Source: Own calculations using the scientific use-files of the EVS (1998, 2003 and 2008) provided by the German Federal Statistical Office (*Statistisches Bundesamt*).

General Conclusions

Main Findings and Policy Implications

This dissertation focuses on several issues relating to the consumption behavior of private households. It contains three chapters that empirically investigate questions regarding intertemporal consumption and the consumer demand for certain commodities using German micro data.

In Chapter 1, the interest rate elasticities of consumption and savings are estimated in a Keynesian consumption function using cross-sectional data on household consumption in Germany for the years 2002-2007 from the Continuous Household Budget Survey (*Laufende Wirtschaftsrechnungen*, LWR). The structural demand model framework of the Quadratic Almost Ideal Demand System (QUAIDS) (see Banks et al., 1997) is used to model the consumption-savings decision of the households with respect to the current income and the prices for current and future consumption, where the latter is the after-tax rate of return. An income tax module was therefore constructed to simulate differential taxation of labor income and income from the investment of capital. The estimates allow parameterizing the income elasticity as well as compensated and uncompensated elasticities with respect to inflation and the real after-tax rate of return. Including the real after-tax rate of return in micro data is challenging and only a few attempts have been made to estimate the interest rate elasticity of savings within this setting (see Attanasio and Weber, 2010, for a survey). The predominant result from the literature can be confirmed that the uncompensated interest rate elasticity of savings is effectively zero. The major findings suggest that savings are a superior good and thus consumption is an inferior good, estimating the income elasticity of savings at 1.9 and of consumption at 0.7 for single households. The uncompensated interest rate elasticity of savings is estimated not significantly different from zero. It is concluded that policy reforms that mainly aim at an increase in aggregate savings should thus focus on increasing households' disposable income, rather than on the net rate of return. Short-term policy-induced variation of net returns to savings, e.g. through a reduction of tax rates on capital income or an increase in the tax deductibility of savings for old age, is expected to have no significant effects on the level of savings. Especially, for poor households with a high consumption ratio, the interest elasticity of savings is significantly negative so that achieving the policy goal of fostering private savings for old-age by interest rate subsidies is counterfactual. The intuition is that the poor households have to compensate a decline in the interest rate by higher savings because they already have a low calculated future consumption level. Reversely, they would reduce savings with rising interest rates.

In general, policy reforms that affect the net rate of return would moreover not be welfare neutral, as the *compensated* interest elasticity of savings is estimated significantly different from zero, with a point estimate of 0.4 at the mean. Here, as the income effect offsets this substitution effect, the total effect is zero.

Chapter 2 analyzes a consumption function in a dynamic framework of an Euler equation that allows for testing the validity of the *Life Cycle-Permanent Income Hypothesis* (PIH) in the data. The hypothesis specifically predicts the effect of a non-anticipated shock to permanent income on consumption to be near one. Lifetime income is allocated to current and future consumption over the remaining periods, with respect to this new information. Consequently, in theory, a transitory shock has an influence near zero on consumption. Evidence was found for deviation from theory predictions and it was investigated to which extent these deviations from the PIH can be traced back to the presence of liquidity constraints in household consumption. A pseudo panel constructed on repeated cross-sections of consumption survey data for Germany (LWR) was used to investigate the consumption effects of income shocks in the context of liquidity constraints. This data set has proven to be rich in the sense that it provides relatively precise measures of the individual income and consumption dynamics, whose joint evolution over time was utilized to disentangle the consumption effects of income shocks into transitory and permanent elements.

In a switching regression approach with unknown sample separation, two regimes of households were identified. One that can be assumed to be affected by liquidity constraints and a second one that seems to be rather unconstrained. Households in these two regimes behave differently w.r.t. permanent and transitory income shocks as well as w.r.t. anticipated income changes. This is the central finding of the analysis. The findings suggest that for households in the constrained regime, reactions to changes in transitory income are significantly greater than for households in the unconstrained regime. The contribution to the literature is evidence for liquidity constraints, based on a pseudo panel of rich German consumption survey data, which has not been exploited for Germany so far in this context to the best of my knowledge.

On the one hand, households' responses to non-anticipated changes in income are at odds with the PIH. Their reaction to permanent shocks is lower than theory predicts and transitory shocks are perceived more sensitively than the model would tell. On the other hand, two groups were identified according to indicators for presence of liquidity constraints. Households identified as constrained react significantly stronger to transitory income shocks than households in the unconstrained group. These results are in line with findings from the relevant literature, where relevance of liquidity constraints has been found. These results have been found to be robust with respect to various model specifications as well as different consumption concepts.

Furthermore, there is evidence for excess sensitivity to anticipated income changes for households in the constrained regime if total consumption, durable as well as non-durable, is considered. Households that are identified to be liquidity constrained are found to respond more strongly to *anticipated* income changes than households that are not liquidity constrained. The conclusion is here that there seems to be a different reaction to anticipated income changes due to the presence of liquidity constraints among the two groups, at least if one considers total consumption, but the two different types of households have proven to be more difficult to identify.

Comparing the income elasticity from Chapter 1 to the reactions with respect to permanent income shocks in Chapter 2 shows that they are not significantly different from each other, neither for the OLS results nor for the single regimes. If this relationship holds, an implication would be that analyses of income elasticities could also be made with the current income as a proxy for permanent income, which means that the assumption of intertemporal separability is fulfilled. But further research with real panel data on consumption will be necessary to confirm this hypothesis.

In Chapter 3, a demand system on energy goods involving the demand for leisure is estimated on German consumption cross-sectional data. For the purpose of evaluating policy reforms of the so called *green taxes*, three survey waves of the Income and Consumption Survey for Germany (*Einkommens- und Verbrauchsstichprobe*, EVS) are used to estimate a demand system that includes the demand for mobility, electricity, heating and other non-durables as well as leisure. The model allows for a reaction of leisure demand at the *extensive*, as well as at the *intensive* margin, to changes in prices and wages and combines both elasticities to a total response elasticity. It is estimated separately for single and couple households to allow for two different types of leisure demand in couple households.

Importantly, the compensated own-wage elasticity of leisure demand (intensive and extensive margins combined) is estimated to be -0.29 for single men and -0.36 for single women, while for couple households the elasticity for males is -0.22 and -0.3 for females. The respective uncompensated elasticities are a bit smaller for the singles with -0.26 for men and -0.32 for women, but not significantly different from the compensated ones because of high standard errors. For couples, they bear the same magnitudes because of the small (but significant) income effects. Comparing intensive and extensive elasticities for single women reveals a higher reaction at the extensive margin, while they are nearly equal at both margins for single males. For females in couple households the extensive reaction is significantly higher than the intensive one, while for males, they are nearly equal.

Interesting cross-price elasticities are found, which amongst others confirm the intuitive view of the substitutional character between mobility and heating and between mobility and leisure. The latter is an important side result, because it lowers the tax on polluting goods that provide mobility in a second-best tax setting. Another result is that there are only small cross-price effects between heating and leisure and between electricity and leisure. They have all a substitutional character except for the relationship between heating and female leisure, which is found to be complementary. In summary, women's labor/leisure decision in couple households seems to depend less on other prices and consumption of the goods that are modeled here than men's decision.

The model is then used for a microsimulation of a hypothetical tax reform of the quantity tax on gasoline and diesel for Germany. Using the EVS 2008, the static tax relief and the compensating variation of a tax cut by 15 cents per liter are simulated. The static results of the relative tax relief compared to the net income show a progressive effect up to the third decile, followed by a regressive effect and an average relief of 0.36%. Compared to the expenditures on non-durable consumption, a progressive effect is found up to the seventh decile and a still high relief for the top decile, while the average relief is 0.66%. The comparison between these two distributions confirms the suggestion that the choice of the economic welfare measure is important for an interpretation of results on the tax incidence. Similar results for the distribution of gasoline consumption were found by Poterba (1991) for the United States. The compensating variations are about 30% lower than the static reliefs and about one half of the substitution comes from within the demand system and the other half from the extensive responses. So, an important result is the relevance of the extensive leisure demand reactions on price changes, which is mostly not explicitly handled in the literature. Another result from the CVs are the high substitution effects for the poorest 20% of the population, which lower the relative relief for this group more than average.

The uncompensated effects suggest an increase in the labor force participation on average by roughly 50,000 persons (0.16% of the working population), where men face stronger relative effects than women. Due to substitution the decline in tax revenue is lowered from 5.1 bn euro per year to 3.1 bn.

Further Research

There are several possible extensions to the models presented in the thesis for further research questions. First of all, since all models are estimated with either pooled cross-sectional data or constructed pseudo panel data from pooled cross-sections, it would be interesting to estimate them with real panel data. Panel data allows to control for unobserved heterogeneity and to model dynamic relationships that are mostly relevant in intertemporal consumption analysis. Especially the reestimation of the models from Chapter 1 and 2 with panel data would be an interesting robustness analysis. With the combined information on consumption and income in a panel, really important research questions concerning life cycle behavior of individuals could be addressed, respectively the results from cross-sectional research like the ones of this thesis could be evaluated. Implications of these analyses are important for policies regarding retirement provision, health insurances, labor market and taxation. Yet, there exists no valid panel data available for Germany that contains income as well as rich information on consumption and that is suitable for this kind of analyses. In 2010, the German Socio-Economic Panel (SOEP) introduced a questionnaire on consumption, which has only been surveyed at this one time yet and a repetition is scheduled for 2015 at the earliest. Until then, the data is also just usable as cross-sectional information. Another survey that could possibly deal with these kinds of research questions in the future is the Panel on Household Finances (PHF) provided by the *Deutsche Bundesbank*. It has a questionnaire on income, wealth and food consumption, which could even be modeled together for several European countries simultaneously. Yet, there exists only one wave of the survey and there could be serious limitations to the analysis if only food consumption is considered as a proxy for total consumption, especially in a dynamic setting (see e.g. Beznoska and Steiner, 2012, for differences in the reactions of food consumption compared to total consumption at the retirement entry).

Interesting further research concerning Chapter 2 would be an extension on asymmetric shocks. In the thesis at hand, all shocks are used to identify the marginal propensity to consume out of them, but several studies suggest that the consumption reaction to a positive shock, like a win in a lottery, might deviate from a negative one like unemployment (see Jappelli and Pistaferri, 2010, for a survey). While liquidity constraints affect mainly the negative shocks, one might get different results from the estimation if the shocks are separately analyzed. If the EVS 2008 and the LWR 2009 are added as survey waves to the constructed pseudo panel, there might be additional variation in consumption and income due to the financial crisis.

The demand system of Chapter 3 also opens several possibilities for extensions. Firstly, it can be used to simulate other possible policy reforms, e.g. a reform that changes not only the price of mobility but has also an effect on the net wages through a simultaneous income tax reform or changes in the social security contributions. Secondly, the model can be rearranged to identify explicit substitution effects of other commodities that are taxed or that are of other special interest. Especially the modeling of durables could be approached, either in a preceding step using the assumption of "Two-stage budgeting" or as an additional commodity group. Furthermore, the commodity group "Mobility" could be broken down to analyze the substitution between individual and public transportation, which could be an interesting topic for public finance on taxation and public goods. Further extensions could be the modeling of a QUAIDS instead of an AIDS model to introduce more flexible Engel curves and to evaluate differences between these types of demand systems or to estimate quantile regressions to carve out more distributional details on the price and income elasticities, which could be interesting for welfare analysis.

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Summary

This dissertation focuses on several issues relating to the consumption behavior of private households. It contains three chapters that empirically investigate questions regarding intertemporal consumption and the consumer demand for certain commodities using German micro data. The contributions of this dissertation have micro- and macroeconomic perspectives and implications.

The first two chapters deal with the intertemporal allocation of consumption and the macroeconomic questions whether the current or the permanent income matters for consumption. In the first chapter, a Keynesian consumption function is estimated using cross-sectional data on household consumption in Germany for the years 2002-2007 from the Continuous Household Budget Survey (*Laufende Wirtschaftsrechnungen*, LWR). The structural demand model framework of the Quadratic Almost Ideal Demand System (QUAIDS) is used to model the consumption-savings decision of the households with respect to the current income and the prices for current and future consumption, where the latter is the after-tax rate of return. An income tax module was therefore constructed to simulate differential taxation of labor income and income from the investment of capital. The estimates allow parameterizing the income elasticity as well as compensated and uncompensated elasticities with respect to inflation and the real after-tax rate of return. The elasticities are evaluated at the mean and at certain quantiles of the consumption distribution using quantile regression technique to look at the distributional heterogeneity, especially against the backdrop of socially motivated policies that affect the net income and the after-tax rate of return. In general, policy reforms that affect the net rate of return would moreover not be welfare neutral, as the *compensated* interest elasticity of savings is estimated significantly different from zero, with a point estimate of 0.4 at the mean. Here, as the income effect offsets this substitution effect, the total effect is zero.

The second chapter wants to answer the question whether the *Permanent Income Hypothesis* (PIH) holds and if not whether the presence of liquidity constraints could be an explanation for the failure. The hypothesis specifically predicts the effect of a non-anticipated shock to permanent income on consumption to be near one. Lifetime income is allocated to current and future consumption over the remaining periods, with respect to this new information. Conse-

quently, in theory, a transitory shock has an influence near zero on consumption. The reason is that a positive transitory deviation from permanent income is saved nearly completely while a negative one is compensated by dissavings or taking-up a credit. The agent perceives the deviation and knows that its expected value will be zero over lifetime, and thus a change in transitory income should have no relevant effect on consumption. Another aspect of the PIH, which has gained much attention in the literature, is the excess sensitivity of consumption to anticipated income changes. Anticipated changes in income should have no effect at all on consumption because they are assumed to be already internalized. These hypotheses can be empirically tested in a dynamic consumption model. Using the same data set as in the first chapter, a pseudo panel is constructed on the repeated cross-sections and the consumption effects of income shocks in the context of liquidity constraints are investigated. For that purpose, a switching regression approach with unknown sample separation is used by applying an iterated two-step procedure with the EM algorithm to identify the two regimes whether to be liquidity constrained or not. The marginal propensity to consume out of permanent and transitory income are evaluated for both regimes and finally compared to the income elasticity of the first chapter. The PIH is rejected in general, but significantly different effects between the two regimes are found with respect to changes in transitory income.

The third and last chapter shifts the focus from intertemporal consumption to the consumer demand of single commodities and the price and cross-price relationships within the consumption budget. Due to the increasing taxation of energy and fuel goods and their high prices, allocational and distributional issues regarding the private households become more important. Especially for Germany, there exist only few studies that analyze the demand of energy goods and none of them incorporate the cross-price relationships to leisure demand yet, which has been emphasized as highly relevant for welfare analysis in studies for the United States. In the third chapter, an Almost Ideal Demand System is estimated to get own-price and cross-price effects of the consumer goods "Mobility", "Electricity", "Heating" and other non-durable goods, as well as of "Leisure". This approach allows calculating the compensated and uncompensated elasticities, which can then be used to simulate behavioral responses and welfare effects of price shifts. The demand system is estimated with pooled German micro data from three survey years of the EVS (Income and Consumption Survey for Germany, *Einkommens- und Verbrauchsstichprobe*). The structural approach applied in this chapter allows for leisure responses at the *intensive* as well as at the *extensive* margin, where reactions at the *extensive* margin refer to changes in labor market participation (or at the macro level in the number of working persons), while changes at the *intensive* margin refer to changes in the average number of hours worked for the working population. The estimates of the Almost Ideal Demand System referring to leisure demand or accordingly to labor supply are interpreted as elasticities at the *intensive* margin, while the *extensive* labor market participation elasticities are estimated in a preceding discrete choice model, which is then linked to the demand system and used for selectivity correction. The elasticities of both margins are combined to get elasticities of total leisure demand, which are then used in the simulation and welfare analysis. There are deviations in the present approach compared to the West and Williams framework, where selection issues are also addressed but the distinction between *extensive* and *intensive* leisure demand is not handled explicitly. Relevant cross-price effects are found e.g. between mobility and leisure, which suggest a substitutional relationship between these two goods.

Finally, the static and behavioral effects of a potential reform of the existing tax on gasoline and diesel consumption are simulated and then used for a distributional and welfare analysis.

German Summary

Diese Dissertation beschäftigt sich mit verschiedenen Fragestellungen, die den Konsum privater Haushalte betreffen. In drei Kapiteln wird sowohl der intertemporale Konsum, als auch die Nachfrage nach bestimmten Gütern empirisch mit Mikrodaten, die Einnahmen und Ausgaben der deutschen Privathaushalte enthalten, analysiert. Die verwendeten Modelle und die Schätzergebnisse sind sowohl für mikro- als auch für makroökonomische Fragestellungen von Relevanz.

Die ersten beiden Kapitel untersuchen den intertemporalen Konsum vor dem Hintergrund der alten makroökonomischen Fragestellung nach dem für den Konsum entscheidenden Einkommenskonzept, das heißt ob das aktuell *verfügbare* oder das *permanente* Einkommen den Konsum determiniere. Im ersten Kapitel, wird eine Keynesianische Konsumfunktion geschätzt mit gepoolten Querschnittsdaten der *Laufenden Wirtschaftsrechnung* (LWR), die Informationen zu den Konsumausgaben privater Haushalte in Deutschland für die Jahre 2002-2007 enthalten. Die Entscheidung zwischen Konsum in der aktuellen Periode oder Konsumverzicht zu Gunsten zukünftigen Konsums (Sparen) wird im Rahmen der strukturelle Nachfragemodellumgebung des Quadratic Almost Ideal Demand System (QUAIDS) untersucht. Hierbei ist die Konsumentscheidung abhängig vom verfügbaren Einkommen, dem aktuellen Preisniveau, dem zukünftig erwarteten Preisniveau und dem Zinssatz nach Steuern. Hierfür wurde ein Einkommensteuer-Mikrosimulationsmodell für die LWR Daten entwickelt, das für jeden Haushalt im Datensatz einen individuellen Steuersatz für die Kapitalerträge simuliert. Mit den Schätzergebnissen aus dem Modell können dann die Einkommens- und Preis-, bzw. Zinselastizitäten für den Konsum und die Ersparnis berechnet werden. Die geschätzten Elastizitäten werden am Mittelwert und an bestimmten Quantilen evaluiert, um die Unterschiede in den Effekten über die Konsumverteilung hinweg herauszustellen, insbesondere vor dem Hintergrund von sozialpolitisch motivierten Maßnahmen, die die Nettozinssätze oder das verfügbare Einkommen betreffen. Zu diesen Maßnahmen zählen Reformen der Abgeltungssteuer oder garantierte Zinssätze in Altersvorsorge- und Bausparverträgen. Die unkompensierte Zinselastizität der Ersparnis wird auf nicht signifikant verschieden von Null geschätzt, was der Intention einiger Politikmaßnahmen, die das Sparen fördern sollen, zuwiderläuft.

Im zweiten Kapitel der Dissertation, wird die *Permanente Einkommenshypothese* (PEH) empirisch überprüft und der Frage nachgegangen, ob Liquiditätsbeschränkungen bestimmter Haushalte der Grund für ein mögliches Verwerfen der Hypothese sind. Die PEH besagt, dass ein Schock, also eine unerwartete Veränderung, des permanenten Einkommens proportional zu einer Konsumveränderung führt. Neue Informationen bezüglich des Lebenszeiteinkommens führen zu einem veränderten Konsumpfad über den Lebenszyklus. Hingegen sollten Schocks, die das transitorische Einkommen betreffen, also von kurzer Dauer sind, keinen Einfluss auf den Konsum haben. Eine positive transitorische Abweichung vom permanenten Einkommen würde nahezu komplett gespart werden und eine negative würde durch Entsparen oder Kreditaufnahme kompensiert werden. Somit bleibt der Konsum fast unberührt von diesem Schock. Eine weitere testbare Implikation der PEH, der in der empirischen Literatur viel Aufmerksamkeit gewidmet wird, ist die "Excess Sensitivity" des Konsums. Antizipierte Änderungen des Einkommens sollten laut PEH keine messbaren Ausschläge der Konsumausgaben mit sich bringen, da der Konsum sich schon im Zeitpunkt der Erwartungsbildung anpassen sollte und nicht erst bei der Realisation der Einkommensänderung. Diese Hypothesen werden im zweiten Kapitel empirisch in einem dynamischen Konsummodell mit den Mikrodaten der LWR getestet. Hierzu wird ein sogenanntes Pseudo Panel mit den Wellen der Jahre 2002-2007 konstruiert und die Effekte von permanenten und transitorischen Schocks auf den Konsum geschätzt, sowie die "Excess Sensitivity" getestet. In einem "Switching Regression" Modell mit unbekannter Sample Selektion wird außerdem Heterogenität in den Ergebnissen identifiziert, die auf Liquiditätsbeschränkungen zurückzuführen ist. Die Gültigkeit der PEH wird auf Grundlage der Schätzergebnisse abgelehnt, allerdings werden signifikante Unterschiede in Abhängigkeit von Liquiditätsbeschränkungen gefunden. Die Reaktionen bezüglich des Einkommens werden auch mit den Ergebnissen aus dem ersten Kapitel verglichen.

Das dritte Kapitel verlegt den Fokus von der intertemporalen Konsumallokation auf die Nachfrage nach bestimmten Gütern. Auf Grund der intensivierten Besteuerung von Energie- und Kraftstoffgütern und der gesteigerten Relevanz dieser Güter aus allokativer und sozialpolitischer Sicht, wird ein Nachfragesystem modelliert, in dem Preis- und Kreuzpreiseffekte zwischen "Mobilität", "Heizgütern", "Elektrizität", sonstigen nicht-dauerhaften Gütern und der Nachfrage nach Freizeit geschätzt werden. Das System wird mit gepoolten Mikrodaten der Jahre 1998, 2003 und 2008 der Einkommens- und Verbrauchsstichprobe (EVS) geschätzt und erlaubt die Berechnung von kompensierten und unkompensierten Preiselastizitäten. Mit diesem Modell lassen sich Wohlfahrtsanalysen und Nachfrageeffekte von Preisveränderungen der Güter simulieren. Insbesondere die Kreuzpreiseffekte zur Nachfrage nach Freizeit erweisen sich hierbei als relevant. Es wird im strukturellen Modell zwischen *intensiver* und *extensiver* Nachfrage nach Freizeit unterschieden, wobei sich die *intensive* Nachfrage auf die Arbeitsmarktpartizipation bezieht und die *extensive* auf Änderungen in den gearbeiteten Stunden. In dem Modellansatz werden die intensiven Nachfrageelastizitäten im Nachfragesystem geschätzt und die extensiven in einem vorgeschalteten Discrete Choice Modell, das zudem für die Selektionskorrektur im Nachfragesystem genutzt wird. Die Nachfrage auf beiden Ebenen wird dann zu einer Gesamtnachfrageelastizität nach Freizeit zusammengeführt. Der gewählte Ansatz unterscheidet sich dadurch zu den in der Literatur angewandten Ansätzen, die die Differenzierung zwischen extensiver und intensiver Reaktion nicht explizit modellieren. Es werden relevante Kreuzpreiseffekte zwischen Mobilität und Freizeit gefunden, die in einer Mikrosimulation einer hypothetischen Steuerreform zum Einsatz kommen, um Wohlfahrts- und Aufkommenseffekte zu berechnen.