LIQUIDITY CONSTRAINTS AND HEALTHCARE EXPENDITURE

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Abstract

Increasing healthcare costs are a big concern for the wellbeing of liquidity-constrained households. This paper evaluates the effect of binding liquidity constraints on healthcare spending decisions. Further, the paper compares the effect of liquidity constraints on healthcare expenditure with the effect on the non-health consumption in particular on the food consumption. I extend a standard incomplete markets model with a health capital in the felicity function. Theoretically, I show that households reduce their healthcare expenditure due to the binding liquidity constraints in the current period, whereas expenditure declines in the next period due to the expected binding constraints one period ahead. I use the extended model to test the incidence of binding liquidity constraints with a linearized Euler equation. Empirically, I show that the test of liquidity constraints for healthcare expenditure reveals different implications than a standard test of liquidity constraints for nondurable consumption. In particular, current binding constraints and expected binding constraints lead to the opposite direction of bias when the liquidity constraints are omitted. The resulting overall bias depends on which constraint has a stronger effect. Moreover, the income elasticity of healthcare expenditure varies significantly between asset poor and rich families, more than the elasticity of non-health consumption among wealth quintiles. Altogether, my findings show that the effects of liquidity constraints are heterogeneous across households and across expenditure categories.

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1 Introduction

Healthcare expenditures have seen a large increase over time in the U.S. and in many other countries. According to Centers for Medicare and Medicaid Services, U.S. healthcare spending has reached to 17.9% of Gross Domestic Product in 2017. Although several insurance schemes exist, households pay around $365.5 billion for out-of-pocket expenditures.[1] This trend is becoming more worrisome for the wellbeing of poor households as income and wealth inequality also rises.

This paper explores how the changes in income and liquidity constraints interact with the healthcare expenditures of households with heterogeneous wealth holdings. More explicitly, the paper assesses whether liquidity constraints bind differentially for healthcare expenditures among wealth groups.

My paper contributes to our understanding of the effect of liquidity constraints on household consumption. I show that this effect is heterogeneous across wealth and across expenditure. In particular, healthcare expenditure has a very different interaction with income across wealth compared to nondurable/ food expenditure. First, this paper provides a methodological contribution by proposing a test of the effect of binding liquidity constraints on the healthcare expenditure using a health capital model. Although the new test is based on the standard test for the effect of liquidity constraints on nondurable consumption, it also differs in important dimensions. The extended test incorporates the tension between current and expectation of one-period ahead binding constraints. This tension results in diverse behavioral responses in consumption between wealthy and poor households. Second, this paper contributes the empirical work in household expenditure by verifying the implications of the test using a representative panel data of U.S. households. I show that healthcare expenditure allocation is different than food expenditure allocation between time periods across wealth quintiles using Panel Study of Income Dynamics (PSID).

I use a life-cycle model with a health capital accumulation. I incorporate health capital à la Grossman [1972] into a heterogeneous agent incomplete markets model. Households receive utility from consumption goods and service flow from their health capital. The form of health capital

[1] The statistics are from: https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/NationalHealthAccountsHistorical.html

is the pure consumption type among Grossman's alternative models, where health capital enters into the instantaneous felicity function but does not alter the earnings. The theoretical model has testable implications for intertemporal allocation of the nondurable good and health capital in the incidence of binding liquidity constraints. In particular, binding liquidity constraints violate the unconstrained Euler equation. For nondurable consumption, the marginal utility for current consumption is higher than expected marginal utility of next period consumption. For health capital, the current marginal utility is higher relative to next period due to currently binding constraints, whereas it is lower relative to next period due to the expected one-period-ahead binding constraints. Hence, there is a tension between current and expected one-period-ahead binding constraints in determining intertemporal allocation.

I test the effect of binding liquidity constraints on the healthcare expenditure of households. I extend the empirical test for the existence of binding liquidity constraints in explaining the failure of permanent income hypothesis employed first by Zeldes [1989] and Runkle [1991]. I do the extension for healthcare expenditures using the theoretical model for health capital.

The new test inherits the tension between current and one-period-ahead binding constraints. In particular, I show that for healthcare expenditure growth, current binding constraints and one period ahead expected binding constraints have opposite effects on expenditure growth. Current binding constraints imply an increase in expenditure growth, whereas expectations of one period ahead binding constraints imply a decrease. Furthermore, the specification for the extended test has a more dynamic structure than a standard test for liquidity constraints due to the incorporation of one-period-ahead expectations as well as the stock-flow adjustment for health capital and healthcare expenditures.

The contrary forces generated by current and expected future constraints alter the implication for empirical tests of binding liquidity constraints for healthcare expenditure compared to the standard test for nondurable consumption. In the standard test, the existence of liquidity constraints are often assessed using log-linearized Euler equations and adding an extra regressor into the empirical model. The extra regressor is usually current or lagged values of income which proxy for binding liquidity constraints but should not have any predictive power for consumption growth for an unconstrained household. For a constrained household, a proxy such as current income shows up as negatively correlated with consumption growth due to omitted variable bias. In the test for healthcare expenditure, income as an extra regressor is used as a proxy for current binding constraint and also for expectation of one period ahead binding constraint. I show that current income as a proxy for current binding constraint have a negative correlation, however current income as a proxy for expectation of one period ahead binding constraint have a positive correlation with expenditure growth. Hence, it is an empirical question which effect dominates.

I test the incidence of binding liquidity constraints for both food consumption with the standard test and healthcare expenditure with the extended test using household level panel data. I compare my results with mainly food consumption to relate it to the existing literature on liquidity constraints, which historically use food consumption due to data availability.

My results reveal that the liquidity constraints are binding differentially for healthcare expenditures among wealth quintiles. Further, I show that the effect of binding liquidity constraints on healthcare expenditure differs from the effect on other consumption categories.

As a first motivation for a differential relation of income with food and healthcare expenditure across wealth, I plot Engel curves for food and healthcare expenditures separately for each wealth quintile. I show that Engel curves for healthcare expenditure share is downward sloping for high wealth households, which indicates that it is a necessity. However, Engel curves for low wealth households are slightly upward sloping, which is an indication for luxury goods. On the other hand, food consumption is a necessity for all wealth groups.

Then, I estimate the empirical models for testing the incidence of liquidity constraints. I separately apply the test for food consumption and healthcare expenditure growth for each wealth quintile. I find that the 1st, 2nd, and 3rd quintiles have a negative and significant bias and 4th and 5th quintiles have an insignificant coefficient for food consumption. This indicates that the liquidity constraints are currently binding for the lowest quintiles. For healthcare expenditure, the test results indicate that lowest quintile has a negative significant bias which means that the current binding constraints are severe for this group and dominates any other effect by expected one-period-ahead binding constraints. On the other hand other quintiles have positive coefficients and significant for the highest quintile, which means that the one-period ahead expected binding constraint dominate the current negative effect. So, even the wealthier households who can spend on their healthcare hold expectations that they can be constrained to spend beyond what they are already spending in the current period.

As a supporting evidence for differential effect, I estimate correlations between income and expenditures. I estimate income elasticity of healthcare expenditure and compare it to the one for non-health expenditures and food consumption. I show that the income elasticity for healthcare expenditure exhibits more variation between wealth quintiles compared to food or combined non-health consumption. The income elasticity varies between 17.5% (for lowest wealth) to - 6.4 % (for highest wealth) for healthcare expenditure. However, it varies between 7.9% to 1.4% for food expenditure.

Related Literature. My paper relates to several strands of the literature in macroeconomics, household finance, and health economics.

First, my paper builds on the vast literature on the response of consumption to changes in economic conditions. More specifically, Permanent Income Hypothesis (PIH) first developed by Friedman [1957], and Life Cycle Hypothesis (LCH) by Ando and Modigliani [1963] have been tested heavily using both aggregate and cross-sectional data. The PIH/LCH are built on the consumption smoothing motivation of consumers due to diminishing marginal utility. However, most of the empirical tests reject the hypothesis that the consumption is determined by 'permanent income' which is a weighted average of current income and expectations of future income. Hence the claim that consumption does not respond to changes in current income is rejected. Flavin [1981] finds that consumption responds to predictable changes in income more than what the permanent income hypothesis suggests. A similar motivation is by Hansen and Singleton [1983] who test the response of consumption to anticipated interest rates in a representative agent framework using Euler equations. They find that the rate of consumption growth is too large relative to the observed changes in real interest rates. The 'excess sensitivity' of consumption to current income or real returns in the data is attributed to imperfect credit markets, liquidity constraints, Keynesian behavior (i.e. consumption is proportional to income) or imperfect fit of the model to the data.

My paper contributes to the empirical Euler equation literature that estimates preference parameters or tests the permanent income hypothesis and the existence of liquidity constraints. Euler equation tests are commonly used in the literature because they do not require a closed form solution for the consumption function. Closed form solutions are not possible with general felicity functions and with potentially binding liquidity constraints.

Hall [1978] is the earliest paper that introduces Euler equations in showing the stochastic process of consumption, Mankiw [1982] and Startz [1989] analyzes time series properties of durable goods. Bernanke [1985] tests permanent-income hypothesis with adjustment costs and nonseparability. Hall (1988) tests intertemporal elasticity of substitution. Dynan [1993] estimates prudence, Parker and Preston [2005] decomposes consumption fluctuations and in particular test the precautionary motive. Attanasio and Low [2004] evaluate the conditions to use log-linearized Euler equations in estimating consistent preference parameters. Zeldes [1989] and Runkle [1991] test the PIH and liquidity constraints.

The existence of liquidity constraints in explaining the failure of permanent income hypothesis is explicitly tested by Runkle [1991] and Zeldes [1989] using household level consumption data. Runkle [1991] rejects the presence of liquidity constraints and concludes that the rejection of permanent income hypothesis using aggregate time-series data must be due to aggregation bias. Zeldes [1989], on the other hand, shows the presence of liquidity constraints in food consumption. He splits sample based on potentially constrained households and unconstrained households, and tests violations of unconstrained Euler equations in these samples. In the present paper, I follow the methodology of Runkle [1991] and Zeldes [1989] in testing the presence and the relative power of liquidity constraints using various expenditure categories, namely, food consumption, non-health expenditures and health-care expenditure.

Second, my paper is related to the health literature that investigates the interaction of income with the demand for healthcare and estimates the income elasticity of healthcare expenditures. Due to data limitations as well as identification difficulties, the income elasticity of health expenditure studies did not reach a consensus for the range of elasticity. Most studies find an inelastic demand for healthcare in micro studies. In a world with perfect insurance markets, this must be the case. However, considering the incompleteness and complicated nature of insurance markets, healthcare demand responds to the income changes.

The challenges for elasticity estimation are also due to the measure of healthcare expenditures. Healthcare is considered a ’luxury’ good due to an income elasticity above unity using aggregate data, i.e. GDP per capita. However, this is inconsistent with micro data where individuals with higher incomes have a lower share of health-care. Newhouse [1977] finds an elasticity around 1.15 and 1.31 in a cross-country study, similarly Leu [1986], Parkin, McGuire and Yule [1987] and Gerdtham et al. [1992] find elasticities as high as 1.39 among OECD countries. Recently, Acemoğlu, Finkelstein and Notowidigdo [2013] finds an elasticity around 0.7 in economic subregions comprised of U.S. counties level by exploiting the differential exposure of local areas to the shocks in oil prices. Di Matteo and Di Matteo [1998] also finds a similar estimate of 0.77 in Canadian provinces. [2]

Aggregate data, both cross-country or time series, incorporate all healthcare spending in a country. The changes in healthcare incorporate the technological advancements in the health industry over time, or technological and institutional differences across countries. Therefore, these studies are not comparable with micro studies, as the elasticities have different interpretations. Among the few micro studies, Phelps [2016] reports elasticities between 0 and 0.2. On the other hand, Tsai [2015] finds an income elasticity of 0.81 - 1.03 among the elderly population by exploiting the changes in Social Security legislation. These are the highest estimates among micro studies. As Getzen [2000] also reports, the estimates are close to zero using household level data.

By correlation estimations for income elasticity, I provide an intuition for the comparison between variable response of healthcare expenditures and other consumption to income changes among wealth quintiles. I show that the health elasticity varies much more between quintiles than food consumption. Further, I show that health expenditures’ interaction with liquidity constraints should be evaluated considering one period ahead expectations which result in distinct behavioral responses. My findings show that in micro level, health-care consumption differs from non-health consumption, in particular from food consumption, in terms of its response to income changes. The closest study to mine that investigate the liquidity-health relationship is by Gross and Tobacman [2014] who estimate the effect of the relaxation of liquidity constraints

[2] Liu and Chollet [2006] provide a comprehensive review on various estimates of healthcare elasticities.

by the 2008 Economic Stimulus Payments on medical care. They find the liquidity increases health care utilization by increasing the need for care such as increasing drug and alcohol related hospitalizations.

Third, my paper is related to the health capital literature that started to flourish after the pioneering work by Grossman [1972]. The demand for health is one of the most fundamental areas in health economics research. Grossman [1972] provided a framework to analyze the demand for healthcare and investment over the lifecycle. Health capital is a human capital of an individual which depreciates as one ages and in which she can invest. Wagstaff [1986], Case and Deaton [2005], Galama [2015] are among the ones theoretically and empirically investigating health capital model and health technology. Recently, the macro-health literature incorporates health capital and estimates health technology parameters using simulation methods in order to analyze the impact of several health reforms. For example, Hall and Jones [2007] incorporates health status into instantaneous utility and explains the rising health spending as a rational response to changing economic conditions. Finkelstein, Luttmer and Notowidigdo [2013] estimate how marginal utility of consumption changes with health and show that marginal utility declines by a declining health status. The impact of health on utility is engaged in the models in Hall and Jones [2007], De Nardi, French and Jones [2010]. Other examples with health technology include Jung and Tran [2016], Feng [2012], Kelly [2017], Halliday et al. [2017]. [3] A comprehensive health capital model is employed by Galama and Van Kippersluis [2018] in order to build a theory of socio-economic disparities over the life cycle. I incorporate health capital into the utility function as in Jung and Tran [2016]. I contribute to this literature by incorporating a health capital model in order to analyze the effect of liquidity constraints on expenditure choices of heterogeneous agents borrowing the tools from the consumption literature.

[3] See also Özkan [2011],Pashchenko and Porapakkarm [2013] and Conesa et al. [2018] for examples of health shocks without explicit modeling of health capital. Relatedly, Feenberg and Skinner [1992] and French and Jones [2004] analyze the time-series properties of the health-care cost process.

2 Health Capital Model

Households maximize a time separable lifetime utility function discounted with subjective discount factor β. The preferences are defined over consumption $C_{i,t}$ and service flow from health stock, $H_{i,t}$. The markets are incomplete. Without loss of generality, it is assumed that households can borrow and save riskless asset $A_{i,t}$. [4]

$$\max \mathbb{E}_t \sum_{\tau=0}^{T-t} \beta^{\tau} u(C_{i,t+\tau}, H_{i,t+\tau}; \Theta_{i,t+\tau}) \tag{1}$$

subject to:

$$C_{i,t} + d_{i,t} + A_{i,t+1} = (1 + r_{i,t})A_{i,t} + Y_{i,t} \qquad \text{(budget constraint)} \tag{2}$$

$$H_{i,t} = (1 - \delta^h)H_{i,t-1} + d_{i,t} \qquad \text{(health capital accumulation)} \tag{3}$$

$$C_{i,t} \geq 0, \;\; d_{i,t} \geq 0 \qquad \text{(nonnegativity constraints)} \tag{4}$$

$$A_{i,t+1} \geq \underline{\text{A}} \qquad \text{(liquidity constraint)} \tag{5}$$

$$A_{i,0}, H_{i,0} \text{ are given}, \;\; H_{i,t} \leq \overline{H} < \infty.$$

Health capital $H_{i,t}$ depreciates at a deterministic rate δ^h. [5] I assume a linear health technology where health expenditures, $d_{i,t}$, are linearly added to the health capital in the current period. [6] [7] The linear and additive health technology is similar to the one proposed by Grossman [1972] who first introduced health capital into the literature. Households face uncertainty in their stochastic income streams $Y_{i,t}$ and stochastic ex-post after-tax returns $r_{i,t}$. [8] $\Theta_{i,t}$ is the household specific

[4] As Zeldes [1989] points out, other contingent claims market may also exist. The Euler equation holds with respect to other assets as well. The only requirement is that the full set of Arrow-Debreu securities do not exist. For brevity, I ignored any other assets that is available to the households in the model.

[5] The terms *health capital* and *health stock* are used interchangeably throughout the paper.

[6] The health technology is possibly nonlinear and exhibits decreasing returns to scale e.g. $\alpha d_{i,t}^{\rho}$. However when the Euler equations are linearized the constants α and ρ become part of constants which do not play a role in the main analysis. To save some notation, I ignore curvature in health investment.

[7] The timing in health capital accumulation is chosen so that the current period investment in health spending affects the current utility.

[8] I do not model health shocks explicitly, however I control for health status and health shocks via taste shifter in

taste shifter which includes observable and unobservable factors that alter the marginal utility.

The expectation is taken conditional on the filtration $\mathcal{F}_{i,t}$, which is household's information set at time t in the current context. Hence, the operator $\mathbb{E}_t[X]$ for any random variable X denotes the conditional expectation of the form $\mathbb{E}[X|\mathcal{F}_{i,t}]$.

The recursive formulation of the problem can be written as:

$$V_t(A_{i,t}, H_{i,t-1}) = \max_{C_{i,t}, H_{i,t}, A_{i,t+1}} \{u(C_{i,t}, H_{i,t}) + \beta \mathbb{E}_t V_{t+1}(A_{i,t+1}, H_{i,t})\} \tag{6}$$

subject to (2)-(5). Substituting (2) into the objective function and taking first order conditions give the equilibrium intertermporal conditions where the variable $\lambda_{i,t}$ is the Lagrange multiplier on budget constraint, $\eta_{1i,t}, \eta_{2i,t}$ on non-negativity constraints and $\mu_{i,t}$ on liquidity constraint.

I assume that the Inada conditions hold so that the nonnegativity constraint for nondurable good does not bind ($\eta_{1i,t} = 0, \ \forall i \ \forall t$). [9] Denote the partial derivatives of felicity function as $u_C^{i,t} = \partial u(C_{i,t}, H_{i,t})/\partial C_{i,t}$ and $u_H^{i,t} = \partial u(C_{i,t}, H_{i,t})/\partial H_{i,t}$.

Proposition 1. *The intertemporal condition for nondurable consumption takes the form:*

$$u_C^{i,t} = \beta \mathbb{E}_t[(1 + r_{i,t+1}) u_C^{i,t+1}] + \mu_{i,t}. \tag{7}$$

This is a classical result shown in the literature that when the liquidity constraints are binding, i.e. $\mu_{i,t} > 0$, the expected marginal utility in the next period is lower than the marginal utility in the current period. Hence, consumption is expected to grow from period t to t+1.

Assumption 1. *Nonnegativity constraint for healthcare expenditure does not bind, i.e.* $\eta_{2i,t} = 0, \ \forall i, \ \forall t.$

Assumption 2. *Households hold constant expectation about future rate of return,* $\mathbb{E}_t[r_{i,t+1}] = \mathbb{E}_{t+1}[r_{i,t+2}]$.

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empirical analysis. I explain possible extensions of the model with health shocks in section 5.

[9]For $\eta_{1i,t}$, the multiplier is always zero with an instantaneous utility function for which Inada conditions hold, i.e. $\partial U(x)/\partial x \rightarrow -\infty \ \ as \ \ x \rightarrow 0$ for x being $C_{i,t}$ or $H_{i,t}$. For $\eta_{2i,t}$, the Inada condition is not enough since the constraint is on health-care expenditure whereas Inada conditions is assumed for health stock which is never zero for an alive human being, so I assume Inada conditions for health stock as well as a nonnegativity constraint for healthcare expenditures since it is not reversible.

Proposition 2. *Under Assumptions 1 - 2, the intertemporal condition for health capital takes the following form:*

$$u_H^{i,t} = \beta \mathbb{E}_t[(1 + r_{i,t+1})u_H^{i,t+1}] - \beta(1 - \delta^h)\frac{\mathbb{E}_t[(1 + r_{i,t+1})\mu_{i,t+1}]}{\mathbb{E}_t[1 + r_{i,t+1}]} + \mu_{i,t}. \tag{8}$$

Proof. see Appendix A.1. □

The intertemporal condition for health capital depends on liquidity constraints in the current period as well as expectations about one period ahead liquidity constraints interacted with the rate of return and discounted by time preference and depreciation of health stock. The current binding constraints have a similar impact on the marginal utility of health stock as in nondurable consumption good. On the other hand, the one period ahead expected binding constraints enter the right hand side of the equation negatively. This points to an opposite direction of effect. That is, one period ahead binding constraints increase the expected marginal utility of health stock from period t to t+1.

The health capital accumulation equation and how it enters into the utility function as a service flow is similar to how durable goods and housing are modeled in the literature.[10] However, health capital cannot be collateralized unlike durable consumption goods, hence the level of health stock does not relax the liquidity constraint.[11] In particular, Browning and Crossley [2009] show that households cut back the durable expenditures disproportionately compared to non-durable goods when faced with temporary income losses. They argue that the reductions in durable expenditures lead to very small cuts in durable consumption since households continue to enjoy flow utility from existing durable stock. They consider small durables which are subject to irreversibility constraints, that is these goods cannot be resold due to poor resale markets. In this sense, health capital naturally exhibits irreversibility which corresponds to the nonnegativity constraint in the above model.[12] I follow Browning and Crossley [2009] to give illustrative special

[10]Examples include but not limited to Browning and Crossley [2009], Cerletti and Pijoan-Mas [2012], Skinner [1989]
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[11]Assuming the black market for kidneys is small and is not accessible by many households.

[12]Their definition of liquidity constraint is that the households cannot borrow against the stock of durables. In the present paper, I assume an ad-hoc borrowing limit $\underline{A}$ which can be a small negative number that is not necessarily zero. The value of the borrowing limit is trivial for the theoretical analysis as long as it differs from the natural borrowing constraint (the constraint that naturally occurs when Inada condition holds as is assumed here) and binds

cases for the intratemporal implications of the binding liquidity constraints. Hence, for the following intratemporal illustrative predictions, r is assumed constant.[13]

In order to emphasize the impact of liquidity constraint, I assume an interior solution in both time periods t and t+1, that is the nonnegativity constraints for the health-care expenditures at time t does not bind and is not expected to bind for the time t+1 throughout the paper.

Proposition 3. *Under Assumption 1 and assuming r is held constant, the marginal rate of substitution (MRS) between health capital and non-durable consumption goods for household i at time t is:*

$$MRS^{i,t}_{H,C} = \frac{u^{i,t}_H}{u^{i,t}_C} = \frac{\delta^h + r}{1+r} + \frac{(1-\delta^h)\mu_{i,t}}{V^{i,t}_A}. \tag{9}$$

Proof. see Appendix A.2. □

Since $\delta^h < 1$, the marginal rate of substitution between health stock and nondurable consumption in the case of binding liquidity constraint ($\mu_{i,t} > 0$) is more than that of the unconstrained case. Marginal utility of health capital is high relative to the marginal utility of nondurable good, hence the health expenditure is low. This means that the consumer is willing to give up more of health stock in order to consume one additional unit of the nondurable good when she is constrained. Put differently, the cost of additional health stock is higher in terms of nondurable consumption in order to keep the same level of utility. This translates into less willingness to pay for healthcare spending in the case of a binding constraint.

In order to evaluate the situation in terms of healthcare expenditure, as in Browning and Crossley [2009], I assume a simple form of homothetic preferences, addilog utility function. Moreover, when r is held constant, the ratio of healthcare expenditure to nondurable good has a simple form.

for some households.

[13] I ignore any price effects and r is held constant as in Browning and Crossley [2009] for this part only since it makes the derivation straightforward and does not play a crucial role in showing the impact of liquidity constraints in the theoretical model.

Lemma 3.1. *Assume $u(C_{i,t}, H_{i,t}) = \ln C_{i,t} + \ln H_{i,t}$ and r is constant. Then, the MRS for the unconstrained case (9) with the assumed preferences gives the ratio of health spending to nondurable consumption as:*

$$\frac{d_{i,t}}{C_{i,t}} = \frac{1+r}{\delta^h + r} + \left[1 - (1-\delta^h)\left(\frac{C_{i,t}}{C_{i,t-1}}\right)^{-1}\right]. \tag{10}$$

This equation means that the healthcare expenditure to nondurable consumption ratio at t is an increasing and concave function of consumption growth from t-1 to t, $\frac{C_{i,t}}{C_{i,t-1}}$. Note that in the absence of constraints the ratio $\frac{C_{i,t}}{C_{i,t-1}}$ is constant and is equal to $\beta(1+r)$. When the liquidity constraints are binding, there is a noise term that changes over time. In Lemma 3.2, the liquidity constraint at t is not binding $\mu_{i,t} = 0$. However, if the constraint was binding in the previous period, $\mu_{i,t-1} > 0$, then the nondurable consumption growth will be high. This will increase the ratio of healthcare spending to nondurable consumption at t compared to the ratio for a more modest or no growth when the constraint was not binding in the previous period, $\mu_{i,t-1} = 0$. Hence, this shows that the changes in healthcare spending are amplified with the binding liquidity constraint.

3 Empirical Specification

I now continue to carry the theoretical predictions into the data. First, I derive the empirical model from the Euler equations of the health capital model.

As in Zeldes [1989], I normalize the Lagrange multipliers with positive non-stochastic terms as of time t which will be useful for empirical specification.

$$\mu'_{i,t} = \frac{\mu_{i,t}}{\beta \mathbb{E}_t[(1 + r_{i,t+1})u_C^{i,t+1}]} \tag{11}$$

$$\mu''_{i,t} = \frac{\mu_{i,t}}{\beta \mathbb{E}_t[(1 + r_{i,t+1})u_H^{i,t+1}]} \tag{12}$$

$$\mu'''_{i,t+1} = \frac{\beta(1 - \delta^h)\mathbb{E}_t[(1 + r_{i,t+1})\mu_{i,t+1}]}{\beta \mathbb{E}_t[(1 + r_{i,t+1})u_H^{i,t+1}]\mathbb{E}_t[1 + r_{i,t+1}]}. \tag{13}$$

Then, substitution of these into the intertemporal conditions and assuming rational expectations results in the following Euler equations:

$$\beta(1 + r_{i,t+1})\frac{u_C^{i,t+1}}{u_C^{i,t}}(1 + \mu'_{it}) = 1 + e'_{i,t+1} \tag{14}$$

$$\beta(1 + r_{i,t+1})\frac{u_H^{i,t+1}}{u_H^{i,t}}(1 + \mu''_{i,t} - \mu'''_{i,t+1}) = 1 + e''_{i,t+1} \tag{15}$$

where $e'_{i,t+1}$ and $e''_{i,t+1}$ are the expectational errors for (14) and (15) respectively, which have conditional mean zero and orthogonal to any information up to time $t + 1$: $\mathbb{E}_t[e'_{i,t+1}] = 0$ and $\mathbb{E}_t[e''_{i,t+1}] = 0$.

If expectation errors have conditional mean zero, $\ln(1 + e'_{i,t+1})$ and $\ln(1 + e''_{i,t+1})$ do not have mean zero expectations. Taking second order Taylor expansion gives:

$$\ln(1 + e'_{i,t+1}) = e'_{i,t+1} - \frac{1}{2}e'^2_{i,t+1} + O(e'^3_{i,t+1}) \tag{16}$$

$$\ln(1 + e''_{i,t+1}) = e''_{i,t+1} - \frac{1}{2}e''^2_{i,t+1} + O(e''^3_{i,t+1}). \tag{17}$$

where the approximation error $O(e^3_{i,t+1}) \to 0$ as $e_{i,t+1} \to 0$. I assume that third and higher order moments are orthogonal to the information set at time t.

Assumption 3. *The felicity function takes additively separable form over non-durable consumption and the service flow from the health stock as well as over time. The consumption good and service flow from health stock take CRRA form.* [14]

$$u(C_{i,t}, H_{i,t}; \Theta_{i,t}) = \left(\frac{C_{i,t}^{1-\phi}}{1-\phi} + \frac{H_{i,t}^{1-\xi}}{1-\xi} \right) exp(\Theta_{i,t}) \tag{18}$$

where $\Theta_{i,t}$ is the household specific taste shifter. The coefficients of relative risk aversion for nondurable consumption and health capital , ϕ and ξ, are assumed equal across households.

Proposition 4. *Under Assumptions 1-3 and the results in Propositions 1-2, the Euler equations for non-durable consumption and health capital take the forms:*

$$C_{i,t} = C_{i,t+1} \left(\frac{1 + e'_{i,t+1}}{\beta(1 + r_{i,t+1})(1 + \mu'_{i,t}) exp(\Delta\Theta_{i,t+1})} \right)^{1/\phi} \tag{19}$$

$$H_{i,t} = H_{i,t+1} \left(\frac{1 + e''_{i,t+1}}{\beta(1 + r_{i,t+1})(1 + \mu''_{i,t} - \mu'''_{i,t+1}) exp(\Delta\Theta_{i,t+1})} \right)^{1/\xi} . \tag{20}$$

Proposition 5. *Taking natural logs of the results in Proposition 4, (19) and (20), and rearranging, the specifications for log-linear Euler equation estimations become:*

$$\Delta \ln C_{i,t+1} = \frac{1}{\phi}\{\ln(1 + \mu'_{i,t}) + \ln \beta_i + \ln(1 + r_{i,t+1}) - \ln(1 + e'_{i,t+1}) + \Delta\Theta_{i,t+1}\} \tag{21}$$

$$\begin{aligned} \Delta \ln d_{i,t+1} = &\frac{\hat{m}}{\xi}\{\ln(1 + \mu''_{i,t} - \mu'''_{i,t+1}) + \ln \beta_i + \ln(1 + r_{i,t+1}) - \ln(1 + e''_{i,t+1}) + \Delta\Theta_{i,t+1}\} \\ &- \frac{\hat{m} - 1}{\xi}\{\ln(1 + \mu''_{i,t-1} - \mu'''_{i,t}) + \ln \beta_i + \ln(1 + r_{i,t}) - \ln(1 + e''_{i,t}) + \Delta\Theta_{i,t}\} \end{aligned} \tag{22}$$

where $\Delta \ln C_{i,t+1} = \ln C_{i,t+1} - \ln C_{i,t}$ is the growth of non-health consumption, and $\Delta \ln d_{i,t+1} = \ln d_{i,t+1} - \ln d_{i,t}$ is the growth of health-care expenditures. $\hat{m}$ is a constant given as $\hat{m} = \frac{\overline{m}^{1/\xi}}{\overline{m}^{1/\xi} - (1-\delta^h)}$, where $\overline{m}$ is a fixed number such that Taylor expansion of the term in parentheses in (20) is taken around it to linearize the Euler relation for the health capital.

[14] I ignore the utility weight on health capital for now since it does not play any role in empirical analysis when it is a constant.

Proof. The proof and discussion about this proposition is in Appendix A.1. □

Proposition (5) is the main assertion that gives the empirical specification for the extended test for healthcare expenditures. The equation (21) is the log-linearized Euler equation specification that are often used to test for excess smoothness of consumption and for the presence of liquidity constraints in the literature.

The equation (22) is the log-linearized Euler equation specification for the health capital model. The dynamics of the model is clearly seen in equation (22). First, the linearized Euler equation includes all the variables in (21), as well as normalized one period ahead expected liquidity constraint. Moreover, it includes all these terms with one period lags. This shows that healthcare expenditure growth is determined by a more dynamic model compared to nondurable consumption. Second, $\hat{m} > 1$, hence the lag terms in the second line of equation (22) enter with a negative coefficient. The contemporaneous terms and lag terms are not taken into account as a simple weighted average for the expenditure growth. Indeed, there is a stock-flow adjustment between time periods. When the health stock is adjusted, the flow responds negatively to the old information. The expenditure responds are stronger to a variable that has a bigger stock. This creates large swings in healthcare expenditure.

The differences between equations (21) and (22) give a clear direction on how the empirical specification and the standard liquidity constraint test will be extended for the healthcare expenditures.

The felicity function, hence consumption and expenditures, is influenced by household specific tastes that also shift across time. The taste shifter has both observable and unobservable components. I assume each household have a different time preference rate, this is equivalent to having a household fixed effect in the change in taste that also captures unobservable heterogeneity across households. Taste shifter is a function of a third order polynomial in age, education, household size, race, marital status, quadratic polynomial in health indices, an indicator for hospitalization shock, time-invariant household specific shifter and aggregate time shifter:

$$\Theta_{i,t} = g_{i,t}(age_{i,t}, edu_{i,t}, size_{i,t}, race_{i,t}, marital_{i,t}, HI^a_{i,t}, HI^c_{i,t}, H^s_{i,t}) + \zeta_i + \chi_t + \nu_{i,t} \tag{23}$$

where ζ_i is the unobservable household fixed effect, χ_t is the aggregate time shifter, and $\nu_{i,t}$ is the innovation in data-generating process for tastes that is assumed to be orthogonal to the observable and unobservable components.

Then, the change in tastes in the Euler equations takes the form:

$$\Delta\Theta_{i,t+1} = \Delta g_{i,t+1} + (\chi_{t+1} - \chi_t) + (\nu_{i,t+1} - \nu_{i,t}) = X'_{i,t+1}\tilde{\Gamma} + (\chi_{t+1} - \chi_t) + (\nu_{i,t+1} - \nu_{i,t}) \tag{24}$$

where the term $X'_{i,t+1}\tilde{\Gamma}$ constitutes the variables in $g_{i,t}(.)$ function and it is formulated as;

$$\begin{aligned} X'_{i,t+1}\tilde{\Gamma} =& \gamma_1 age_{i,t} + \gamma_2 age^2_{i,t} + \gamma_3 edu_{i,t} + \gamma_4 size_{i,t} + \gamma_5 HI^a_{i,t} + \gamma_6 HI^c_{i,t} + \gamma_7 H^s_{i,t} + \gamma_8 \Delta HI^a_{i,t+1} \\ &+ \gamma_9 \Delta HI^c_{i,t+1} + \gamma_{10} \Delta H^s_{i,t+1} + \sum_p \gamma^p_{11} race_p + \sum_q \gamma^q_{12} sex_q + \sum_r \gamma^r_{13} mar_r \end{aligned} \tag{25}$$

$race_p$ is an indicator function for $p = 1, 2, 3$, $\mathbb{1}[race = p]$, where category 1 indicates White, 2 indicates Black and 3 for others. Similarly, sex_q is an indicator for sex of head, mar_r is an indicator for marital status. $HI^a_{i,t}$ is the acute illness index, $HI^c_{i,t}$ is the chronic illness index, and $H^s_{i,t}$ is the hospitalization shock calculated for head and spouse total.

Differencing drops the household fixed effect from the equation. However, in the empirical specification, I control for unobserved heterogeneity across households due to heterogeneity in discount rates. Moreover, I am adding education, size, chronic and acute health indices, and hospitalization index in levels in order to account for possible nonlinearities that these variables enter in taste-shifter function, as well as a full set of dummies for race, sex and marital status of head. In a robustness analysis, I also control for insurance type with dummies for public insurance, private insurance, and uninsured.

Substituting (24) into (21) and (22) yields the regression equation for non-health consumption growth: [15]

$$\Delta \ln C_{i,t+1} = \underbrace{\frac{1}{\phi}\{\gamma_1 + \frac{1}{2}\sigma_e^2\}}_{\alpha_0^c} + \underbrace{\frac{1}{\phi}\ln \beta_i}_{\alpha_{1i}^c} + \underbrace{\frac{1}{\phi}(\chi_{t+1} - \chi_t)}_{\alpha_{2t}^c} + \frac{1}{\phi}\ln(1 + r_{i,t+1}) + \frac{1}{\phi}X'_{i,t+1}\tilde{\Gamma}$$
$$+ \underbrace{\frac{1}{\phi}\{(\nu_{i,t+1} - \nu_{i,t}) - \ln(1 + e'_{i,t+1}) - \frac{1}{2}\sigma_e^2\}}_{\epsilon_{it+1}^c} + \frac{1}{\phi}\ln(1 + \mu'_{i,t}) \tag{26}$$

The Kuhn-Tucker multipliers are not observed, hence they enter the error term. These are combined with the innovation and the terms in expectation error as $u_{it+1}^c = \epsilon_{it+1}^c + \ln(1 + \tilde{\mu}'_{i,t})$. Further taking first order Taylor expansion for after-tax return as $ln(1 + x) \approx x$, and relabeling the coefficients such that $\alpha_3^c = 1/\phi$ and $\Gamma^c = \tilde{\Gamma}/\phi$ gives;

$$\Delta \ln C_{i,t+1} = \alpha_0^c + \alpha_{1i}^c + \alpha_{2t}^c + \alpha_3^c r_{i,t+1} + X'_{i,t+1}\Gamma^c + u_{it+1}^c \tag{27}$$

The regression equation for healthcare expenditure growth is dynamically more involved. It includes the lag values of all covariates, rate of return, and error terms. [16]

$$\Delta \ln d_{i,t+1} = \alpha_0^d + \alpha_{1i}^d + \alpha_{2t}^d + \alpha_3^d r_{i,t+1} + \alpha_4^d r_{i,t} + X'_{i,t+1}\Gamma_1^d + X'_{i,t}\Gamma_2^d + u_{it+1}^d \tag{28}$$

[15] By adding σ_e^2 into α_0^c, I am implicitly assuming that expectational errors are drawn from the same distribution for households. However, this is not a critical assumption and does not effect anything, assuming different distributions for each i would place σ_e^2 into α_{1i}^c and the fixed effects would then include the households specific expectational error variation.

[16] The derivation is in Appendix A.1. The error term in healthcare expenditure growth includes lag forecast errors which introduce an MA(1) error structure. Therefore, the instrument set should account for the autocorrelation for consistency of estimates. In empirical analysis I use only time t-1 variables as instruments in instrumental variable regressions.The derivations and detailed arguments regarding these terms are discussed in Appendix A.1 and A.2.

The change in innovations in taste, $(\nu_{i,t+1} - \nu_{i,t})$, is assumed to be stationary and have mean zero. So, conditional on information set at time t, the error terms in (27) and (28) have mean zero, $\mathbb{E}[\epsilon_{it+1}|\mathcal{F}_{i,t}] = 0$ and $\mathbb{E}[u_{it+1}|\mathcal{F}_{i,t}] = 0$.

The ex-post after-tax real return on savings is household specific and is given as;

$$r_{i,t+1} = \frac{[1 + i_t(1 - \tau_{i,t+1})]}{1 + \pi_{t+1}} - 1 \tag{29}$$

where i_t is the nominal interest rate, τ_{it} is the consumer i's marginal tax rate at time t, π_{t+1} is the inflation rate between t and t+1.

The ex-post after tax interest rate for households, $r_{i,t+1}$, is not observed at time t and it is possibly correlated with expectation error on growth of consumption. For this reason, I follow previous papers and use an instrumental variable approach. The instruments for ex-post after-tax returns are the marginal tax rates for head and spouse at time t-1 and log of disposable household income, $\ln y_{i,t-1}$.

I follow Zeldes [1989] and Runkle [1991] in testing the presence of liquidity constraints. Mainly, the test is based on violation of unconstrained Euler equation for households that are likely experiencing binding liquidity constraints. In this regard the households are stratified into groups based on their wealth. I split the sample based on total household net worth. Then, the identifying assumption is that the household income and asset holdings are not correlated with expectational errors (by rational expectations assumption) and change in innovations in household taste shifters after controlling for change in observables in taste shifters, household and time fixed effects.

For an initial analysis, I split the sample into 2 groups of observations based on median wealth, for the first group the constraints are likely to be binding ($\mu_{i,t} > 0$), and for the second group they are slack ($\mu_{i,t} = 0$). Then, I further split the observations into 5 groups based on wealth quintiles. The motivation to have a finer split is that the degree that the constraints are binding may differ among wealth groups. A finer split will allow one to observe for the pattern in the degree to which the constraints bind. Moreover, since the wealth and consumption are measured with possibly large errors, it is not easy to find the cutoff in dividing into subgroups and any division will be misleading due to extraordinary observations in noisy datasets. Having a finer division increases these concerns on the one hand due to the lower number of observations in each sample, however the difference between quintiles makes binding liquidity constraints more visible, that is, instead of comparing 2 groups, comparing 5 groups makes imperfect division less of a concern.

The aim in this paper is not analyzing the impact of liquidity constraints on consumption per se, but evaluating the differential impact of binding constraints on health-care expenditures versus non-health consumption. Therefore, it is important to emphasize the theoretical implications of the health capital model. The derived Euler equations imply that health-care expenditures might be differing from the optimal level due to binding constraints in the current period as well as expectations about one period ahead binding constraints. Either considering liquidity constraints are persistent for at least one more period, or current binding constraints lead to expectations such that the constraints will also bind in the future, the constrained Euler equations imply that health-care expenditures deviate from unconstrained level more than non-health consumption due to an extra expectation term. [17]

4 Empirical Assessment

4.1 Specification in levels

Before proceeding to Euler equation tests of consumption growth, I will look at the econometric specification in logs of consumption in order to motivate the tests for the differential impact of liquidity constraints on the healthcare expenditures. I estimate income elasticity of non-health consumption and health-care expenditures as a first pass using OLS. Although this specification does not give unbiased elasticities due to many endogeneity concerns, it provides a motivation for a comparative analysis of the liquidity constraints. The econometric models take the following forms:

[17]"more" here refers to marginal utilities, not the exact levels, both because of the parameter differences, also because what a 'unit' health equivalent in terms of the consumption good is very ambiguous.

$$\ln C_{it} = \omega_0^c + \omega_1^c \ln y_{it} + \omega_2^c HI_{i,t}^a + \omega_3^c HI_{i,t}^c + \omega_4^c H_{i,t}^s + W_{it}'\omega_5^c + b_i^c + b_t^c + \iota_{i,t}^c \tag{30}$$

$$\ln d_{it} = \omega_0^d + \omega_1^d \ln y_{it} + \omega_2^d HI_{i,t}^a + \omega_3^d HI_{i,t}^c + \omega_4^c H_{i,t}^s + W_{it}'\omega_5^d + b_i^d + b_t^d + \iota_{i,t}^d \tag{31}$$

where $\log C_{i,t}$ is the log family consumption and $\ln d_{it}$ is the log of out-of-pocket health-care expenditures. In the empirical assessment, the consumption variable is separately defined as (i) all non-health consumption, (ii) food consumption. Food consumption is used to compare the results with the previous literature since most early papers are relying on household food expenditures such as Zeldes [1989] which is the most available consumption category in the data. In the regression equations above, $HI_{i,t}^a$ is an index of family (head and spouse) acute health status. $HI_{i,t}^c$ is an index of family chronic health status, $H_{i,t}^s$ is the index whether head or spouse is hospitalized during the previous year, $\ln y_{i,t}$ is the total family income, $W_{i,t}$ is a vector of control variables that includes family size dummies, race, sex, marital status of head, years of schooling and a quadratic in the age of head, type of health insurance dummies and state dummies, b_i is individual fixed effects and b_t is year fixed effects. The elasticities are estimated separately for each wealth quintile. [18]

4.2 Specification in growths

The main tests in the present paper depend on the Euler equations from the health-capital model. Therefore, the model-implied specifications are in growths of consumption rather than levels. Combining constant terms, household specific time-invariant and time-varying terms together and rearranging we reach equations (27) and (28). Hence, the main tests for the presence of the binding liquidity constraints are done using these equations with an instrumental variable approach. The regressions are run separately for each wealth quintile.

[18]In alternative specifications, I replaced health indices with self-reported health status of head and spouse. The coefficients are less precise for these alternative variables. The reliability of self-reported health status and comparability between households is contentious in the literature. Several researchers have developed indexes to measure the health level, such as a frailty index. However, there is no easy way to assess how healthy an individual is.

$$\Delta \ln C_{i,t+1} = \alpha_0^c + \alpha_{1i}^c + \alpha_{2t}^c + \alpha_3^c r_{i,t+1} + \alpha_4^c \ln y_{i,t} + X'_{i,t+1}\Gamma^c + u_{it+1}^c \tag{32}$$

$$\Delta \ln d_{i,t+1} = \alpha_0^d + \alpha_{1i}^d + \alpha_{2t}^d + \alpha_3^d r_{i,t+1} + \alpha_4^d r_{i,t} + \alpha_5^d \ln y_{i,t} + X'_{i,t+1}\Gamma_1^d + X'_{i,t}\Gamma_2^d + u_{it+1}^d \tag{33}$$

In this specification, $\ln y_{i,t}$ is added as an extra regressor to the equation. Under the null hypothesis that the permanent income hypothesis holds, income should not have any explanatory power in variations in consumption growth. However, when the liquidity constraint is binding, the income variable is correlated with the error term and this would bias the coefficient on income which is the essence of the test.

Note that $\ln y_{i,t-1}$ is also added as a regressor for health expenditure growth in order to proxy for lag binding constraint.

4.3 Data

Data comes from 1999-2015 waves of Panel Study of Income Dynamics (PSID). Starting from 1968, PSID collected data on demographics, employment, asset holdings, expenditures and health factors of 5,000 U.S. households over their life course and their children (SRC sample). Later, more samples added as to represent Latino population and lower income levels (Latino and SEO sample). The survey initially collected food, childcare and housing expenditures, however, after 1999 more comprehensive expenditure categories are added. The empirical analysis in the present paper incorporates all households excluding SEO and Latino samples.

The consumption data uses the aggregated consumption variables imputed by the PSID staff in the main family files. These variables span food, housing, transportation, education, childcare and health-care expenditures and their subcategories. Healthcare expenditure consists of health insurance premiums paid by household and out-of-pocket health-care spending. The wealth variable used in this analysis is all assets net of debt, including home equity. Disposable income is calculated as family unit federal taxable income minus federal, state and social security taxes plus credits.

The ex-post rate of return formulation gives the tax-augmented Fisher equation as $r_{i,t+1} =$

$i_t(1-\tau_{i,t+1})-\pi_{t+1}$ as in Shapiro [1984] . Nominal interest rate i_t is a monthly average of 3-month T-bill rate in the previous year. The inflation rate is the annual percentage change in Personal Consumption Expenditures (PCE) excluding food and energy extracted from St. Louis Fed database. Marginal tax rates and the variables in disposable income calculations are estimated using NBER's TAXSIM simulator.

I constructed health indices using the categorization employed by Conley and Thompson [2011], however the index construction serves a different purpose in the sense that I construct them as a measure of family health status rather than to identify health shocks. Instead, I use the hospitalization index as a proxy for a health shock. Specifically, acute illnesses consists of stroke, heart attack, and cancer. Chronic illnesses consist of diabetes, lung disease, heart disease, psychological problems, arthritis, asthma, memory loss, and learning disorder. The index is the sum of the existence of each illness for head and spouse combined. Acute and chronic health indices indicate the state of health in the family. Hospitalization index takes values 0, 1 or 2 if either one of head or spouse (1) , both (2) or none (0) of them is hospitalized during previous calendar year.

The sample consists of households with heads between ages 25-65. The health variables are constructed using head and spouse health conditions. Income, consumption and wealth variables are at the household level. I trimmed the data if food consumption grows or shrinks more than 400%. I also dropped observations if a household has a negative checking/saving account or negative stocks, which is possibly due to the imputation of wealth variables. All nominal variables are deflated to 2010 dollars using CPI-U. Food variables are deflated using food CPI and healthcare expenditure variables are deflated using medical CPI.

Table 1 Descriptive Statistics

	Wealth Quintiles					
	1st	2nd	3rd	4th	5th	Total
Net Wealth	-22.2	23.0	85.7	228.8	1,311.4	325.3
Disposable Income	27.0	31.6	41.9	53.4	96.8	50.2
Total Consumption	36.3	39.3	46.4	53.6	70.9	49.3
Food Consumption	6.9	7.6	8.4	9.3	10.9	8.6
Health Expenditure	3.7	4.2	4.8	5.9	8.3	5.4
Age	37.4	38.8	42.7	46.6	50.4	43.2
Education	13.4	13.1	13.5	14.1	15.0	13.8
Household Size	2.7	2.8	3.0	2.9	2.9	2.9
Observations	5,930	5,925	5,927	5,927	5,927	29,636

Wealth, income and consumption are in thousand $s. Mean of corresponding variable for each wealth quintile.

4.4 Euler equation tests

4.4.1 Test for nondurable consumption

Euler equation tests are based on the existence of Lagrange multiplier, $\mu_{i,t}$, in the error term, which creates an omitted variable bias. Under the null hypothesis that the liquidity constraints do not exist, the parameter estimates should be similar across wealth groups. Under the alternative hypothesis that the liquidity constraints exist and binding for some groups, the parameter estimates differ across groups. More specifically, the error term for the households for which the constraints are binding ($\mu_{i,t} > 0$), would be correlated with income which otherwise should have no effect on consumption growth, hence the parameters on income that is added as an extra regressor will be biased and will show up significantly different from zero.

Any other bias that might be occurring due to, for example, omitted variables, higher order terms that enter the error term after log-linearization or mis-measurement of consumption data can also invalidate the identifying assumptions. However, there is no reason to believe that such sort of bias will vary between quintiles. Hence, any difference in parameter estimates between quintiles must be coming from binding liquidity constraints. Having settled with this test, the second step is to assess how distinct the impact of binding liquidity constraints on the health-care spending compared to non-health consumption, in particular, to food consumption.

Zeldes [1989] divides the sample into two groups based on wealth to income ratio and shows the distinct response of these groups to the changes in income. The low wealth group has a significant bias on extra regressor, while high wealth group has no effect. On the other hand, Runkle [1991] divides samples based on homeownership and whether annuitized value of the household's asset income less than two month's income. He does not find any significant difference between the groups. I divide my sample based on net worth first into two groups and then continue with a finer division with five groups. For wealth quintiles division, it can be expected that the constraints are not binding for 4^{th} and 5^{th} wealth quintiles, and binding for 1^{st}, 2^{nd} and 3^{rd} quintiles with the degree to which it binds being more severe for the lowest wealth groups.

4.4.2 Test for healthcare expenditure

I extend the test by Zeldes [1989] and Runkle [1991] to the case of the health capital model. The extension of the test for health expenditures comes from the Euler equation for health stock (8). The unconstrained Euler equation for health may not hold due to (i) binding liquidity constraints today, i.e. $\mu_{i,t} > 0$, similar to non-durable consumption Euler equation (7) and (ii) expectations about future binding constraints, i.e. $\mathbb{E}_t[\mu_{i,t+1}] > 0$. The deviation (ii) arises due to the recursive nature of health capital. Then, the test is extended considering 4 possible cases, with some abuse of notation:

- **Case 1:** $\mu_{i,t} > 0$ and $\mathbb{E}_t[\mu_{i,t+1}] = 0$

  Liquidity constraint at time t is binding, however there is no expectation about future binding constraints.

- **Case 2:** $\mu_{i,t} = 0$ and $\mathbb{E}_t[\mu_{i,t+1}] > 0$

  Liquidity constraint is not binding at t, however it is expected to bind at t+1.

- **Case 3:** $\mu_{i,t} > 0$ and $\mathbb{E}_t[\mu_{i,t+1}] > 0$

  Liquidity constraint at time t is binding and it is expected to bind at time t+1.

- **Case 4:** $\mu_{i,t} = 0$ and $\mathbb{E}_t[\mu_{i,t+1}] = 0$

  Liquidity constraint at t is not binding and is not expected to bind at t+1.

Note that the expectation for $\mu_{i,t+1}$ is unlikely to be zero. $\mu_{i,t+1}$ has a weakly positive support, it can take zero or a positive value assuming that the households cannot be constrained from saving. If there is even a very small probability for the constraint to bind in the future, the expectation will be a small positive number. So, in the above notation, $\mathbb{E}_t[\mu_{i,t+1}] = 0$ is used in place of $\mathbb{E}_t[\mu_{i,t+1}] = \epsilon$ for some small $\epsilon > 0$, and consequently, $\mathbb{E}_t[\mu_{i,t+1}] > 0$ indicates a large positive expectation.

Case 1 is the same as Runkle-Zeldes test for nondurable consumption. The Lagrange multiplier for binding constraint at t, $\mu_{i,t}$, is positively correlated with the income that is added as an extra regressor to the empirical model. However, it is negatively correlated with consumption growth. This shows up as a negative bias on the income variable. In this case, a negative coefficient on income is expected.

Case 2 has quite different implications for the bias on income. The Lagrange multiplier for binding constraint at t+1, $\mu_{i,t+1}$, is negatively correlated with consumption growth. The household cannot increase consumption if she expects not to have enough resources for the next period. This can be because the resources are enough for the time t to cover the health spending, hence the constraint is not binding contemporaneously, but the resources are not enough to cover prolonged costs beyond what is already being spent at the time t. Moreover, $\mathbb{E}_t[\mu_{i,t+1}]$ is negatively correlated with expected income at t+1. The income may not be changing between t and t+1 so that $\mathbb{E}_t[\mu_{i,t+1}]$ is also negatively correlated with income at t, or it may be temporarily high at t than what is expected at t+1 which further increases negative correlation. Overall, both negative correlations induce a positive bias on the extra income regressor in the model, hence, a positive coefficient is expected in case 2.

Case 3 is the combination of Case 1 and Case 2. When the liquidity constraint is binding at t and is expected to bind at t+1, there is both a positive bias and a negative bias on income variable. These opposing biases may cancel out, or one of them may dominate. In this case, any situation for coefficient estimate on income is possible.

Case 4 is again same as Runkle-Zeldes test for unconstrained households. The liquidity constraint is not binding at t and is not expected to bind at t+1 since the household has enough resources to cover her expenditures. Hence, the extra regressor income is expected to have an insignificant coefficient since it is not predicted to have an impact on consumption growth by the PIH/LCH theory.

Figure (1) shows the illustration of how the multipliers associated with liquidity constraints at t and t+1 might affect the coefficients of log income in the tests. Panel [a] illustrates Case 1 discussed above and panel [b] illustrates Case 2.

Figure 1 Direction of bias in expenditure growth

(+)

$$\Delta d_{i,t+1} = \beta_0 + \beta_1 X_{i,t} + \beta_2 r_{i,t+1} + \beta_3 y_{i,t} + \epsilon_{i,t}$$

(−)

$$\boxed{\beta_3 < 0} \qquad \mu_{i,t}$$

[a] Case 1: direction of bias due to binding constraint at t

(−)

$$\Delta d_{i,t+1} = \beta_0 + \beta_1 X_{i,t} + \beta_2 r_{i,t+1} + \beta_3 y_{i,t} + \epsilon_{i,t}$$

(−)

$$\boxed{\beta_3 > 0} \qquad \mathbb{E}_t[\mu_{i,t+1}]$$

[b] Case 2: direction of bias due to expected binding constraint at t+1

Notes: The figure plots illustration of direction of bias for binding liquidity constraints. $\Delta d_{i,t+1}$ is the expenditure growth, $y_{i,t}$ is the log income at t which is the variable of interest for liquidity constraint tests. $\mu_{i,t}$ is the Lagrange multiplier for constraint at t and $\mathbb{E}_t[\mu_{i,t+1}]$ is the expectation of Lagrange multiplier for the constraint at t+1. Lagrange multipliers are omitted in the regression. β_3 takes zero when the constraints are not binding, i.e. when multipliers are zero. When liquidity constraints are binding, multipliers are positive and correlated with both income and expenditure growth and enter into the error term. This creates omitted variable bias for β_3.

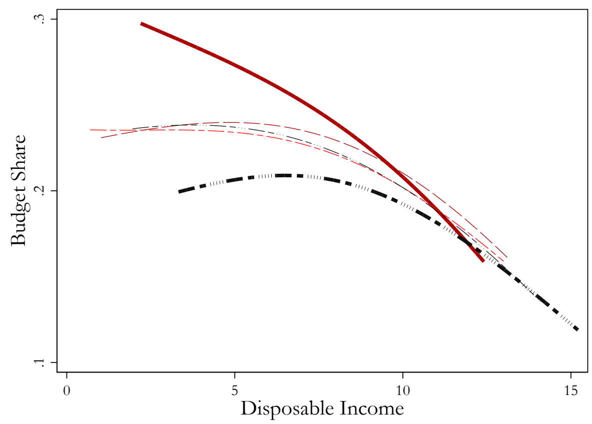
5 Empirical Findings

In order to motivate the divergent behavior of healthcare expenditures between heterogeneous agents compared to other consumption, I plot the Engel curves, share of consumption category in total consumption as a function of disposable income, for healthcare expenditures, non-health consumption and food consumption for each wealth quintiles. The sample is the same as the one used in the empirical analysis. The Engel curves are drawn using raw consumption shares and plotted against disposable income for each wealth quintile.

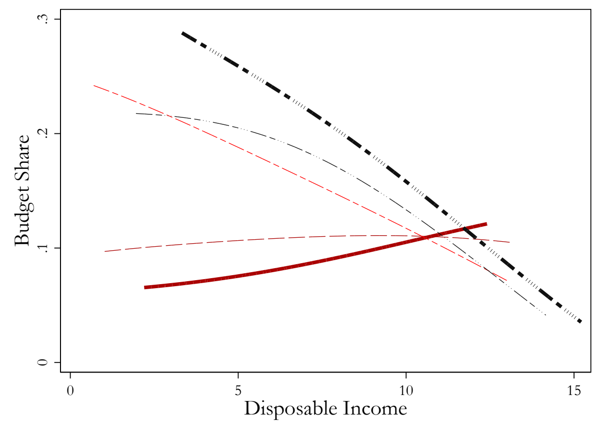
First observation is that the budget share of healthcare expenditures are very low for low wealth households, less than 10% for most households in 1^{st} and 2^{nd} quintiles. The share of food consumption is as high as 25-30% for very poor families. Second, the share of food consumption falls with the income for all wealth quintiles. This shows that food is a necessity for everyone. However, the behavior of healthcare expenditure differs between asset-rich and asset-poor households. While for high wealth households, it is a necessity, health care is inelastic or even slightly luxury for low wealth households as its share increases with income for the most constrained. These figures provide a first motivation for why healthcare expenditure has a differential interaction with income changes. [19]

[19]In Appendix B, I also plot Engel curves for housing, education, and transportation. The plots are very interesting for these consumption categories as they become more luxury as the incomes rise for most households. However, it is not the goal of this paper and I leave it to future work with models incorporating these expenditures as well.

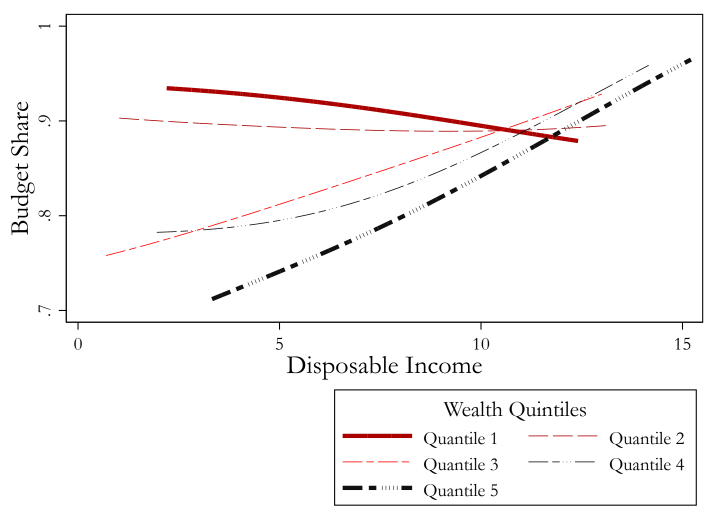
Figure 2 Engel Curves: budget share as a function of disposable income



[a] Food Expenditure Share



[b] Healthcare Expenditure Share



[c] Non-Health Expenditure Share

Notes: Engel Curves for Non-Health Expenditure, Healthcare Expenditure and Food Expenditure. The curves are expenditure shares log of consumption categories as a function of disposable income, fitted for each wealth quintile. The fits are nonparametric local linear polynomial regressions using Gaussian kernel weights and a bandwidth choice of 4. The healthcare expenditure is the sum of out-of-pocket health spending and health insurance payments of household. Food consumption includes food at home and food away from home. Non-health consumption includes food, housing, education, childcare, transportation spending of families. The data is from 1999-2015 waves of PSID, includes families with heads between 25-65 years old.

5.1 Results in levels

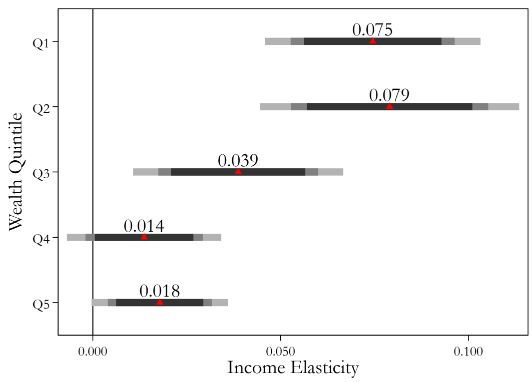
In order to give more motivation for the effect of liquidity constraints, I estimate the income elasticity of healthcare expenditures. The estimates show that the correlation between income and healthcare expenditure vary between low wealth and high wealth households.

Figure (3) plots the elasticity estimates for food consumption, healthcare spending and all non-health consumption and total consumption for each wealth quintile. The coefficients are plotted along with 99%, 95%, 90% confidence levels with fading colors.

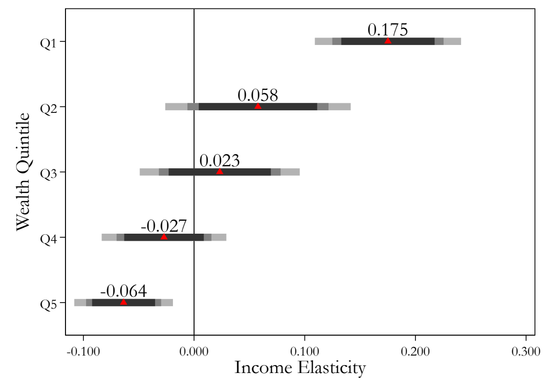
Overall, the elasticities for households in the lowest quintile are higher in magnitude for all consumption categories. In line with the theoretical and empirical findings in the literature, consumption moves with current income for constrained households. Food consumption elasticity varies between 8.2% and 2%. As is clear in panel b, the difference in elasticities of healthcare is much more stark between wealth quintiles. For the lowest quintile the elasticity is 12.5% whereas it is negative and significant for the highest quintiles with −9.5% and −9.7%.

Negative elasticity indicates that healthcare spending is an inferior consumption category. This is implausible. However, it is important to note that these estimates possibly suffer from endogeneity. The wealthier households can also be healthier and invest in preventive healthcare more when they have extra money and they can afford better insurance contracts as their income increase which makes them pay less out of pocket.

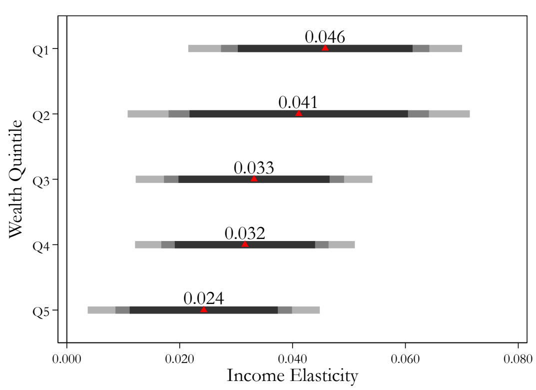
Figure 3 Income elasticity of expenditures



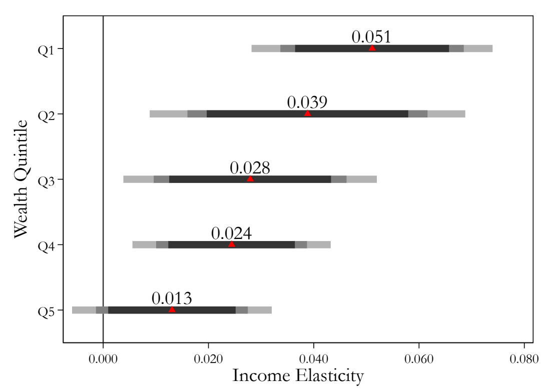
[a] Food Expenditure



[b] Healthcare Expenditure



[c] Non-health Expenditure



[d] Total Expenditure

Notes: The figure plots coefficients from regressing food consumption in panel a, healthcare spending in panel b and all non-health consumption in panel c and total consumption in panel d on log disposable income for each wealth quintiles Q1-Q5 with the upmost coefficient belonging to the first quintile. The confidence intervals are also plotted at 99%, 95%, 90% confidence levels with fading colors respectively. The regressions include all control variables as well as time and individual fixed effects.

Table 2 Crowding-out effect of health status and hospitalization shock on expenditure

	Wealth Quintiles				
	1st	2nd	3rd	4th	5th
	Dependent Variable: Food Expenditure				
Acute index	-0.039	0.044	-0.039	0.027	0.040*
	(0.043)	(0.038)	(0.036)	(0.029)	(0.021)
Chronic index	-0.032**	0.004	-0.005	-0.020	0.014
	(0.015)	(0.015)	(0.012)	(0.013)	(0.011)
Hospitalization	-0.055*	-0.032	-0.023	-0.061***	-0.006
	(0.028)	(0.023)	(0.023)	(0.020)	(0.017)
	Dependent Variable: Non-health Expenditure				
Acute index	0.019	0.046*	-0.011	-0.003	0.020
	(0.03)	(0.024)	(0.025)	(0.023)	(0.021)
Chronic index	-0.010	0.003	-0.006	-0.013	0.006
	(0.011)	(0.009)	(0.009)	(0.009)	(0.012)
Hospitalization	-0.041**	-0.012	-0.030*	0.009	-0.022
	(0.019)	(0.017)	(0.016)	(0.016)	(0.019)

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: Robust standard errors clustered at household level in parentheses. The table shows the coefficients of health indices and health shock from income elasticity regressions.

The elasticity regressions also reveal some crowding out the effect of health shocks and bad health into food and non-health consumption. Table (2) summarizes some findings of this effect. The detailed tables are presented in Appendix C.2. As seen in the table, a hospitalization shock reduces non-health consumption of the lowest quintile households significantly by 4.1% and of 3rd quintile households by 3%. And a shock reduces food consumption of the lowest quintile by 5.4% and one additional chronic illness in the family reduces food consumption by 3.2%. The crowd out of hospitalization shock is also true for 4th quintile households which is possibly due to more luxury food such as dining in a restaurant. Indeed, all quintiles have a negative effect of a health shock on their food spending though not all are statistically significant. In this regard, Mohanan [2013] reports small negative crowd out of health shocks on consumption of housing, festivals and more on education but the estimates are insignificant. He finds a significant impact of shocks on household indebtedness using a quasi-experimental design in India. I am not giving any causal interpretation to my results, however, they give a motivation for the importance of health shocks in household budget allocation.

5.2 Results in growths

I begin by presenting the results for sample split based on median net worth. I add $\ln Y_{i,t}$ as an extra regressor to the equation that proxy for the binding constraints. If the PIH holds, then the variations in expected after-tax real rate of return must be explaining the variations in consumption growth rates, no other variable that is already in the household's information set must have explanatory power. The results of binding liquidity constraints test are reported in 3. Column (1) gives a significant explanatory power for income for food consumption growth for low wealth households. As expected, the sign of the coefficient is negative, which is a clear indication of the binding liquidity constraints for this group.

Columns (3) and (4) show the results for healthcare expenditures. The coefficient on income variable is significantly negative for low wealth households, again it's an indication of a strong effect of binding liquidity constraints. These results correspond to Case 1 and Case 3 in the test described above. Since it is more reasonable to think that low wealth households with binding constraints would form expectations that the constraint will be binding in the next period as well, I consider Case 3 as the more plausible scenario. In this case, the negative results indicate that the binding constraint at the current period has more impact than any expectations in determining health expenditure growth. On the other hand, the results imply a very different pattern for high wealth households. The coefficient is positive and statistically significant. This corresponds to Case 2 of the test. That is, the liquidity constraints are not binding in the current period, however, these households hold expectations about future binding constraints. Note that this does not mean that the constraints are expected to bind for all expenditures nor that the households cannot afford healthcare next period. The results indicate that these households hold expectations that they may not afford more healthcare expenditure beyond the level what they are already spending in the current period, which limits their spending in the current period compared to what they could actually spend. However, as income rises, they can afford more healthcare expenditure in the next period.

Columns (5) and (6) show the results for total consumption. The results are interesting in this case, indicating a binding constraint for all households. However, since this category consists of all consumption items that is recorded in PSID, that are food, housing, transportation, education, childcare and healthcare expenditures, it is hard to interpret the findings. The housing, transportation and education categories for high wealth households possibly include more luxury type expenditures.

The expectations about future binding constraints cannot be proxied with given data, hence, I cannot further test the model including expectations.

An interesting point that is worth discussing is the estimate of intertemporal elasticity of substitution from the Euler equations. The IES is positive using food consumption, however, it is negative for healthcare expenditures though it is not significantly estimated. Hall [1988] also reports negative IES using aggregate data. Negative IES implies a convex utility function which cannot be the interpretation in this case since it is the service flow from health capital that enters into the utility function, not the healthcare expenditures in current period. Hall [1988] also draws the conclusion that the IES is not strongly positive but avoids a nonconcave utility interpretation. For IES to be negative, the substitution effect from a change in interest rates must be dominating the income effect. For example, when interest rates rise, consumers want to increase consumption due to the income effect, but also increase savings by the substitution effect. In this case, for food consumption the income effect is more operative. However, for healthcare, the fact that substitution effect dominates income effect means that although higher income makes households relatively rich for food, they do not feel rich enough to spend extra income on healthcare. Instead, they increase savings which they possibly want to use for food or other consumption in the future that bring higher marginal utility than the marginal utility of healthcare expenditures today. This situation shows the secondary role given to healthcare spending as it is relatively more luxury and it arises due to the fact that health capital enters into the utility.

Table 3 Instrumental Variable Estimation of Consumption Growth

	Food Consumption		Healthcare Expenditure		Total Consumption	
	Low Wealth (1)	High Wealth (2)	Low Wealth (3)	High Wealth (4)	Low Wealth (5)	High Wealth (6)
Ex-post rate	0.144	0.059	-0.299	-1.870	0.124	-0.520
	(0.130)	(1.043)	(0.427)	(2.778)	(0.161)	(1.013)
Current income	-0.077***	-0.010	-0.070**	0.063**	-0.038***	-0.014**
	(0.012)	(0.008)	(0.031)	(0.032)	(0.01)	(0.007)
Acute index	0.049	0.029*	0.019	0.433*	0.066**	-0.012
	(0.039)	(0.017)	(0.201)	(0.239)	(0.027)	(0.016)
Chronic index	0.01	0.012	0.043	0.143	0.005	0.0001
	(0.014)	(0.01)	(0.104)	(0.089)	(0.011)	(0.009)
Δ Acute index	0.061*	0.045***	-0.05	-0.015	0.062***	0.008
	(0.034)	(0.016)	(0.077)	(0.044)	(0.023)	(0.014)
Δ Chronic index	0.011	0.017**	0.042	0.043**	0.014*	0.005
	(0.011)	(0.008)	(0.027)	(0.02)	(0.008)	(0.007)
Hospitalization	-0.004	0.029	-0.223	-0.313*	-0.004	0.019
	(0.029)	(0.018)	(0.238)	(0.187)	(0.021)	(0.017)
Δ Hospitalization	-0.016	0.002	0.101**	0.153***	0.006	0.031**
	(0.021)	(0.014)	(0.051)	(0.040)	(0.015)	(0.013)
Household size	-0.055***	-0.053***	-0.009	-0.025	-0.058***	-0.013*
	(0.009)	(0.008)	(0.027)	(0.026)	(0.007)	(0.007)
Education	0.019**	-0.012	0.003	0.022	0.002	-0.002
	(0.01)	(0.009)	(0.031)	(0.036)	(0.007)	(0.009)
Constant	0.581	0.411	3.189	-0.907	0.763	1.267
	(1.168)	(1.029)	(3.134)	(4.152)	(0.859)	(1.117)
Age polynomial	✓	✓	✓	✓	✓	✓
Household FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
N	12449	14726	12449	14726	12449	14726
R^2	0.011	0.006	0.008	0.002	0.033	0.009
Within R^2	0.023	0.014	0.021	0.01	0.043	0.024

Notes: Robust standard errors clustered at household level in parentheses. The regressions include household specific rate of return, taste shifters as well as time and individual fixed effects. Instrument set consists of time t-1 values of the variables which are head and spouse marginal tax rates, log disposable income and average hours per week of head. A total of 21 instruments are used.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

I then proceed with a finer division in order to analyze the severity of the binding constraints. Figure (4) shows the results for the instrumental variable regression of the liquidity constraint test for wealth quintiles.

The Euler equation test results are summarized in Figure 4.[a]-[c]. The figures plot the estimated coefficient on log income with 99%, 95%, and 90% level confidence intervals for each wealth quintile regressions. Figure 4.[a] shows the results for food consumption, Figure 4.[b] shows the results for out-of-pocket healthcare expenditures and Figure 4.[c] shows the results for total consumption.

The sign of the coefficient in food consumption is negative for 1^{st} , 2^{nd} and 3^{rd} quintiles. This is in line with the predictions of the permanent income hypothesis that if the liquidity constraints are not binding the changes in income should not be affecting consumption growth since they can be smoothed out. However, when the constraints are binding, the households cannot smooth consumption in case of an income fall, the unconstrained Euler equation is violated for these groups. Hence, an income fall will induce current consumption to be low and it is expected to grow. The inverse of this, when there is temporary income rise in the current period, the household can always save and smooth away consumption, hence there shouldn't be any change in consumption growth. This explains the negative and significant coefficient for liquidity-constrained households in this group.

In the case of healthcare expenditures, except the households in 1^{st} quintile, the coefficient on income variable is positive, indicating a positive bias and significant for the 3^{rd} and 5^{th} quintiles.

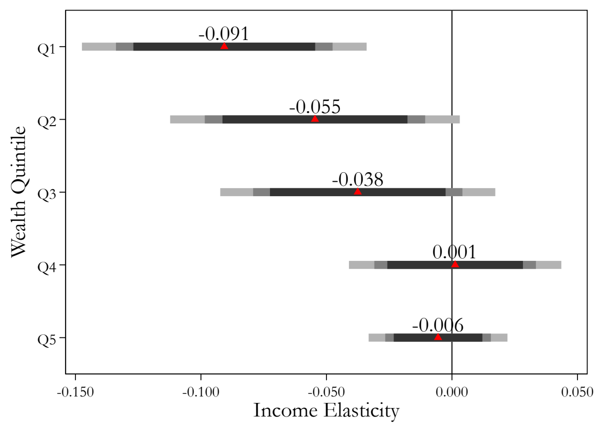
The households in 1^{st} quintile are likely to be the group in Case 3. The liquidity constraint is binding at time t which shows up as a negative bias in income variable for food consumption. Since they are very poor households, it is likely that they also expect the constraints will bind at time t+1. However, if the households are expecting the constraint to bind in period t+1, then the healthcare expenditure model predicts an ambiguity of the direction of bias. The 1^{st} quintile have a significant negative bias in healthcare expenditure growth indicating that the negative bias arising from time t constraints is so severe that it is dominating any positive bias by expectations about binding constraints in the next period.

The 2^{nd} and 3^{rd} quintiles likely correspond to Case 3 again. The binding constraints at t translate into a negative bias in food consumption test. Expectations about future binding constraints are also strong for these quintiles so there is a positive coefficient for healthcare. In the case nth3 quintile the result is significant.

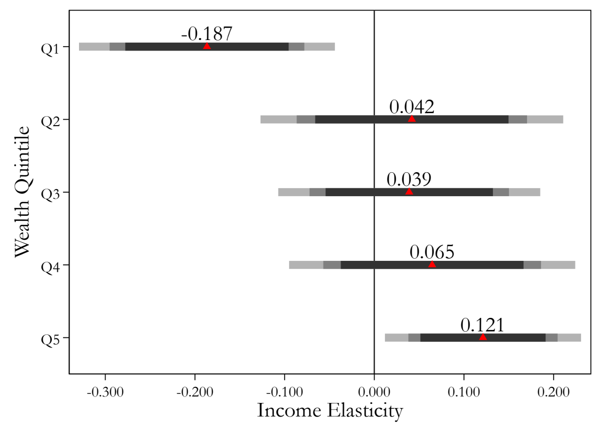
The households in 4^{th} and 5^{th} quintiles can be thought of the group in Case 2. The liquidity constraint is not binding at t, hence the income variable in food consumption regression does not show any bias. However, the coefficient in healthcare expenditures regression is positive, significant for 5th quintile. This indicates an expectation that the constraint might bind at time t+1.

The group in 1st, 2nd and 3rd quintiles are relatively asset-poor households that do not have enough resources for consumption and especially for healthcare expenditures. This is amplified by the unexpected nature of healthcare expenditures. There is not much 'consumption smoothing' for health-care spending as the households need to spend in the period when a negative shock hits. The difference is when the liquidity constraints are not binding, an extra income can translate into better healthcare in the current period (as the results in levels show) as well as better healthcare in the subsequent periods as the healthcare needs may be persistent and the health bills are paid over time. The households in 4th and 5th quintiles are relatively wealthy, they have enough resources for healthcare costs but may not have enough to increase these expenditures beyond the level what they are already spending.

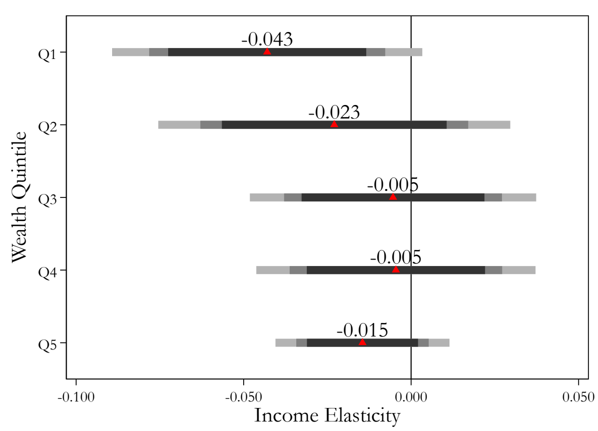
Figure 4 Income elasticity of expenditure growth



[a] Food Expenditure



[b] Healthcare Expenditure



[c] Total Expenditure

Notes: The figure plots coefficients from regressing growth of food consumption in panel a, growth of healthcare spending in panel b and growth of total consumption in panel c on disposable income for each wealth quintiles Q1-Q5 with the upmost coefficient belonging to the first quintile. The confidence intervals are also plotted at 99%, 95%, 90% confidence levels with fading colors respectively. The instrumental variable regressions include household specific rate of return, taste shifters as well as time and individual fixed effects. Instrument set consists of time t-1 values of the variables which are head and spouse marginal tax rates, log disposable income and average hours per week of head. Robust standard errors are clustered at household level.

5.3 Econometric Considerations

5.3.1 Measurement Error

The measurement error in consumption is of particular concern in empirical estimations using consumption data. For example Runkle [1991] finds an estimate around 76% of the variation in PSID food consumption that can be attributable to the measurement error, Alan and Browning [2010] finds a higher estimate of 86 % variance of noise. [20] In linearized Euler equations, the concern is alleviated by assuming a multiplicative measurement error which then enters into the residual term additively. In this regard, I follow the literature and assume that consumption is measured with a multiplicative error term $\kappa_{i,t}$. Let $C^a_{i,t}$ be actual consumption and the observed consumption data is $C_{i,t} = C^a_{i,t} * \kappa_{i,t}$. The Euler equations hold for actual level of consumption. Substituting $C^a_{i,t} = \frac{C_{i,t}}{\kappa_{i,t}}$ into $\Delta \ln C^a_{i,t+1} = \ln C^a_{i,t+1} - \ln C^a_{i,t} = \ln(\frac{C_{i,t+1}}{\kappa_{i,t+1}}) - \ln(\frac{C_{i,t}}{\kappa_{i,t}}) = \Delta \ln C_{i,t+1} - \Delta \ln \kappa_{i,t+1}$ and rearranging, the equation (21) can be written as;

$$\Delta \ln C_{i,t+1} = \frac{1}{\phi}\{\ln(1+\mu'_{i,t}) + \ln \beta_i + \ln(1+r_{i,t+1}) - \ln(1+e'_{i,t+1}) + \Delta\Theta_{i,t+1}\} + \Delta \ln \kappa_{i,t+1}$$

The classical measurement error enters into the equation as an additive term due to log-linearization. I assume that the measurement error is stationary and independent of other regressors including lagged masurement error and expectation error as in Alan, Attanasio and Browning [2009]. As long as the error term is not correlated with the instruments, the classical measurement error is not a concern in linearized models. [21] Moreover, measurement error introduces an MA(1) structures to the residuals. To address these concerns, I use time t-1 values of variables as instruments. For consumption growth to be a valid instrument it must be lagged at least twice. Nevertheless, any lagged consumption growth is not used in any regressions. Similar arguments apply for measurement error in healthcare expenditures and again t-1 variables are used as instruments.

[20] Runkle [1991] assumes no household fixed effects, no measurement error in $r_{i,t}$ and no random shocks to utility. Therefore his estimate can be considered as an upper bound for measurement error in consumption.

[21] As a supportive evidence for this assumption, Alan and Browning [2010] finds no heterogeneity in measurement error between less educated and more educated groups.

5.3.2 Log-linearization

Another concern arises due to log-linear approximations to dynamic Euler equations. Ludvigson and Paxson [2001] and Carroll [2001] show using simulation methods that the higher order terms omitted in linear approximations may create substantial bias in estimating the structural parameters of interest such as the coefficient of relative risk aversion, the coefficient of relative prudence and intertemporal elasticity of substitution. Ludvigson and Paxson [2001] uses a second order approximation to test precautionary savings motive. Their regressions of consumption growth on consumption growth squared produce prudence parameter that is biased down due to omitted third and higher moments. Instrumental variables correct some of this bias but not all since the typical instruments used in the literature are correlated with the higher order moments of the consumption growth. The approximation bias is more pronounced for households with low cash on hand relative to income as the consumption growth and variance of consumption growth are both higher for them due to their inability to smooth consumption. Hence, they appear to be less prudent because of the higher downward approximation bias. Carroll [2001] also verifies that the linear approximations to Euler equations yield poor estimates of structural parameters due to omitted higher order terms that are endogenous with respect to first-order terms. These papers show that the structural parameters are most of the time downward biased. They do not show how the approximation bias can invalidate the liquidity constraints test.

For the current analysis following the literature, I assumed that higher order moments that enter the approximation error in Taylor expansion are orthogonal to the information set at time t. For the liquidity constraint test, if the extra regressor is correlated with the omitted terms then the test coefficient might be showing some of these terms. In a first-order approximation, a second order term, consumption growth squared, is omitted. If low income today is associated with more consumption variance, then these terms are negatively correlated.

However, all the analysis in this paper is *relative* in the sense that I am comparing healthcare spending with food consumption in a first layer, and response of heterogeneous agents in wealth in the second layer. So if the approximation bias is interacting with the bias due to liquidity constraints for food consumption, the argument should also apply for healthcare expenditures. If we accept that in food consumption the test coefficients are downward biased due to approximation bias for all wealth groups, it is interesting to see the positive test coefficient for healthcare expenditures for high wealth group while a significant negative coefficient for low wealth group. It is implausible to think that the approximation bias is changing non-monotonically with wealth level. Based on this argument, I am assuming that the omitted higher order conditional moments are not differentially biasing healthcare expenditures between wealth groups compared to food consumption.

5.3.3 Misspecification

Incorporating Health Shocks Health shocks can be incorporated into the model in two ways. One way which is the one that empirical analysis implicitly assumes is to consider them as shocks to marginal utility. Then, the extension is straightforward via the taste shifter. Note that I assumed the taste shifter takes the following form:

$$\Theta_{i,t} = g_{i,t}(age_{i,t}, edu_{i,t}, size_{i,t}, race_{i,t}, marital_{i,t}, HI^{a}_{i,t}, HI^{c}_{i,t}, H^{s}_{i,t}) + \zeta_i + \chi_t + \nu_{i,t}$$

Taste shifter enters into the Euler equations as difference $\Delta\Theta_{i,t+1}$. Here, $H^{s}_{i,t}$ is a direct proxy for health shocks that ended in hospitalization. Moreover, the change in illness indexes $\Delta HI^{a}_{i,t}$ and $\Delta HI^{c}_{i,t}$ in $\Delta\Theta_{i,t+1}$ are also health shocks to the households. I use both levels and changes of health indexes and hospitalization shock as controls in empirical analysis.

An alternative way of incorporating health shocks is as an additive shock term to the health capital accumulation.

$$H_{i,t} = (1 - \delta^{h})H_{i,t-1} + d_{i,t} + \varepsilon^{h}_{i,t}$$

In this case, the idiosyncratic health shock can be considered as an medical expense shock and can be combined with health expenditure in period t by defining $\tilde{d}_{i,t} = d_{i,t} + \varepsilon^{h}_{i,t}$ and writing health capital process as:

$$H_{i,t} = (1-\delta^h)H_{i,t-1} + \tilde{d}_{i,t}$$

Then all the derivations apply with $\tilde{d}_{i,t}$ instead of $d_{i,t}$.

These approaches are extensively used in macro-health literature. De Nardi, French and Jones [2010] model healthcare related uncertainty in two ways, both as an uncertainty to health status that has a stationary Markov process which effects marginal utility of consumption, as well as a medical expense uncertainty. Similarly, Pashchenko and Porapakkarm [2013] incorporate medical expenses as a shock into the budget constraint and Conesa et al. [2018] model health status as a finite state Markov process and medical expenses as a function of age and health status that determines the out-of-pocket spending of households.

Labor supply margin Another issue arises due to misspecification of the instantaneous utility function. I assumed away any complementarities between food consumption, health capital and leisure in order to simplify the model. However, the labor supply is also determined in equilibrium and affect the consumption decision as discussed in Attanasio [1999]. Although it is not explicitly modeled, I add average weekly hours of head, $L_{i,t}$, as an explanatory variable. In my preferred specification, I avoid using hours as a regressor due to correlation with extra omitted terms in healthcare expenditure equation. However, the results are similar in this specification and presented in Table (4) and Figure (5).

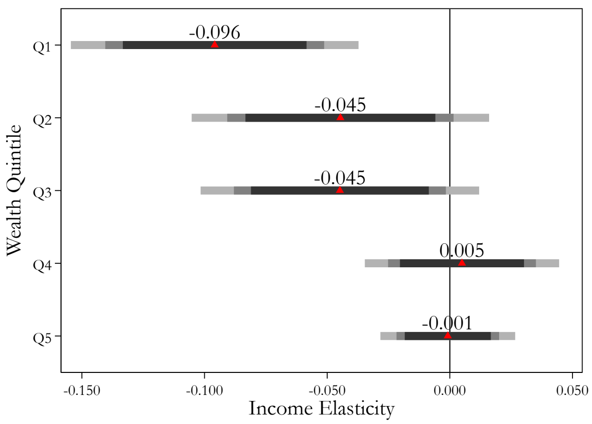
Table 4 Instrumental Variable Estimation of Consumption Growth

	Food Consumption		Healthcare Expenditures		Total Consumption	
	Low Wealth (1)	High Wealth (2)	Low Wealth (3)	High Wealth (4)	Low Wealth (5)	High Wealth (6)
Ex-post rate	0.144	-0.016	-0.304	-1.932	0.124	-0.596
	(0.130)	(1.018)	(0.430)	(2.758)	(0.161)	(0.991)
Current income	-0.077***	-0.005	-0.076**	0.059*	-0.039***	-0.013*
	(0.013)	(0.007)	(0.033)	(0.031)	(0.01)	(0.007)
Acute index	0.049	0.028	0.022	0.434*	0.067**	-0.013
	(0.04)	(0.017)	(0.20)	(0.24)	(0.027)	(0.016)
Chronic index	0.009	0.009	0.046	0.143	0.005	-0.0006
	(0.0143)	(0.009)	(0.104)	(0.088)	(0.011)	(0.009)
Δ Acute index	0.061*	0.045***	-0.049	-0.016	0.062***	0.007
	(0.034)	(0.016)	(0.077)	(0.044)	(0.023)	(0.014)
Δ Chronic index	0.011	0.016**	0.043	0.044**	0.014*	0.005
	(0.011)	(0.008)	(0.027)	(0.02)	(0.008)	(0.007)
Hospitalization	-0.0035	0.03	-0.226	-0.316*	-0.005	0.019
	(0.03)	(0.018)	(0.238)	(0.187)	(0.021)	(0.017)
Δ Hospitalization	-0.016	0.001	0.100**	0.152***	0.006	0.031**
	(0.021)	(0.014)	(0.051)	(0.04)	(0.015)	(0.013)
Household Size	-0.054***	-0.053***	-0.009	-0.025	-0.058***	-0.013*
	(0.009)	(0.008)	(0.027)	(0.026)	(0.008)	(0.007)
Education	0.0193**	-0.012	0.003	0.022	0.002	-0.002
	(0.01)	(0.009)	(0.031)	(0.036)	(0.007)	(0.009)
Hours	-0.0001	-0.002***	0.002	0.002	0.0003	-0.0004
	(0.0008)	(0.0005)	(0.0019)	(0.0016)	(0.0006)	(0.0005)
Constant	0.579	0.386	3.271	-0.896	0.776	1.269
	(1.168)	(1.033)	(3.137)	(4.154)	(0.860)	(1.117)
Age polynomial	✓	✓	✓	✓	✓	✓
Household FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
N	12449	14726	12449	14726	12449	14726
R^2	0.011	0.005	0.008	0.002	0.033	0.009
Within R^2	0.023	0.014	0.021	0.010	0.043	0.022

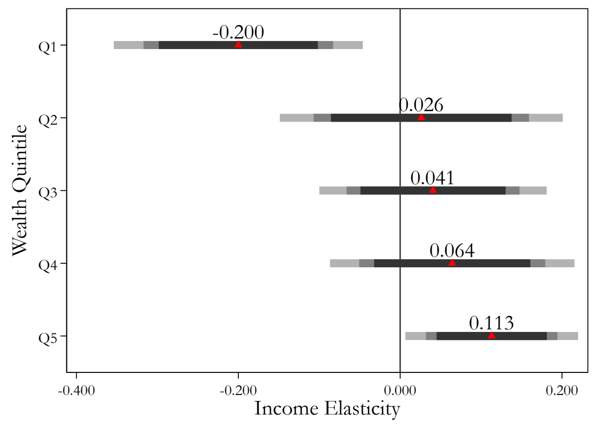
Notes: Robust standard errors clustered at household level in parentheses. The instrumental variable regressions include household specific rate of return, taste shifters as well as time and individual fixed effects. Instrument set consists of time t-1 values of the variables which are head and spouse marginal tax rates, log disposable income and average hours per week of head. A total of 22 instruments is used.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

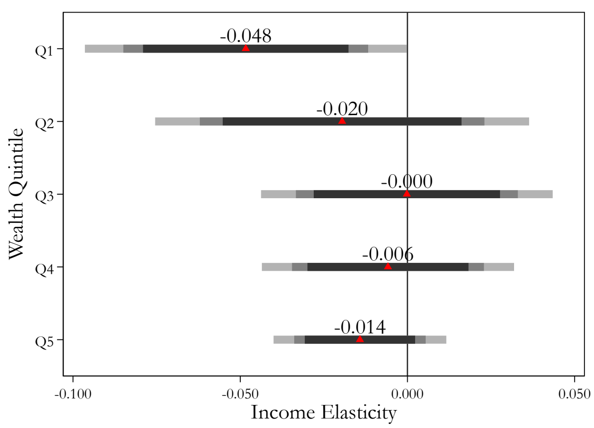
Figure 5 Income elasticity of expenditure growth



[a] Food Consumption



[b] Healthcare Expenditures



[c] Total Consumption

Notes: The figure plots coefficients from regressing growth of food consumption in panel a, growth of healthcare spending in panel b and growth of total consumption in panel c on disposable income for each wealth quintiles Q1-Q5 with the upmost coefficient belonging to the first quintile. The confidence intervals are also plotted at 99%, 95%, 90% confidence levels with fading colors respectively. The IV regressions include household specific rate of return, taste shifters as well as time and individual fixed effects. Instrument set consists of time t-1 values of the variables which are head and spouse marginal tax rates, log disposable income and average hours per week of head. Robust standard errors are clustered at household level.

6 Conclusion

This paper investigates the differential effect of binding liquidity constraint on healthcare expenditures compared to other consumption categories. I start by showing theoretical implications of the health capital model for the healthcare expenditures and compare it with nondurable consumption goods. In particular, I incorporate health capital in the instantaneous felicity function which has a recursive accumulation with investment in the health stock à la Grossman [1972]. I incorporate potentially binding liquidity constraints in the Euler equations and show the dynamics for healthcare expenditure. It is well known that the Euler equation for nondurable consumption deviates from optimal level by the binding liquidity constraints in the current period. I show that the optimal healthcare expenditure deviates from unconstrained case by two additive terms, one is the liquidity constraint in the current period similar to nondurable consumption Euler equation, and the other is the expectations about one period ahead constraints discounted by time preference and health depreciation rate unlike the nondurable case.

Then, I carry the theoretical findings into the data using the Panel Study of Income Dynamics from 1999 to 2015. I extend the liquidity constraint test by Zeldes [1989] and Runkle [1991] for the health capital model by incorporating the expectations about one period ahead binding constraints. In the standard test for nondurable consumption growth, the unobserved binding liquidity constraints lead to an omitted variable bias for an extra regressor such as current income. In the extended test for healthcare expenditure growth, there are two terms that might create omitted variable bias that are the binding constraints in the current period and expectations about binding constraints one period ahead. I show that contemporaneous binding constraints induce a negative bias on the income variable which is predicted to have no impact by PIH, whereas expectation about one period ahead binding constraints would create a positive bias. The resulting bias depends on the strength of these two opposing effects.

I apply the test separately for food consumption and healthcare spending for each wealth group. According to the test, the 1$^{\text{st}}$, 2$^{\text{nd}}$, and 3$^{\text{rd}}$ quintiles have a negative and significant bias and 4$^{\text{th}}$ and 5$^{\text{th}}$ quintiles have an insignificant coefficient for food consumption which is the most commonly used nondurable consumption in the literature. For healthcare expenditure, the lowest quintile has a negative significant bias which means that the current binding constraints are severe for this group and dominates any other effect by expected binding constraints. The higher quintiles have a positive coefficient, significant for 5^{th}, which means that the expectations about one period ahead binding constraints dominate any effect of current binding constraints.

My analysis shows a differential impact of liquidity constraints on healthcare expenditures. The results raise questions regarding public policy. The healthcare policy interventions should be taken differently from food or other types of nondurable consumption policies and incorporate the fact that the one period ahead expectations also play an important role for the healthcare spending behaviors.

A promising avenue for research is to analyze the empirical results in alternative economic environments with a calibrated model which I am currently pursuing.

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8 Appendices

A Proofs

A.1 Derivation of Euler Equations

This appendix contains derivation of Euler Equations with liquidity constraints, (7) and (8) as well as (19) and (20) and linearized equation (22).

Rewriting the recursive formulation of the problem, we have:

$$V_t(A_{i,t}, H_{i,t-1}) = \max_{C_{i,t}, H_{i,t}, A_{i,t+1}} \{u(C_{i,t}, H_{i,t}) + \beta \mathbb{E}_t V_{t+1}(A_{i,t+1}, H_{i,t})\} \tag{A.34}$$

subject to:

$$C_{i,t} + d_{i,t} + A_{i,t+1} = (1 + r_{i,t})(A_{i,t} + Y_{i,t}) \qquad \text{(budget constraint)} \tag{A.35}$$

$$H_{i,t} = (1 - \delta^h) H_{i,t-1} + d_{i,t} \qquad \text{(health capital accumulation)} \tag{A.36}$$

$$C_{i,t} \geq 0, \;\; d_{i,t} \geq 0 \qquad \text{(non-negativity constraints)} \tag{A.37}$$

$$A_{i,t+1} \geq \underline{A} \qquad \text{(liquidity constraint)} \tag{A.38}$$

$$A_{i,0}, H_{i,0} \text{ is given}$$

Substitute (A.36) into the value function:

$$V_t(A_{i,t}, H_{i,t-1}) = \max_{C_{i,t}, d_{i,t}, A_{i,t+1}} \{u(C_{i,t}, (1 - \delta^h) H_{i,t-1} + d_{i,t}) + \beta \mathbb{E}_t V_{t+1}(A_{i,t+1}, (1 - \delta^h) H_{i,t-1} + d_{i,t})\} \tag{A.39}$$

Maximize (A.39) subject to (A.35), (A.37), (A.38) and let $\lambda_{i,t}$ is Kuhn-Tucker multipler on budget constraint, $\mu_{i,t}$ is the Lagrange multiplier on liquidity constraint and $\eta_{1i,t}$ and $\eta_{2i,t}$ are Lagrange multipliers on non-negativity constraints. Moreover, denote the partial derivatives of value function with respect to state variables as $V_A^{i,t+1} = \partial V_{t+1}(A_{i,t+1}, H_{i,t})/\partial A_{i,t+1}$ and $V_H^{i,t+1} = \partial V_{t+1}(A_{i,t+1}, H_{i,t})/\partial H_{i,t}$ in order to simplify notation. The first order necessary conditions with respect to $C_{i,t}$, $d_{i,t}$ and $A_{i,t+1}$ and the Envelope conditions for state variables $A_{i,t}$ and $H_{i,t-1}$ are derived as:

F.O.C.s:

$$u_C^{i,t} - \lambda_{i,t} + \eta_{1i,t} = 0 \tag{A.40}$$

$$u_H^{i,t} + \beta \mathbb{E}_t V_H^{i,t+1} - \lambda_{i,t} + \eta_{2i,t} = 0 \tag{A.41}$$

$$\beta \mathbb{E}_t V_A^{i,t+1} - \lambda_{i,t} + \mu_{i,t} = 0 \tag{A.42}$$

Envelope Conditions:

$$V_A^{i,t} = (1 + r_{i,t})\lambda_{i,t} \tag{A.43}$$

$$V_H^{i,t} = (1 - \delta^h)\beta \mathbb{E}_t V_H^{i,t+1} + (1 - \delta^h)u_H^{i,t} = (1 - \delta^h)\{u_H^{i,t} + \beta \mathbb{E}_t V_H^{i,t+1}\} \tag{A.44}$$

The complementary slackness condition from a constrained optimization problem implies that when constraints are slack, Kuhn-Tucker multiplier on the constraint must be zero.

I assume for now that the nonnegativity constraints do not bind ($\eta_{1i,t} = 0, \eta_{2i,t} = 0$) which holds for the most common instantaneous utility functions assumed in the literature (This is also verified by the data in hand).

Proposition 1. *The intertemporal condition for nondurable consumption takes the form:*

$$u_C^{i,t} = \beta \mathbb{E}_t[(1 + r_{i,t+1})u_C^{i,t+1}] + \mu_{i,t}. \tag{7}$$

Proof. Combine (A.42) and (A.43):

$$V_A^{i,t} = (1 + r_{i,t})\{\beta \mathbb{E}_t V_A^{i,t+1} + \mu_{i,t}\}. \tag{$A.43'$}$$

Combine (A.40) and (A.42):

$$u_C^{i,t} = \beta \mathbb{E}_t V_A^{i,t+1} + \mu_{i,t} = \frac{V_A^{i,t}}{(1 + r_{i,t})}. \tag{A.45}$$

Iterate (A.43) and take expectations of both sides:

$$\mathbb{E}_t V_A^{i,t+1} = \mathbb{E}_t[(1 + r_{i,t+1})\lambda_{i,t+1}] \tag{A.46}$$

Then, plugging (A.46) into (A.45) and using (A.40) gives us the Euler equation for consumption good (7) :

$$u_C^{i,t} = \beta \mathbb{E}_t[(1 + r_{i,t+1})u_C^{i,t+1}] + \mu_{i,t}. \tag{7}$$

□

Assumption 1. *Nonnegativity constraint for healthcare expenditure does not bind, i.e.* $\eta_{2i,t} = 0,\ \forall i,\ \forall t.$

Assumption 2. *Households hold constant expectation about future rate of return,* $\mathbb{E}_t[r_{i,t+1}] = \mathbb{E}_{t+1}[r_{i,t+2}]$.

Proposition 2. *Under Assumptions 1 - 2, the intertemporal condition for health capital takes the following form:*

$$u_H^{i,t} = \beta \mathbb{E}_t[(1 + r_{i,t+1})u_H^{i,t+1}] - \beta(1 - \delta^h)\frac{\mathbb{E}_t[(1 + r_{i,t+1})\mu_{i,t+1}]}{\mathbb{E}_t[1 + r_{i,t+1}]} + \mu_{i,t}. \tag{8}$$

Proof. In order to derive Euler equation for health capital, combine (A.41) and (A.44):

$$
\begin{aligned}
V_H^{i,t} &= (1-\delta^h)(u_H^{i,t} + \beta \mathbb{E}_t V_H^{i,t+1}) = (1-\delta^h)\lambda_{i,t} \\
\lambda_{i,t} &= \frac{V_H^{i,t}}{1-\delta^h} \quad \text{(A.47)} \\
\lambda_{i,t+1} &= \frac{V_H^{i,t+1}}{1-\delta^h} \quad \text{(A.47')}
\end{aligned}
$$

Insert (A.42) into (A.46):

$$
\lambda_{i,t} = \beta \mathbb{E}_t[(1+r_{i,t+1})\lambda_{i,t+1}] + \mu_{i,t} \tag{A.48}
$$

Insert (A.47) and (A.47′) into (A.48):

$$
\begin{aligned}
V_H^{i,t} &= \beta \mathbb{E}_t[(1+r_{i,t+1})V_H^{i,t+1}] + (1-\delta^h)\mu_{i,t} \quad \text{(A.49)} \\
V_H^{i,t} &= \mathbb{E}_t[(1+r_{i,t+1})]\beta \mathbb{E}_t[V_H^{i,t+1}] + (1-\delta^h)\mu_{i,t} \\
\Rightarrow \ \beta \mathbb{E}_t[V_H^{i,t+1}] &= \frac{V_H^{i,t} - (1-\delta^h)\mu_{i,t}}{\mathbb{E}_t[1+r_{i,t+1}]} \quad \text{(A.50)}
\end{aligned}
$$

Note that in deriving (A.50), the fact that $r_{i,t+1}$ and $V_H^{i,t+1}$ are independent conditional on information set at t, $\mathcal{F}_{i,t}$, is used. This is because $H_{i,t}$ is chosen at time t hence is depending on $r_{i,t}$ (not on $r_{i,t+1}$) which is in $\mathcal{F}_{i,t}$. $H_{i,t}$ is the state variable in $V_{t+1}(A_{i,t+1}, H_{i,t})$ and the partial is $V_H^{i,t+1} = \partial V_{t+1}(A_{i,t+1}, H_{i,t})/\partial H_{i,t}$.

Insert (A.47) and (A.50) into (A.41):

$$
\begin{aligned}
u_H^{i,t} + \beta \mathbb{E}_t V_H^{i,t+1} &= \frac{V_H^{i,t}}{1-\delta^h} \\
u_H^{i,t} &= \frac{V_H^t}{1-\delta^h} - \frac{V_H^{i,t} - (1-\delta^h)\mu_{i,t}}{\mathbb{E}_t[1+r_{i,t+1}]} = \frac{V_H^{i,t}(\delta + \mathbb{E}_t[r_{i,t+1}]) + (1-\delta^h)^2 \mu_{i,t}}{(1-\delta^h)\mathbb{E}_t[1+r_{i,t+1}]} \\
\Rightarrow V_H^{i,t} &= \frac{(1-\delta^h)\mathbb{E}_t[1+r_{i,t+1}]}{\delta^h + \mathbb{E}_t[r_{i,t+1}]} u_H^{i,t} - \frac{(1-\delta^h)^2 \mu_{i,t}}{\delta^h + \mathbb{E}_t[r_{i,t+1}]}
\end{aligned} \tag{A.51}
$$

Now plug (A.51) and one period iteration of (A.51) into (A.49):

$$
\begin{aligned}
&\frac{(1-\delta^h)\mathbb{E}_t[1+r_{i,t+1}]}{\delta^h + \mathbb{E}_t[r_{i,t+1}]} u_H^{i,t} - \frac{(1-\delta^h)^2 \mu_{i,t}}{\delta^h + \mathbb{E}_t[r_{i,t+1}]} \\
&= \beta \mathbb{E}_t \left[(1+r_{i,t+1}) \left(\frac{(1-\delta^h)\mathbb{E}_{t+1}[1+r_{i,t+2}]}{\delta^h + \mathbb{E}_{t+1}[r_{i,t+2}]} u_H^{i,t+1} - \frac{(1-\delta^h)^2 \mu_{i,t+1}}{\delta^h + \mathbb{E}_{t+1}[r_{i,t+2}]} \right) \right] + (1-\delta^h)\mu_{i,t}
\end{aligned} \tag{A.52}
$$

I assume that the households have constant subjective expectations about future interest rate, i.e., $\mathbb{E}_t[r_{i,t+1}] = \mathbb{E}_{t+1}[r_{i,t+2}]$. This is a similar assumption to the one in Hayashi [1985]. He assumes that household j have static and point expectations about future rates at t such that $r_{j,t+1} = r_{j,t+2}$. Note that by the Tower rule, $\mathbb{E}_t[\mathbb{E}_{t+1}[r_{i,t+2}]] = \mathbb{E}_t[r_{i,t+2}]$ since the information set is a filtration such that $\mathcal{F}_{i,t} \subseteq \mathcal{F}_{i,t+1}$. Then, the assumption reduces to $\mathbb{E}_t[r_{i,t+1}] = \mathbb{E}_t[r_{i,t+2}]$, i.e. $\mathbb{E}_t[\Delta r_{i,t+2}] = 0$. This is a milder assumption than assuming rate of return has a martingale property which would be the case if $\mathbb{E}_t[r_{i,t+1}] = r_{i,t}$ also holds.

$$
\begin{aligned}
&\frac{(1-\delta^h)\mathbb{E}_t[1+r_{i,t+1}]}{\delta^h + \mathbb{E}_t[r_{i,t+1}]} u_H^{i,t} - \frac{(1-\delta^h)^2 \mu_{i,t}}{\delta^h + \mathbb{E}_t[r_{i,t+1}]} \\
&= \beta \mathbb{E}_t \left[(1+r_{i,t+1}) \left(\frac{(1-\delta^h)\mathbb{E}_t[1+r_{i,t+1}]}{\delta^h + \mathbb{E}_t[r_{i,t+1}]} u_H^{i,t+1} - \frac{(1-\delta^h)^2 \mu_{i,t+1}}{\delta^h + \mathbb{E}_t[r_{i,t+1}]} \right) \right] + (1-\delta^h)\mu_{i,t} \\
&= \frac{\beta \mathbb{E}_t[1+r_{i,t+1}](1-\delta^h)\mathbb{E}_t[(1+r_{i,t+1})u_H^{i,t+1}]}{\delta^h + \mathbb{E}_t[r_{i,t+1}]} - \frac{\beta(1-\delta^h)^2 \mathbb{E}_t[(1+r_{i,t+1})\mu_{i,t+1}]}{\delta^h + \mathbb{E}_t[r_{i,t+1}]} + (1-\delta^h)\mu_{i,t}
\end{aligned}
$$

Simplifying and reorganizing give the Euler equation for health stock in (8):

$$\begin{aligned}
&\mathbb{E}_t[1 + r_{i,t+1}]u_H^{i,t} - (1 - \delta^h)\mu_{i,t} \\
&= \beta\mathbb{E}_t[1 + r_{i,t+1}]\mathbb{E}_t[(1 + r_{i,t+1})u_H^{i,t+1}] - \beta(1 - \delta^h)\mathbb{E}_t[(1 + r_{i,t+1})\mu_{i,t+1}] + (\delta^h + \mathbb{E}_t[r_{i,t+1}])\mu_{i,t}
\end{aligned}$$

$$u_H^{i,t} = \beta\mathbb{E}_t[(1 + r_{i,t+1})u_H^{i,t+1}] - \beta(1 - \delta^h)\frac{\mathbb{E}_t[(1 + r_{i,t+1})\mu_{i,t+1}]}{\mathbb{E}_t[1 + r_{i,t+1}]} + \mu_{i,t}. \tag{8}$$

□

In order to derive Euler equations in terms of consumption levels, a preference structure must be determined. I assume CRRA form for instantaneous utility function with additively separable nondurable consumption and health capital as in (18).

Assumption 3. *The felicity function takes additively separable form over non-durable consumption and the service flow from the health stock as well as over time. The consumption good and service flow from health stock take CRRA form.* [22]

$$u(C_{i,t}, H_{i,t}; \Theta_{i,t}) = \left(\frac{C_{i,t}^{1-\phi}}{1-\phi} + \frac{H_{i,t}^{1-\xi}}{1-\xi}\right) exp(\Theta_{i,t}) \tag{18}$$

where $\Theta_{i,t}$ is the household specific taste shifter. The coefficients of relative risk aversion for nondurable consumption and health capital , ϕ and ξ, are assumed equal across households.

The derivation with alternative utility functions will be similar. However, when health is non-separable, the consumption of other goods will enter the regression equations as extra regressor. I assume away complementarities between leisure, consumption and health in order to show the impact of liquidity constraints alone.

[22] I ignore the utility weight on health capital for now since it does not play any role in empirical analysis when it is a constant.

Then, the Euler equations in (19) and (20) are written in terms of non-health consumption and health stock.

Proposition 4. *Under Assumptions 1-3 and the results in Propositions 1-2, the Euler equations for non-durable consumption and health capital take the forms:*

$$C_{i,t} = C_{i,t+1}\left(\frac{1+e'_{i,t+1}}{\beta(1+r_{i,t+1})(1+\mu'_{i,t})exp(\Delta\Theta_{i,t+1})}\right)^{1/\phi} \tag{19}$$

$$H_{i,t} = H_{i,t+1}\left(\frac{1+e''_{i,t+1}}{\beta(1+r_{i,t+1})(1+\mu''_{i,t}-\mu'''_{i,t+1})exp(\Delta\Theta_{i,t+1})}\right)^{1/\xi}. \tag{20}$$

Proof. Insert $u_C^{i,t}$ into 7 and $u_H^{i,t}$ into 8 using Assumption 3. □

Since there is no data about health stock, the Equler equation (20) cannot be used for empirical analysis. An Euler equation for healthcare expenditures must be derived.

Proposition 5. *Taking natural logs of the results in Proposition 4, (19) and (20), and rearranging, the specifications for log-linear Euler equation estimations become:*

$$\Delta \ln C_{i,t+1} = \frac{1}{\phi}\{\ln(1+\mu'_{i,t}) + \ln\beta_i + \ln(1+r_{i,t+1}) - \ln(1+e'_{i,t+1}) + \Delta\Theta_{i,t+1}\} \tag{21}$$

$$\begin{aligned}\Delta \ln d_{i,t+1} =& \frac{\hat{m}}{\xi}\{\ln(1+\mu''_{i,t}-\mu'''_{i,t+1}) + \ln\beta_i + \ln(1+r_{i,t+1}) - \ln(1+e''_{i,t+1}) + \Delta\Theta_{i,t+1}\}\\ &- \frac{\hat{m}-1}{\xi}\{\ln(1+\mu''_{i,t-1}-\mu'''_{i,t}) + \ln\beta_i + \ln(1+r_{i,t}) - \ln(1+e''_{i,t}) + \Delta\Theta_{i,t}\}\end{aligned} \tag{22}$$

where $\Delta \ln C_{i,t+1} = \ln C_{i,t+1} - \ln C_{i,t}$ is the growth of non-health consumption, and $\Delta \ln d_{i,t+1} = \ln d_{i,t+1} - \ln d_{i,t}$ is the growth of health-care expenditures. $\hat{m}$ is a constant given as $\hat{m} = \frac{\overline{m}^{1/\xi}}{\overline{m}^{1/\xi}-(1-\delta^h)}$, where $\overline{m}$ is a fixed number such that Taylor expansion of the term in parentheses in (20) is taken around it to linearize the Euler relation for the health capital.

Proof. Let's call the term inside parenthesis in (20) as $1/m_{t+1}$ for expositional purposes.[23] Thus, the equilibrium condition (20) is written as:

$$H_{i,t+1} = H_{i,t} m_{t+1}^{1/\xi} \tag{A.53}$$

Then, using the law of motion for health stock, we can write the Euler equation in terms of health-care expenditures d_t.

$$\begin{aligned}
H_{i,t+1} &= (1-\delta^h)H_{i,t} + d_{i,t+1} = H_{i,t} m_{t+1}^{1/\xi} \\
d_{i,t+1} &= H_{i,t}[m_{t+1}^{1/\xi} - (1-\delta^h)] \\
&= H_{i,t-1} m_t^{1/\xi}[m_{t+1}^{1/\xi} - (1-\delta^h)] \\
&= \frac{d_{i,t}}{m_t^{1/\xi} - (1-\delta^h)} m_t^{1/\xi}[m_{t+1}^{1/\xi} - (1-\delta^h)]
\end{aligned}$$

taking logs;

$$\ln d_{i,t+1} = \ln d_{i,t} + \frac{1}{\xi}\ln m_t + \ln(m_{t+1}^{1/\xi} - (1-\delta^h)) - \ln(m_t^{1/\xi} - (1-\delta^h)) \tag{A.54}$$

taking 1st order Taylor approximation of $\ln(m_{t+1}^{1/\xi} - (1-\delta^h))$ and $\ln(m_t^{1/\xi} - (1-\delta^h))$ around a fixed $\overline{m}$ gives [24];

$$\begin{aligned}
\ln(m_{t+1}^{1/\xi} - (1-\delta^h)) &\approx \ln(\overline{m}^{1/\xi} - (1-\delta^h)) + \frac{1}{\xi}\frac{\overline{m}^{1/\xi-1}}{\overline{m}^{1/\xi} - (1-\delta^h)}(m_{t+1} - \overline{m}) \\
&= \ln(\overline{m}^{1/\xi} - (1-\delta^h)) + \frac{1}{\xi}\frac{\overline{m}^{1/\xi}}{\overline{m}^{1/\xi} - (1-\delta^h)}\left(\frac{m_{t+1} - \overline{m}}{\overline{m}}\right)
\end{aligned}$$

[23] I am ignoring i subscript in m_{t+1} for brevity as it does not play any role.
[24] $\overline{m}$ can be interpreted as the steady state value of m_t.

$$
\begin{aligned}
\ln(m_t^{1/\xi} - (1-\delta^h)) &\approx \ln(\overline{m}^{1/\xi} - (1-\delta^h)) + \frac{1}{\xi}\frac{\overline{m}^{1/\xi-1}}{\overline{m}^{1/\xi} - (1-\delta^h)}(m_t - \overline{m}) \\
&= \ln(\overline{m}^{1/\xi} - (1-\delta^h)) + \frac{1}{\xi}\frac{\overline{m}^{1/\xi}}{\overline{m}^{1/\xi} - (1-\delta^h)}\left(\frac{m_t - \overline{m}}{\overline{m}}\right)
\end{aligned}
$$

Further approximating $\left(\frac{m_{t+1}-\overline{m}}{\overline{m}}\right) - \left(\frac{m_t-\overline{m}}{\overline{m}}\right) = \frac{1}{\overline{m}}\Delta m_{t+1} \approx \Delta \ln m_{t+1}$ and inserting into (A.54),

$$
\begin{aligned}
\Delta \ln d_{i,t+1} &\approx \frac{1}{\xi}\ln m_t + \frac{1}{\xi}\frac{\overline{m}^{1/\xi}}{\overline{m}^{1/\xi} - (1-\delta^h)}\left(\frac{m_{t+1} - \overline{m}}{\overline{m}}\right) - \frac{1}{\xi}\frac{\overline{m}^{1/\xi}}{\overline{m}^{1/\xi} - (1-\delta^h)}\left(\frac{m_t - \overline{m}}{\overline{m}}\right) \\
&\approx \frac{1}{\xi}\ln m_t + \frac{1}{\xi}\frac{\overline{m}^{1/\xi}}{\overline{m}^{1/\xi} - (1-\delta^h)}\Delta \ln m_{t+1} \\
&= \frac{1}{\xi}\frac{\overline{m}^{1/\xi}}{\overline{m}^{1/\xi} - (1-\delta^h)}\ln m_{t+1} + \frac{1}{\xi}\left(1 - \frac{\overline{m}^{1/\xi}}{\overline{m}^{1/\xi} - (1-\delta^h)}\right)\ln m_t \\
&= \frac{1}{\xi}\underbrace{\frac{\overline{m}^{1/\xi}}{\overline{m}^{1/\xi} - (1-\delta^h)}}_{\hat{m}}\ln m_{t+1} - \frac{1}{\xi}\underbrace{\frac{1-\delta^h}{\overline{m}^{1/\xi} - (1-\delta^h)}}_{\hat{m}-1}\ln m_t
\end{aligned}
$$

Plugging back m_t and m_{t+1} to get (22);

$$
\begin{aligned}
\Delta \ln d_{i,t+1} =& \frac{\hat{m}}{\xi}\{\ln(1+\mu''_{i,t} - \mu'''_{i,t+1}) + \ln\beta_i + \ln(1+r_{i,t+1}) - \ln(1+e''_{i,t+1}) + \Delta\Theta_{i,t+1}\} \\
&- \frac{\hat{m}-1}{\xi}\{\ln(1+\mu''_{i,t-1} - \mu'''_{i,t}) + \ln\beta_i + \ln(1+r_{i,t}) - \ln(1+e''_{i,t}) + \Delta\Theta_{i,t}\}
\end{aligned}
$$

Rearranging;

$$
\begin{aligned}
\Delta \ln d_{i,t+1} = & \underbrace{\frac{1}{\xi}\{\gamma_1 + \frac{1}{2}\sigma_e^2\}}_{\alpha_0^d} + \underbrace{\frac{1}{\xi}\ln \beta_i}_{\alpha_{1i}^d} + \underbrace{\frac{\hat{m}}{\xi}(\chi_{t+1} - \chi_t) + \frac{1-\hat{m}}{\xi}(\chi_t - \chi_{t-1})}_{\alpha_{2t}^d} \\
& + \underbrace{\frac{\hat{m}}{\xi}}_{\alpha_3^d} \ln(1 + r_{i,t+1}) + \underbrace{\frac{1-\hat{m}}{\xi}}_{\alpha_4^d} \ln(1 + r_{i,t}) + \frac{\hat{m}}{\xi} X'_{i,t+1}\tilde{\Gamma}_1 + \frac{1-\hat{m}}{\xi} X'_{i,t}\tilde{\Gamma}_2 \\
& + \underbrace{\frac{\hat{m}}{\xi}\{(\nu_{i,t+1} - \nu_{i,t}) - \ln(1 + e''_{i,t+1}) - \frac{1}{2}\sigma_e^2\} + \frac{1-\hat{m}}{\xi}\{(\nu_{i,t} - \nu_{i,t-1}) - \ln(1 + e''_{i,t}) - \frac{1}{2}\sigma_e^2\}}_{\epsilon_{it+1}^d} \\
& + \frac{\hat{m}}{\xi}\ln(1 + \mu''_{i,t} - \mu'''_{i,t+1}) - \frac{\hat{m}-1}{\xi}\ln(1 + \mu''_{i,t-1} - \mu'''_{i,t})
\end{aligned}
$$

□

Since the Kuhn-Tucker multipliers are not observed,they enter the error term. These are combined with the innovation and the terms in expectation error as $u_{it+1}^d = \epsilon_{it+1}^d + \hat{m}/\xi \ln(1 + \mu''_{i,t} - \mu'''_{i,t+1}) - (\hat{m} - 1)/\xi \ln(1 + \mu''_{i,t-1} - \mu'''_{i,t})$. Also, taking first order Taylor expansion for after-tax return and relabeling $\hat{m}/\xi\ \tilde{\Gamma}_1 \equiv \Gamma_1^d$ and $(1 - \hat{m})/\xi\ \tilde{\Gamma}_2 \equiv \Gamma_2^d$ gives equation (28):

$$
\Delta \ln d_{i,t+1} = \alpha_0^d + \alpha_{1i}^d + \alpha_{2t}^d + \alpha_3^d r_{i,t+1} + \alpha_4^d r_{i,t} + X'_{i,t+1}\Gamma_1^d + X'_{i,t}\Gamma_2^d + u_{it+1}^d \tag{28}
$$

The error term includes $\mu_{i,t-1}$, $\mu_{i,t}$, and$\mu_{i,t+1}$. For the current binding constraint, the term $\mu_{i,t}$ enters twice into u_{it+1}^d, however note that its loading factor would be $2\hat{m}/\xi$, a positive number, if it were a linear function. For the lag binding constraint $\mu_{i,t-1}$, the loading factor is negative since $\hat{m} > 1$. I control for the lag binding constraint by adding lag income as an additional regressor.

A.2 Derivation of Marginal Rate of Substitution

This appendix contains derivation of marginal rate of substitution between health capital and non-durable consumption (9) and spending ratio (10) .

Assume $u(C_{i,t}, H_{i,t}) = \ln C_{i,t} + \ln H_{i,t}$ and r is constant. Then, the MRS for the unconstrained case (9) with the assumed preferences gives the ratio of health spending to nondurable consumption as:

Proposition 3. *Under Assumption 1 and assuming r is held constant, the marginal rate of substitution (MRS) between health capital and non-durable consumption goods for household i at time t is:*

$$MRS_{H,C}^{i,t} = \frac{u_H^{i,t}}{u_C^{i,t}} = \frac{\delta^h + r}{1+r} + \frac{(1-\delta^h)\mu_{i,t}}{V_A^{i,t}}. \tag{9}$$

Proof. From F.O.C.s plug (A.42) into (A.41):

$$u_H^{i,t} = \beta \mathbb{E}_t V_A^{i,t+1} - \beta \mathbb{E}_t V_H^{i,t+1} + \mu_{i,t} - \eta_{2i,t}. \tag{A.55}$$

Premultiply by $(1-\delta^h)$ and rearrange:

$$(1-\delta^h)(u_H^{i,t} + \beta \mathbb{E}_t V_H^{i,t+1}) = (1-\delta^h)(\beta \mathbb{E}_t V_A^{i,t+1} + \mu_{i,t} - \eta_{2i,t}). \tag{A.56}$$

Plug (A.44) and (A.45) into (A.56):

$$V_H^{i,t} = (1-\delta^h)\frac{V_A^{i,t}}{1+r_{i,t}} - (1-\delta^h)\eta_{2i,t}. \tag{A.57}$$

Assume $r_{i,t}$ is constant at the rate r, and iterate (A.57) by one period:

$$\mathbb{E}_t V_H^{i,t+1} = (1-\delta^h)\frac{\mathbb{E}_t[V_A^{i,t+1}]}{1+r} - (1-\delta^h)\mathbb{E}_t[\eta_{2i,t+1}]. \tag{A.58}$$

Insert (A.58) into (A.55):

$$u_H^{i,t} = \beta\mathbb{E}_t V_A^{i,t+1} + \mu_{i,t} - \eta_{2i,t} - \beta(1-\delta^h)\frac{\mathbb{E}_t[V_A^{i,t+1}]}{1+r} + \beta(1-\delta^h)\mathbb{E}_t[\eta_{2i,t+1}]. \tag{A.59}$$

Simplifying and using (A.43′) gives:

$$u_H^{i,t} = \frac{\delta^h + r}{1+r}\frac{V_A^{i,t}}{1+r} + \frac{1-\delta^h}{1+r}\mu_{i,t} - \eta_{2i,t} - \beta(1-\delta^h)\mathbb{E}_t[\eta_{2i,t+1}]. \tag{A.60}$$

Then, $MRS_{H,C}^{i,t}$ is the ratio of (A.60) to (A.45):

$$MRS_{H,C}^{i,t} = \frac{u_H^{i,t}}{u_C^{i,t}} = \frac{\delta^h + r}{1+r} + \frac{(1-\delta^h)\mu_{i,t}}{V_A^{i,t}} - \frac{(1+r)\eta_{i,2t}}{V_A^{i,t}} + \frac{\beta(1-\delta^h)(1+r)\mathbb{E}_t[\eta_{2i,t+1}]}{V_A^{i,t}}. \tag{A.61}$$

Assuming interior solution in both periods, $\eta_{2i,t} = 0$ and $\eta_{2i,t+1} = 0$,gives:

$$MRS_{H,C}^{i,t} = \frac{u_H^{i,t}}{u_C^{i,t}} = \frac{\delta^h + r}{1+r} + \frac{(1-\delta^h)\mu_{i,t}}{V_A^{i,t}}. \tag{9}$$

□

Lemma 3.1.

$$\frac{d_{i,t}}{C_{i,t}} = \frac{1+r}{\delta^h + r} + \left[1 - (1-\delta^h)\left(\frac{C_{i,t}}{C_{i,t-1}}\right)^{-1}\right]. \tag{10}$$

Proof. For the ratio equation in (10), the derivation is done assuming preferences are of the form $U(C_{i,t}, H_{i,t}) = \ln C_{i,t} + \ln H_{i,t}$. Also, assume constraint at t is not binding, $\mu_{i,t} = 0$. The MRS in (9) becomes:

$$\frac{H_{i,t}}{C_{i,t}} = \frac{1+r}{\delta^h + r}. \tag{A.62}$$

Then, substituting health capital accumulation gives:

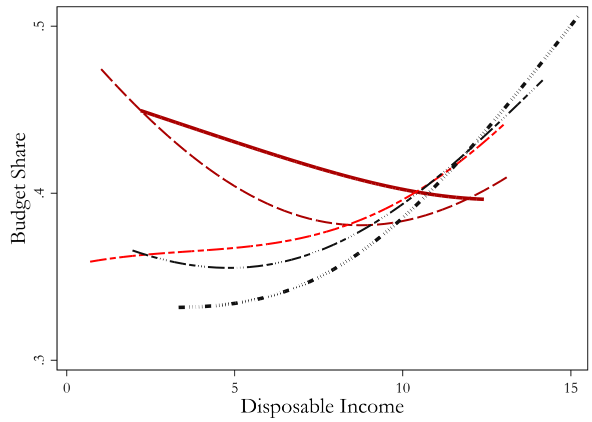
$$\frac{d_{i,t}}{C_{i,t}} = \frac{H_{i,t} - (1-\delta^h)H_{i,t-1}}{C_{i,t}} = \frac{H_{i,t}}{C_{i,t}} - (1-\delta^h)\frac{H_{i,t-1}}{C_{i,t}} = \frac{1+r}{\delta^h + r} - (1-\delta^h)\frac{1+r}{\delta^h + r}\frac{C_{i,t-1}}{C_{i,t}} \tag{A.63}$$

$$\Rightarrow \quad \frac{d_{i,t}}{C_{i,t}} = \frac{1+r}{\delta^h + r} + \left[1 - (1-\delta^h)\left(\frac{C_{i,t}}{C_{i,t-1}}\right)^{-1}\right]. \tag{10}$$

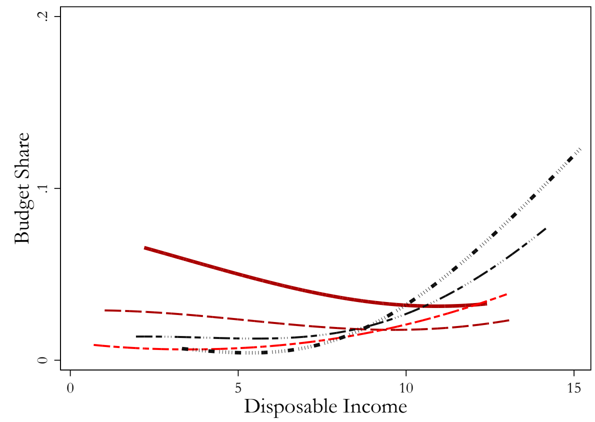
□

B Additional Figures

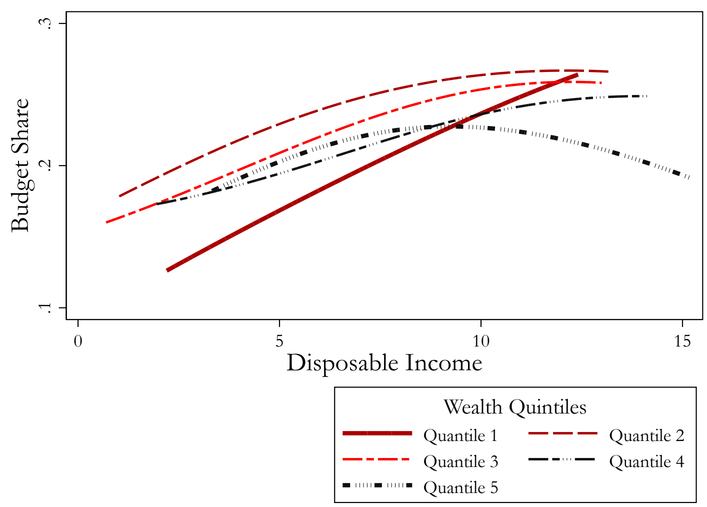
B.1 Engel Curves for housing, education and transportation expenditure shares



[a] Housing Expenditure Share



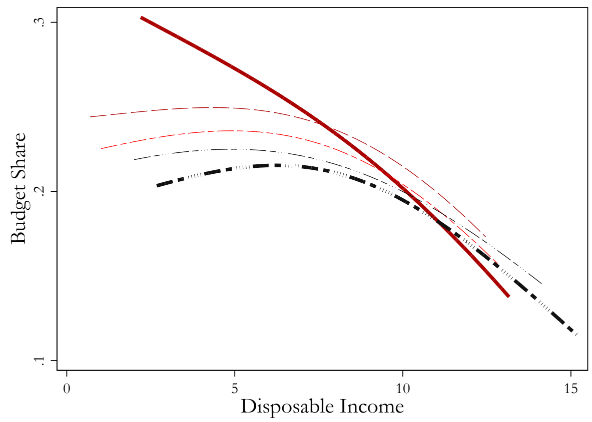
[b] Education Expenditure Share



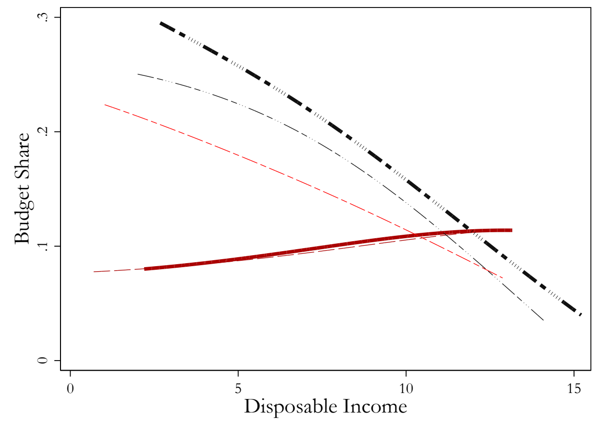
[c] Transportation Expenditure Share

Notes: Engel Curves for Housing end Education and Transportation Expenditures. The curves are expenditure shares log of consumption categories as a function of disposable income, fitted for each wealth quintile. The fits are nonparametric local linear polynomial regressions using Gaussian kernel weights and a bandwidth choice of 4. The data is from 1999-2015 waves of PSID, includes families with heads between 25-65 years old.

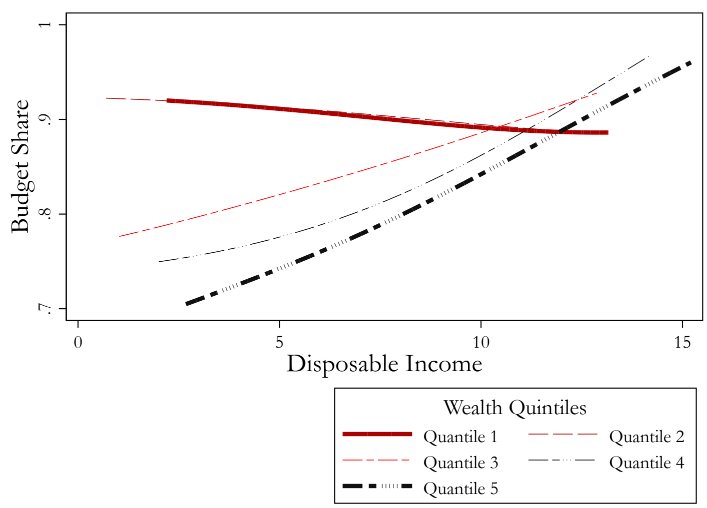
B.2 Engel Curves with alternative sample splitting



[a] Food Consumption Share



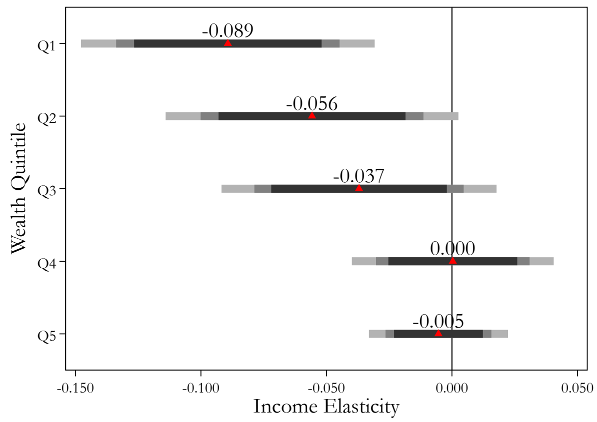
[b] Healthcare Expenditure Share



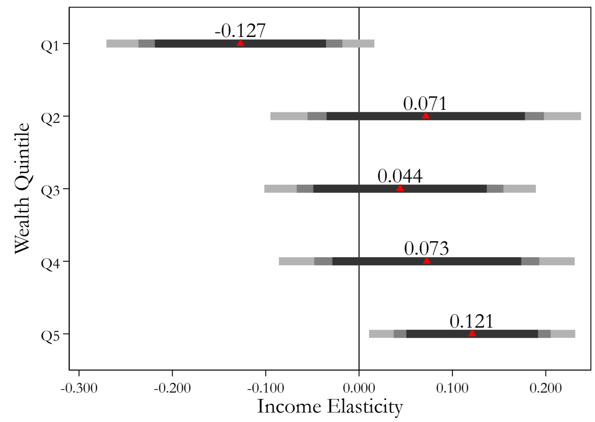
[c] Non-Health Consumption Share

Notes: Engel Curves for Non-Health consumption, Healthcare Expenditure and Food Consumption. The curves are expenditure shares log of consumption categories as a function of disposable income, fitted for each wealth quintile. The fits are nonparametric local linear polynomial regressions using Gaussian kernel weights and a bandwidth choice of 4. The healthcare expenditure is the sum of out-of-pocket health spending and health insurance payments of household. Food consumption includes food at home and food away from home. Non-health consumption includes food, housing, education, childcare, transportation spending of families. The data is from 1999-2015 waves of PSID, includes families with heads between 25-65 years old. The alternative sample split is based on net worth excluding home equity.

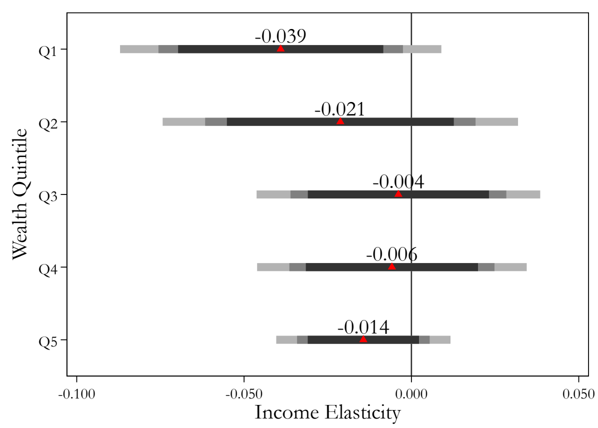
B.3 Euler Equation Estimates with insurance dummies



[a] Food Consumption Growth



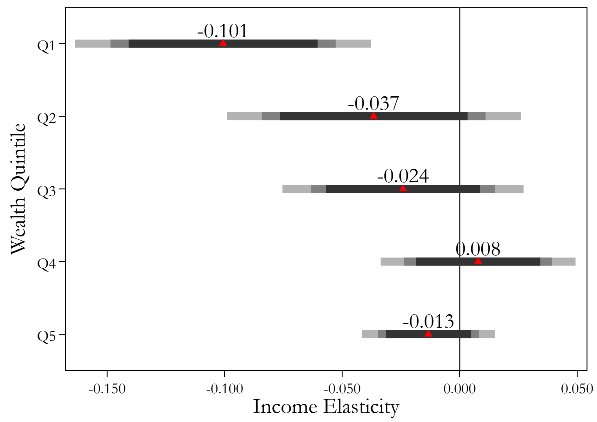
[b] Healthcare Expenditure Growth



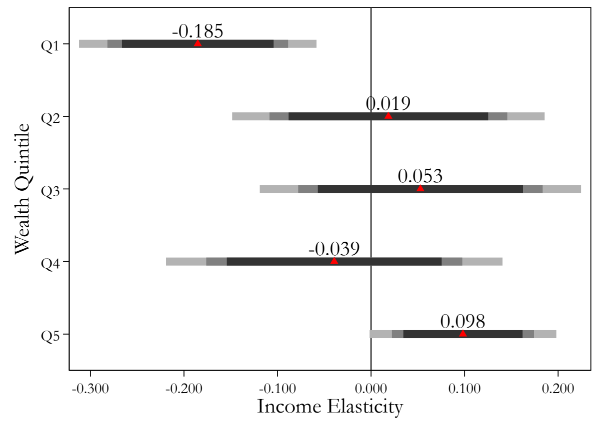
[c] Non-Health Consumption Growth

Notes: The figure plots coefficients from regressing growth of food consumption in panel a, growth of healthcare spending in panel b and growth of total consumption in panel c on disposable income for each wealth quintiles Q1-Q5 with the upmost coefficient belonging to the first quintile. The confidence intervals are also plotted at 99%, 95%, 90% confidence levels with fading colors respectively. The IV regressions include household specific rate of return, taste shifters as well as time and individual fixed effects. Instrument set consists of time t-1 values of the variables which are head and spouse marginal tax rates, log disposable income and average hours per week of head. Robust standard errors are clustered at household level. Insurance types are private, public and uninsured.

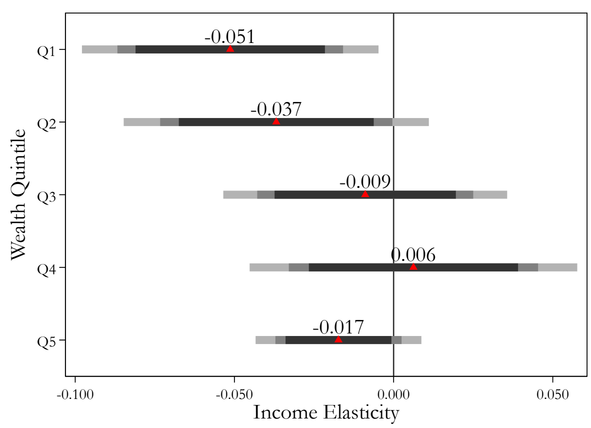
B.4 Euler Equation Estimates with alternative splitting



[a] Food Consumption Growth



[b] Healthcare Expenditure Growth



[c] Non-Health Consumption Growth

Notes: The figure plots coefficients from regressing growth of food consumption in panel a, growth of healthcare spending in panel b and growth of total consumption in panel c on disposable income for each wealth quintiles Q1-Q5 with the upmost coefficient belonging to the first quintile. The confidence intervals are also plotted at 99%, 95%, 90% confidence levels with fading colors respectively. The IV regressions include household specific rate of return, taste shifters as well as time and individual fixed effects. Instrument set consists of time t-1 values of the variables which are head and spouse marginal tax rates, log disposable income and average hours per week of head. Robust standard errors are clustered at household level. The alternative sample split is based on net worth excluding home equity.

C Additional Tables

Table C1 Health Index Statistics

	Wealth Quintiles					
	1st	2nd	3rd	4th	5th	Total
Acute illness index	0.094	0.106	0.159	0.202	0.298	0.172
Chronic illness index	0.856	0.748	0.797	0.844	0.872	0.823
Hospitalization shock	0.136	0.120	0.125	0.114	0.122	0.123
Observations	7,111	7,109	7,105	7,108	7,108	35,541

Notes: Mean health index for each quintile. Higher index corresponds to more illnesses.

Table C2 Insurance Statistics

	Wealth Quintiles					
	1st	2nd	3rd	4th	5th	Total
Private insurance	67.73	76.76	82.28	81.98	78.60	77.47
Public insurance	11.50	8.26	9.63	13.65	18.91	12.39
Uninsured/Unknown	20.77	14.98	8.09	4.38	2.49	10.14
Observations	7,111	7,109	7,105	7,108	7,108	35,541

Notes: Percent insured for each insurance type within wealth quintiles.

Table C3 Instrumental Variable Estimation of Consumption Growth controlling for insurance types

	Food Consumption		Healthcare Expenditure		Total Consumption	
	Low Wealth (1)	High Wealth (2)	Low Wealth (3)	High Wealth (4)	Low Wealth (5)	High Wealth (6)
Ex-post rate	0.104	-0.0798	-0.262	-2.458	0.0527	-0.804
	(0.109)	(0.987)	(0.383)	(2.771)	(0.112)	(0.959)
Current income	-0.076***	-0.01	-0.024	0.068**	-0.033***	-0.013*
	(0.012)	(0.008)	(0.03)	(0.032)	(0.01)	(0.007)
Acute index	0.049	0.028*	0.014	0.412*	0.066**	-0.013
	(0.039)	(0.017)	(0.202)	(0.240)	(0.027)	(0.016)
Chronic index	0.009	0.011	0.034	0.122	0.005	-0.001
	(0.014)	(0.01)	(0.101)	(0.088)	(0.012)	(0.009)
Δ Acute index	0.061*	0.044***	-0.053	-0.016	0.062***	0.007
	(0.034)	(0.016)	(0.077)	(0.044)	(0.023)	(0.014)
Δ Chronic index	0.011	0.017**	0.045*	0.044**	0.014*	0.005
	(0.011)	(0.008)	(0.026)	(0.02)	(0.008)	(0.007)
Hospitalization	-0.003	0.029	-0.182	-0.309*	-0.001	0.017
	(0.029)	(0.018)	(0.228)	(0.188)	(0.021)	(0.017)
Δ Hospitalization	-0.016	0.001	0.122**	0.146***	0.008	0.029**
	(0.0207)	(0.0137)	(0.0503)	(0.0397)	(0.0146)	(0.0127)
Household Size	-0.054***	-0.053***	-0.005	-0.03	-0.06***	-0.013*
	(0.009)	(0.008)	(0.027)	(0.026)	(0.007)	(0.007)
Education	0.019**	-0.012	-0.002	0.029	0.001	-0.001
	(0.01)	(0.009)	(0.03)	(0.036)	(0.007)	(0.009)
Constant	0.567	0.479	1.492	0.130	0.693	1.408
	(1.170)	(1.027)	(3.151)	(4.215)	(0.871)	(1.121)
Age polynomial	✓	✓	✓	✓	✓	✓
Household FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
N	12449	14726	12449	14726	12449	14726
R^2	0.012	0.005	0.03	0.004	0.03	0.008
Within R^2	0.023	0.013	0.043	0.009	0.044	0.015

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: Robust standard errors clustered at household level in parentheses. The instrumental variable regressions include household specific rate of return, taste shifters as well as time and individual fixed effects. Instrument set consists of time t-1 values of the variables which are head and spouse marginal tax rates, log disposable income and average hours per week of head. Insurance types are private, public and uninsured.

C.1 Elasticity Estimations

Table C4 Log of total consumption

	Dependent variable: Log of total consumption				
	(1)	(2)	(3)	(4)	(5)
Acute index	-0.003	0.03	-0.004	-0.009	-0.002
	(0.025)	(0.022)	(0.021)	(0.018)	(0.016)
Chronic index	-0.001	0.003	0.009	-0.015**	0.002
	(0.01)	(0.008)	(0.008)	(0.007)	(0.009)
Hospitalization	-0.016	0.015	-0.014	0.032**	-0.009
	(0.017)	(0.015)	(0.014)	(0.014)	(0.015)
Current income	0.051***	0.039***	0.028***	0.024***	0.013*
	(0.009)	(0.012)	(0.009)	(0.007)	(0.007)
Household Size	0.121***	0.082***	0.069***	0.067***	0.071***
	(0.009)	(0.008)	(0.007)	(0.008)	(0.011)
Education	0.012*	-0.012**	0.005	0.007	0.004
	(0.007)	(0.009)	(0.01)	(0.012)	(0.015)
Age	0.073***	0.044**	0.027	0.035*	0.074***
	(0.021)	(0.02)	(0.02)	(0.019)	(0.02)
Age^2	-0.0003***	-0.0004***	-0.0003***	-0.0004***	-0.0004***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Constant	6.167***	8.671***	9.400***	9.555***	7.456***
	(0.917)	(0.924)	(1.045)	(1.101)	(1.266)
Race	✓	✓	✓	✓	✓
Marital Status	✓	✓	✓	✓	✓
Insurance type	✓	✓	✓	✓	✓
Household FE	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓
State FE	✓	✓	✓	✓	✓
N	7111	7109	7105	7108	7108
Adjusted R^2	0.214	0.213	0.155	0.133	0.081

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: Robust standard errors clustered at household level in parentheses. The table shows the fixed effect regression coefficients of log of total consumption on log of family disposable income and covariates for each wealth quintile. Wealth is net worth of family that is sum of all assets minus debts that include housing equity.

Table C5 Log of health-care expenditure

	Dependent variable: Log of health-care expenditure				
	(1)	(2)	(3)	(4)	(5)
Acute index	0.120	0.029	0.145**	-0.078	-0.036
	(0.110)	(0.086)	(0.066)	(0.063)	(0.041)
Chronic index	0.078**	0.072**	0.093***	0.027	0.026
	(0.032)	(0.033)	(0.027)	(0.024)	(0.021)
Hospitalization	0.087	0.234***	0.119**	0.204***	0.139***
	(0.067)	(0.061)	(0.048)	(0.05)	(0.042)
Current income	0.175***	0.058*	0.023	-0.027	-0.064***
	(0.026)	(0.033)	(0.028)	(0.022)	(0.017)
Household size	0.145***	0.119***	0.072**	0.099***	0.112***
	(0.034)	(0.027)	(0.029)	(0.026)	(0.028)
Education	-0.026	-0.038	0.024	0.048	0.044
	(0.027)	(0.031)	(0.023)	(0.039)	(0.033)
Age	0.168**	0.171**	0.0719	0.130**	0.194***
	(0.083)	(0.075)	(0.074)	(0.066)	(0.057)
Age^2	-0.0004	-0.001***	-0.0008***	-0.0008***	-0.001***
	(0.0003)	(0.0003)	(0.0002)	(0.0002)	(0.0002)
Constant	-1.500	2.012	5.776	1.434	2.165
	(3.596)	(3.431)	(3.872)	(3.766)	(3.562)
Race	✓	✓	✓	✓	✓
Marital Status	✓	✓	✓	✓	✓
Insurance type	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓
State FE	✓	✓	✓	✓	✓
N	7109	7109	7105	7108	7108
Adjusted R^2	0.149	0.153	0.092	0.077	0.060

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: Robust standard errors clustered at household level in parentheses. The table shows the fixed effect regression coefficients of log of healthcare expenditure on log of family disposable income and covariates for each wealth quintile. Healthcare expenditure consists of out-of-pocket expenditure and insurance premium paid by the household. Wealth is net worth of family that is sum of all assets minus debts that include housing equity.

Table C6 Log of food consumption

	Dependent variable: Log of food consumption				
	(1)	(2)	(3)	(4)	(5)
Acute index	-0.04	0.044	-0.04	0.027	0.040*
	(0.043)	(0.038)	(0.036)	(0.029)	(0.021)
Chronic index	-0.032**	0.004	-0.005	-0.020	0.014
	(0.015)	(0.015)	(0.012)	(0.013)	(0.011)
Hospitalization	-0.055*	-0.032	-0.023	-0.061***	-0.006
	(0.028)	(0.023)	(0.023)	(0.020)	(0.017)
Current income	0.082***	0.086***	0.058***	0.02*	0.034***
	(0.013)	(0.016)	(0.018)	(0.012)	(0.011)
Household size	0.083***	0.098***	0.112***	0.111***	0.120***
	(0.015)	(0.013)	(0.011)	(0.012)	(0.01)
Education	0.002	-0.008	0.031**	0.017	0.018
	(0.011)	(0.013)	(0.013)	(0.015)	(0.014)
Age	0.032	0.079**	0.013	0.084***	0.042**
	(0.031)	(0.034)	(0.027)	(0.024)	(0.021)
Age^2	-0.0004***	-0.0003**	-0.0003***	-0.0004***	-0.0003***
	(0.0002)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Constant	6.121***	5.162***	7.081***	4.940***	6.999***
	(1.322)	(1.496)	(1.248)	(1.268)	(1.125)
Race	✓	✓	✓	✓	✓
Marital Status	✓	✓	✓	✓	✓
Insurance type	✓	✓	✓	✓	✓
Household FE	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓
State FE	✓	✓	✓	✓	✓
N	5930	5925	5927	5927	5927
Adjusted R^2	0.095	0.100	0.099	0.089	0.084

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: Robust standard errors clustered at household level in parentheses. The table shows the fixed effect regression coefficients of log of food consumption on log of family disposable income and covariates for each wealth quintile. Wealth is net worth of family that is sum of all assets minus debts that include housing equity.

Table C7 Log of non-health consumption

	Dependent variable: Log of non-health consumption				
	(1)	(2)	(3)	(4)	(5)
Acute index	-0.008	0.032	-0.024	-0.005	-0.005
	(0.026)	(0.023)	(0.021)	(0.017)	(0.018)
Chronic index	-0.005	-0.001	-0.002	-0.020***	0.002
	(0.010)	(0.009)	(0.008)	(0.007)	(0.009)
Hospitalization	-0.048***	-0.009	-0.027*	0.003	-0.036**
	(0.017)	(0.015)	(0.014)	(0.015)	(0.017)
Current income	0.046***	0.041***	0.033***	0.032***	0.024***
	(0.009)	(0.012)	(0.008)	(0.008)	(0.008)
Household Size	0.123***	0.081***	0.074***	0.066***	0.074***
	(0.010)	(0.008)	(0.008)	(0.008)	(0.011)
Education	0.012	-0.020**	0.004	-0.005	0.0008
	(0.008)	(0.01)	(0.01)	(0.012)	(0.015)
Age	0.065***	0.033	0.022	0.039**	0.064***
	(0.022)	(0.021)	(0.020)	(0.02)	(0.023)
Age^2	-0.0003***	-0.0003***	-0.0003***	-0.0004***	-0.0004***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Constant	6.485***	8.932***	9.211***	9.364***	7.490***
	(0.952)	(0.959)	(1.062)	(1.141)	(1.441)
Race	✓	✓	✓	✓	✓
Marital Status	✓	✓	✓	✓	✓
Insurance type	✓	✓	✓	✓	✓
Household FE	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓
State FE	✓	✓	✓	✓	✓
N	7111	7109	7105	7108	7108
Adjusted R^2	0.181	0.178	0.150	0.117	0.074

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: Robust standard errors clustered at household level in parentheses. The table shows the fixed effect regression coefficients of log of total non-health consumption on log of family disposable income and covariates for each wealth quintile. Wealth is net worth of family that is sum of all assets minus debts that include housing equity.

C.2 Euler Equation Estimations

Table C8 Growth in total consumption

	Dependent variable: Growth in total consumption				
	(1)	(2)	(3)	(4)	(5)
Ex-post rate	4.055	0.0386	2.851	-2.429	-1.568
	(2.961)	(0.0648)	(2.076)	(2.442)	(1.548)
Acute index	0.109	0.055	0.02	-0.042	0.007
	(0.069)	(0.037)	(0.049)	(0.036)	(0.024)
Chronic index	0.040	-0.003	0.037	-0.008	-0.002
	(0.031)	(0.018)	(0.024)	(0.019)	(0.014)
Δ Acute index	0.081	0.090^{***}	0.03	-0.014	0.00522
	(0.0651)	(0.033)	(0.037)	(0.026)	(0.023)
Δ Chronic index	0.028	0.013	0.022	-0.007	0.008
	(0.018)	(0.013)	(0.014)	(0.015)	(0.011)
Hospitalization	0.082	-0.025	0.097^{***}	0.026	0.003
	(0.053)	(0.034)	(0.035)	(0.034)	(0.032)
Δ Hospitalization	0.019	0.019	0.068^{***}	0.052^{**}	0.002
	(0.036)	(0.024)	(0.024)	(0.024)	(0.022)
Current income	-0.043^{**}	-0.023	-0.005	-0.005	-0.015
	(0.018)	(0.020)	(0.017)	(0.016)	(0.010)
Household size	-0.075^{***}	-0.058^{***}	-0.010	-0.02	0.004
	(0.017)	(0.013)	(0.012)	(0.014)	(0.014)
Education	0.0027	0.02^{**}	-0.018	0.011	-0.022
	(0.022)	(0.01)	(0.019)	(0.017)	(0.015)
Constant	1.63	-1.15	-0.73	-0.195	3.255
	(1.849)	(1.629)	(1.755)	(2.009)	(2.100)
Age polynomial	✓	✓	✓	✓	✓
Race	✓	✓	✓	✓	✓
Sex	✓	✓	✓	✓	✓
Marital Status	✓	✓	✓	✓	✓
Household FE	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓
N	4711	4978	5552	5813	6121
R^2	0.024	0.00001	0.002	0.001	0.002

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: Robust standard errors clustered at household level in parentheses. The instrumental variable regressions include household specific rate of return, taste shifters as well as time and individual fixed effects. Instrument set consists of time t-1 values of the variables which are head and spouse marginal tax rates, log disposable income and average hours per week of head.

Table C9 Growth in health-care expenditures

	Dependent variable: Growth in health-care expenditure				
	(1)	(2)	(3)	(4)	(5)
Ex-post rate	-6.803	-0.015	1.889	-1.880	-7.601*
	(9.479)	(0.108)	(5.773)	(5.212)	(4.486)
Acute index	0.238	-0.0458	-0.0214	-0.193	0.759**
	(0.522)	(0.456)	(0.309)	(0.611)	(0.370)
Chronic index	-0.063	0.057	-0.05	0.140	0.002
	(0.172)	(0.287)	(0.270)	(0.166)	(0.137)
Δ Acute index	-0.038	0.137	-0.270**	-0.027	-0.036
	(0.197)	(0.127)	(0.132)	(0.081)	(0.075)
Δ Chronic index	0.012	0.058	0.039	0.079*	0.010
	(0.058)	(0.054)	(0.044)	(0.042)	(0.031)
Hospitalization	-0.478	-0.086	-0.200	0.250	-0.520*
	(0.554)	(0.500)	(0.282)	(0.431)	(0.299)
Δ Hospitalization	0.003	0.132	0.197**	0.218***	0.085
	(0.106)	(0.098)	(0.084)	(0.082)	(0.061)
Current income	-0.187***	0.042	0.039	0.065	0.121***
	(0.055)	(0.066)	(0.057)	(0.062)	(0.043)
Household size	-0.001	-0.041	0.018	-0.070	-0.008
	(0.062)	(0.053)	(0.045)	(0.045)	(0.055)
Education	-0.003	0.016	-0.037	-0.056	0.057
	(0.098)	(0.057)	(0.048)	(0.077)	(0.054)
Constant	12.30*	-5.907	-12.51**	2.083	9.274
	(7.169)	(6.644)	(6.223)	(6.784)	(8.049)
Age polynomial	✓	✓	✓	✓	✓
Race	✓	✓	✓	✓	✓
Sex	✓	✓	✓	✓	✓
Marital Status	✓	✓	✓	✓	✓
Household FE	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓
N	4711	4978	5552	5813	6121
R^2	0.002	0.0006	0.003	0.005	0.005

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: Robust standard errors clustered at household level in parentheses. The IV regressions include household specific rate of return, taste shifters as well as time and individual fixed effects. Instrument set consists of time t-1 values of the variables which are head and spouse marginal tax rates, log disposable income and average hours per week of head.

Table C10 Growth in food consumption

	Dependent variable: Growth in food consumption				
	(1)	(2)	(3)	(4)	(5)
Ex-post rate	3.591	0.089**	1.018	-1.336	0.894
	(3.031)	(0.040)	(2.499)	(2.469)	(1.37)
Acute index	0.150	0.043	0.057	0.087**	0.012
	(0.113)	(0.091)	(0.052)	(0.038)	(0.026)
Chronic index	0.062*	-0.015	0.014	0.030	0.008
	(0.036)	(0.029)	(0.028)	(0.02)	(0.015)
Δ Acute index	0.085	0.038	0.03	0.055*	0.053**
	(0.084)	(0.056)	(0.043)	(0.031)	(0.026)
Δ Chronic index	0.046*	0.019	-0.0003	0.017	0.024**
	(0.024)	(0.021)	(0.018)	(0.015)	(0.012)
Hospitalization	-0.027	-0.038	0.029	0.069*	0.031
	(0.063)	(0.056)	(0.041)	(0.038)	(0.03)
Δ Hospitalization	-0.070	-0.019	-0.004	0.017	0.016
	(0.045)	(0.036)	(0.031)	(0.025)	(0.021)
Current income	-0.091***	-0.055**	-0.038*	0.001	-0.006
	(0.022)	(0.022)	(0.021)	(0.016)	(0.011)
Household size	-0.066***	-0.043**	-0.040**	-0.063***	-0.064***
	(0.025)	(0.017)	(0.016)	(0.017)	(0.015)
Education	0.010	0.028	-0.018	0.020	-0.028**
	(0.026)	(0.017)	(0.019)	(0.021)	(0.014)
Constant	2.289	-1.099	3.237	-0.390	-0.431
	(2.696)	(2.310)	(2.323)	(1.999)	(1.781)
Age polynomial	✓	✓	✓	✓	✓
Race	✓	✓	✓	✓	✓
Sex	✓	✓	✓	✓	✓
Marital Status	✓	✓	✓	✓	✓
Household FE	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓
N	4711	4978	5552	5813	6121
R^2	0.017	0.0001	0.004	0.001	0.0001

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: Robust standard errors clustered at household level in parentheses. The IV regressions include household specific rate of return, taste shifters as well as time and individual fixed effects. Instrument set consists of time t-1 values of the variables which are head and spouse marginal tax rates, log disposable income and average hours per week of head.