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The Effect of Health on the Marginal Utility of Consumption for Retirees in Europe

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Abstract
This paper investigates the effect of health on marginal utility of consumption for the elderly population in Europe. The method used is based on the approach of Finkelstein et al. (2008) and includes Mundlak (1978) variables to account for correlated unobserved heterogeneity. The model is estimated using data from the Survey of Health, Ageing and Retirement in Europe (SHARE), and financial wellbeing is chosen as a proxy for utility. The baseline results show that when an individual who is healthy experiences an adverse health shock, the marginal utility declines with 15.9 percent. Correspondingly, the point estimate indicates that a one-standard deviation increase in an individuals' limitations in activities of daily living (ADL) is associated with a 3 percent decline in marginal utility. Hence, negative health state dependence is observed. Unfortunately, the findings are very sensitive to the proxy for utility and the choice of health measure. Moreover, results indicate that there is a positive association between numeracy and health state dependence. No health state dependence was found for individuals with a higher than average level of numeracy. For individuals with a lower than average level of numeracy, an adverse health shock results in a decline in marginal utility of 17.7 percent, which is higher than in the baseline model. Hence, numeracy positively influences health state dependence. Governments could provide funded financial education to raise the level of numeracy in order to lower the negative implications that an adverse health shock has on the marginal utility.

Keywords: Consumer Economics, Health, Economics of the Elderly, Demographics, Labor Economics, Labor Policy, Microeconomics

JEL-code: D12, I1, J14

1 Introduction

Governments of many countries are heavily debating the consequences of the global trend in population ageing. Research by the United Nations projected that the number of people in the world aged 60 or over is to grow by 56 percent between 2015 and 2030. Moreover, by 2050 the global population of older individuals is projected to more than double its size since 2015 (United Nations, 2015). As a result of this trend, many high-income countries have undertaken reforms in their pension systems by raising the statutory pensionable age, reducing benefits or increasing contribution rates. Additionally, several countries have proposed or are implementing reforms that make long-term care insurance less generous (Van Ooijen et al., 2018). However, in order to decide upon policy reforms, one needs to determine the optimal level of insurance and savings during an individuals' lifetime. The Life-Cycle Hypothesis (LCH) presumes that individuals plan their consumption over their lifetimes, taking into account their future income. The theory predicts that individuals smooth their marginal utility intertemporally. Hence, standard practice in research to perform analyses on optimal levels of insurance and savings is to look at the utility function and measure the marginal utility of consumption. Research used to assume that the marginal utility of consumption is independent of the health status of an individual. However, it has now been recognized that health state dependence, which can be defined as the effect of health on the marginal utility of a constant amount of nonmedical consumption, is present among individuals and can have important implications for a range of economic behaviors (Finkelstein et al., 2009). Initiators of using this approach to analyze health care and health insurance include Zeckhauser (1970), Arrow (1984), Hirshleifer (1971), and Eisner and Trotz (1961).

A priori, the sign of any health state dependence is ambiguous. On the one hand a negative health state dependence could be observed, which implies that the marginal utility of consumption declines with deteriorating health. This is intuitive since many consumption goods such as expenditures related to traveling are complements to good health. As individuals experience a negative health shock, they may not be able to participate in these activities anymore and therefore reduce their level of consumption. Consequently, this may for example affect the optimal level of life-cycle savings, which would be lower than when no state dependency would have been observed. Besides negative health state dependence, a positive health state dependence could be present, which implies that the marginal utility of consumption increases with deteriorating health. After experiencing a negative health shock, individuals might demand more goods that are substitutes for good health. Examples are market services for physically demanding housework like gardening and house-cleaning and consumption goods such as prepared meals. In contrast to a negative health state dependence, a positive health state dependence would require a higher optimal level of life-cycle savings. Research has found that even moderate amounts of health state dependence can have significant effects on the optimal level of health insurance benefits and level of life-cycle savings (Finkelstein et al., 2009).

This paper adopts the approach developed by Finkelstein et al. (2008), who estimate how within-person adverse health events affect utility. They compare this effect across the elderly and near-elderly in the United States with different levels of permanent income. This approach reasons that if the difference in utility between the sick state and the healthy state increases with consumption, negative state dependence is observed. The level of utility of individuals with a high level of consumption decreases more than the level of utility of individuals with a lower level of consumption. Hence, from this it can be inferred that consumption has a lower impact on utility after experiencing an adverse health shock, suggesting negative health state dependence. In other words, the gradient of utility with respect to consumption becomes lower when health deteriorates. On the other hand, it could be the case that individuals with lower levels of consumption experience a higher drop in utility after an adverse health shock compared to individuals with a higher level of consumption. This means that while both groups experience the same health shock, the individuals with a higher level of consumption experience a lower drop in their level of utility. Even though their health deteriorated, they still retrieve some utility from their high level of consumption, implying positive health state dependence. This paper adopts a similar approach to measure health state dependence in Europe.

Health state dependence is estimated for a number of European countries using the Survey of Health, Ageing and Retirement in Europe (SHARE). The sample is restricted to individuals aged 65 and older to minimize the effect of health on nonmedical consumption through changes in labor income. Therefore, the main purpose of this paper is to investigate how marginal utility of consumption varies with health for the population of retirees in a subsample of European countries with a more or less comparable health care system. This paper uses a model which is based on the models of Finkelstein et al. (2008). Furthermore, the effect of numeracy on health state dependence is investigated. Research has shown that financial literacy is positively related to retirement planning and the development of a savings plan (Van Rooij, Lusardi and Alessie, 2012). This paper intends to investigate whether numeracy influences the level of health state dependence. There is expected to be a significant effect of numeracy on health state dependence. The direction of this effect is expected to be positive as more financially literate people are better able to save part of their earnings as a buffer in case of unexpected shocks. Hence, they are less compelled to change their consumption behavior in case of an adverse health shock.

Statistically significant evidence is found that the marginal utility of consumption declines as health, which is measured as limitations in activities of daily living (ADL), deteriorates. Results show that when an individual who is healthy experiences an adverse health shock, the marginal utility declines with 15.9 percent. Correspondingly, the point estimate of the baseline specification indicates that, relative to marginal utility of consumption when the individual had

no limitations in activities of daily livin, a one-standard deviation increase in an individuals' limitations in ADL is associated with a 3 percent decline in marginal utility. Using the model developed by Finkelstein et al. (2008), similar estimates are found for the health state dependence parameter. Furthermore, the findings are robust against a number of alternative specifications and assumptions. Unfortunately, results are very sensitive to the chosen proxy for utility and health measure. Another part of the analysis concerns the effect of numeracy. Results indicate that there is a positive association between numeracy and health state dependence. No health state dependence was observed for the group of individuals with a higher than average level of numeracy. However, individuals with a lower level of numeracy appear to show a higher level of negative health state dependence. When a healthy individual with a lower than average numeracy level experiences an adverse health shock, the marginal utility declines with 17.7 percent, which is higher than the 15.9 percent found in the baseline model. Hence, as was expected, numeracy positively influences health state dependence.
The contribution of this paper to the literature is threefold. Firstly, compared to Finkelstein et al. (2008), a simpler but valid econometric model is used to estimate the health state dependence parameter and its standard errors.[1] As will be argued in section 3, Finkelstein et al. (2008) have estimated the health state dependence parameter inconsistently. This paper addresses this problem by adjusting their econometric model. Secondly, the effect of numeracy on health state dependence is investigated. Thirdly, by analyzing both different measures of utility and health, insights are provided into the mechanisms behind health state dependence.
This paper is structured as follows; section 2 contains a literature review on the evolution of the research on the effect of health on the marginal utility of consumption and the different methods to measure this. Section 3 describes the methodology used in this paper. Moreover, section 4 elaborates on the data and section 5 presents the results of the research. Section 6 provides robustness checks and finally, section 7 concludes.

2 Literature Review

2.1 Health state dependence

In the most basic von Neumann-Morgenstern framework, individual utility depends on a single attribute which is one's wealth (Viscusi and Evans, 1990). However, assuming that the utility function is independent of the health status of an individual appeared excessively restrictive, for example when conducting research on the optimal level of medical insurance (Arrow, 1984). Since the health of an individual affects the utility one receives from other consequences, for example income, it should be considered when measuring utility.

[1] Finkelstein et al. (2008) use a complicated bootstrap method to compute the standard errors.

Much research has been done to determine the effect of health on the utility function. In the most general form, one could treat health status as a component of an individuals' utility function (Evans and Viscusi, 1991). In this specification utility is a function of income Y and the health state and can be described in the following form:

$$E(U) = \left[1 - \sum_{i-1}^{n} s_i\right] U(Y) + \sum_{i=1}^{n} s_i V_i(Y_i) \tag{1}$$

where U and Y represent respectively the utility and income in the healthy state, and V_i and Y_i the utility and income in the unhealthy state. There are n different types of unhealthy states i and the probability of being in an unhealthy state is represented by s_i. It is assumed that people have a higher utility in good health than in bad health, hence:

$$U(Y) > V_i(Y), i = 1, \dots, n. \tag{2}$$

However, this effect of health is less obvious when looking at the marginal utility of income. On the one hand, an adverse health shock could lower the marginal utility so that:

$$\frac{\delta U}{\delta Y} > \frac{\delta V_i}{\delta Y}. \tag{3}$$

On the other hand, a lower health state could be tantamount to a drop in income which would increase the marginal utility of income:

$$\frac{\delta U}{\delta Y} < \frac{\delta V_i}{\delta Y}. \tag{4}$$

Since the character of health effects on utility functions has fundamental economic implications on for example the optimal structure of health insurance and optimal life-cycle savings, much research has been conducted on this topic. Standard practice in research is to look at the utility function and assume that the shape of the utility function does not vary with health (i.e. $U(.) = V_i(.)$). In this case, an adverse health effect could be treated identical to a loss in income**.** As a result of a health shock, the utility simply drops by the amount of income loss and the marginal utility of income increases. However, this simple reasoning is often not observed in the case of illness. There are many states of individualism in which medical care is of little use and the possibility of deriving satisfaction from consumption is small (Arrow, 1984). Consequently, assuming a utility function independent of health status biases findings and recent studies have

focused on including health status when determining the shape of the utility function (e.g. Finkelstein et al. (2008), Kools and Knoef (2017), and Viscusi and Evans (1990)).
Unfortunately, empirical work on the effect of health on consumption preferences provide ambiguous results. Some papers find positive health state dependence (e.g. Kools and Knoef (2017), Edwards (2008) and Lillard and Weiss (1998)), some find negative health state dependence (e.g. Sloan et al. (1988), Viscusi and Evans (1990) and Finkelstein et al. (2008)) and a third group of research find no health state dependence at all (e.g. Evans and Visusi (1991) and De Nardi et al. (2010)). Finkelstein et al. (2009) state that these variations in outcomes can be attributed to the type of data and methods used. Moreover, the different assumptions made regarding the coefficient of relative risk aversion could explain the contrasting findings. Kools and Knoef (2017) state that some differences in outcomes can also proceed from the choice of sample and health measures used. Despite its potential importance for solving economic questions, relatively little empirical work has been done on this topic. Finkelstein et al. (2013) attribute the relatively small amount of empirical work on this topic to the considerable empirical challenges involved in constructing credible estimates.
The next section discusses several empirical approaches for estimating health state dependence.

2.2 Measuring health state dependence

There are many ways in which to measure health state dependence. Finkelstein et al. (2009) formulate two broad empirical approaches. The first class involves approaches based on individuals' revealed demand for moving resources across health states, and the second class is based on observed utility changes associated with health changes for individuals of different consumption or resource levels.

2.2.1 Revealed demand for moving resources across health states

The first class focusses on consumption itself. A first way to estimate health state dependence using this approach is to examine the willingness to pay for products that offer payoff streams that are dependent on an individuals' health state. An example of such a product is health insurance. Under perfect circumstances, health insurance companies would equate the marginal utility of consumption across different states of health to determine the optimal structure of the health insurance policy. Even though this practice seems straightforward, it faces several challenges. Firstly, market imperfections like moral hazard and adverse selection limit the range of health insurance options available. As a result of moral hazard, health insurance policies often pay out more than the medical expenditures that the individual had to make. Hence, observing the equilibrium purchases of this limited set of health insurance products might not accurately reflect the marginal utility of consumption in different health states. Secondly, this calculation is very sensitive to the assumption made about other parameters like the level of relative risk aversion. The higher the assumed level of risk aversion, the less positive is the state dependence. Since literature finds a large range of estimates of risk aversion ranging from 1 to over 50, approaches that are very sensitive to this assumption are hard to interpret (Cohen and Einav, 2007). Moreover, in order to implement this approach, one needs to observe a wide set of insurance choices ranging from insurances covering many medical expenditures to insurances only covering some basic medical expenditures. Since this choice is hard to find in practice, this method has not been used often. However, an example of research that has implemented this approach related to willingness-to-pay is the paper by Edwards (2008). He investigates the role of self-perceived health in explaining continued reductions in financial risk taking after retirement. The research finds that individuals who perceive a higher probability of uninsured health shocks hold a lower share of their assets in risky securities, implying positive health state dependence. However, the assumption had to be made that changes in health do not have a direct effect on portfolio choice.

Within the class of estimating health state dependence based on the demand for moving resources across states, another method regards considering the relationship between health and the time profile of consumption. This approach is based on the assumption that optimizing individuals increase their consumption when marginal utility is high and decrease consumption in periods that marginal utility is low. Combining these observations on the consumption profiles with the health status of individuals, the relative demand for resources across health states can be inferred. In order to get the most accurate results, differences in consumption profiles across individuals of the same demographics facing different health shocks are compared. However, as it is hard to obtain such specific data, many researchers have focused on individual persons experiencing unexpected health shocks. A challenge in estimating the effect on consumption preferences from observed expenditures is to disentangle the effect on the value of consumption from other motivational factors to change spending (Van Ooijen et al., 2018). An example is the effect of bequest motives. A decline in consumption after experiencing an adverse unexpected health shock can both imply that one demands less products because of its deteriorated health status, or that one has a strategic bequest motive. Since the life-cycle budget constraint needs to be satisfied, any inference about state dependence will be sensitive to what is assumed about bequest motive (Finkelstein et al., 2008). However, there is a lack of consensus on how to model bequest motives. If it is assumed that individuals do not receive utility from bequests and all bequests are accidental, then in case of negative health state dependence, individuals who expect their health to deteriorate should have a front-loaded consumption profile. However, if it is assumed that bequests are intentional and do influence utility, then the strong assumption needs to be made that marginal utility of consumption depends on health, but marginal utility of bequests does not. Much research has been done that refutes this assumption. For example, Bernheim et al. (1985) developed a bequest model in which individuals receive utility from seeing their children and consequently

decrease their consumption in case of an adverse health shock in order to increase their bequests.
Another issue related to this approach was mentioned by Van Ooijen et al. (2018) and regards the fact that health may have different impacts on different spending categories. When determining the aggregate effect of health, one also needs to account for the relative importance of the various spending categories in different health states. This approach was pursued in a research by Lillard and Weiss (1997). They attempted to analyze the impact of health and survival uncertainty on the saving and consumption decision of retirees. By building a structural model, they analyze income flows and asset changes of retirees and compare various consumption paths across individuals with different health shocks. They find that a negative health shock raises the marginal utility of consumption and that this is 55 percent higher than in the healthy state. Moreover, Van Ooijen et al. (2018) examine the relationship between consumption and health in the Netherlands when disposable income and non-discretionary medical spending are kept constant. By estimating a demand system, they investigate the impact of health on total non-medical spending and spending on different expenditure categories. They find that non-medical expenditures slightly decline after an adverse health shock and medical expenditures increase, even though they do not seem to drive the decline in non-medical expenditures. Hence, implying negative health state dependence.

2.2.2 Observed utility changes

The second class identified by Finkelstein et al. (2009) is based on observed utility changes associated with health changes for individuals with different consumption or resource levels. This method is also adopted in this paper. Research based on this approach estimate how within-individual utility changes as a result of health shocks, and therefore estimate the utility function itself. A first way to apply this approach is by asking individuals how much money they would require in order to compensate them for hypothetical exposure to certain health risks. Then it can be examined how these reported compensating differentials vary with income (Viscusi and Evans (1990), Evans and Viscusi (1991)). This can be done by for example estimating compensating wage differentials associated with various job-related health risks. Viscusi and Evans (1990) estimate the state dependent utility of chemical workers in the United States by evaluating answers to a survey question on the amount of money they would require to compensate them for hypothetical exposure to new chemicals. Results show that the marginal utility in the diseased state is between 77 and 93 percent of the marginal utility in the healthy state, hence suggesting negative health state dependence. Numerous researches have estimated the marginal utility in a similar way and the estimates obtained vary significantly. In their research, Sloan et al. (1988) use an estimation approach to assess intangible health losses associated with multiple sclerosis (MS). They found that the marginal utility of income in the state of MS is merely eight percent of the marginal utility in the healthy state. Finkelstein et al.

(2009) explain this wide range of estimates by stating that this is due to different assumption concerning the curvature of the utility function and the use of different diseases and studied populations. A disadvantage of this approach is that it does required individuals to forecast how their utility function will change once they become ill. Research by Loewenstein et al. (2003) find that people exaggerate the degree to which their future tastes will resemble their current tastes. They label this phenomenon 'projection bias' and state that people put too much weight on their current preferences when forecasting their future preferences. This implies that healthy individuals underestimate the effect of an adverse health shock on their marginal utility and do not sufficiently adjust their future expected demand. This approach in which people need to make projections concerning future spending patterns would therefore not resemble true future consumption.

A second and often used approach within this class based on observed utility changes, which is also adopted in this paper, makes use of utility proxies. Within a panel, analyses can be done on how this utility proxy changes in response to health shocks across different individuals. One of the benefits of this approach is that individuals do not need to make forecasts on how their consumption pattern would change as an effect of some hypothetical health shock. Even though this approach seems intuitive, it requires a direct measure of utility which makes it very cumbersome. Subjective wellbeing is frequently used as a proxy for utility. However, wellbeing is a subjective measure which is hard to compare across individuals. In order to use this measure in investigating health state dependence, it is necessary to interpret it numerically and hence translate it into a cardinal measure. Finkelstein et al. (2008) have used this approach and estimate how within-person adverse health events affect subjective wellbeing in the United States. Moreover, they compare this effect across individuals with different levels of permanent income. They find that a deterioration in health is associated with a statistically significant decline in the marginal utility of consumption. Their results indicate that a one-standard deviation increase in the number of chronic diseases is associated with a 10%-25% decline in the marginal utility of consumption relative to having no chronic diseases. This implies that after individuals experience an adverse health shock, their marginal utility of consumption declines. Nonetheless, since using subjective wellbeing can bias results, other proxies for utility have been used to overcome this potential bias. An example is the research by Kools and Knoef (2017), who use financial wellbeing as a proxy for utility. They develop a new approach that builds upon the approach of Finkelstein et al. (2008) and uses insights from the domain of living standards and income adequacy. They construct a parameter, defined as the health equivalence scale, which indicates how much extra (or less) income is needed in the sick state to be financially as well of as in the healthy state. A random ordered probit model is estimated in order to determine the minimum required income levels in both the healthy and the sick state to reach a certain level of financial wellbeing. In contrast to Finkelstein et al. (2008), who focus on the United States, they find a positive health state dependence in Europe. Van Ooijen et al.

(2018) provide a potential explanation for these findings by stating that inhabitants of the United States have different spending patterns than inhabitants of Europe.

3 Empirical approach

As was mentioned before, this paper falls within the class of approaches focused on estimating the utility function itself. It compares within-individual utility changes associated with health shocks to determine the change in marginal utility due to health shocks. Financial wellbeing is chosen as a proxy for utility. A straightforward method to measure how the marginal utility of consumption changes due to health shocks would be to regress the utility measure on consumption, health, their interaction term and some controlling variables. The coefficient of the interaction term between consumption and health would give an estimate of state-dependent utility. However, this approach requires detailed data on consumption, which in practice is scarce. Therefore, this research uses a measure of lifetime income instead. This can be done since the approach that is used yields conditions under which it can be inferred how marginal utility of consumption varies with health status from estimates of how marginal utility of lifetime income varies with health status. The key requirement is that consumption in the sick state is predetermined. This implies that in case an individual experiences an adverse health shock, this health shock does not directly lead to changes in consumption. This assumption can be made more plausible by selecting an appropriate sample. Since the sample of this research only contains individuals older than 65 with an income lower than 2000 euros per month, it can be assumed that these individuals do not receive labor income. Hence falling sick does not directly affect their wealth through a reduction in labor income. Furthermore, since in most countries under consideration in this study medical expenditures are covered by health insurance, adverse health shocks do not directly affect wealth through medical expenditures.
Section 3.1 provides the theoretical framework used and section 3.2 explains the empirical method. Furthermore, some potential threats to validity are identified in section 3.3.

3.1 Theoretical framework

The theoretical framework used in this paper is based on the working paper by Finkelstein et al (2008). In order to allow for health state dependence, the following utility function is assumed:

$$U(C_1, C_2, S) = \left(\frac{1}{1-\alpha}\right) C_1^{1-\alpha} + \left(\frac{1}{1+\delta}\right) U(C_2, S), \tag{5}$$

where

$$U(C_2, S) = \gamma_0 S + (1 + \gamma_1 S)\left(\frac{1}{1-\alpha}\right) C_2^{1-\alpha}. \tag{6}$$

Here, C_t denotes consumption in period t (t=1,2), S denotes a state of bad health, α represents the coefficient of relative risk aversion and δ denotes the discount rate. The utility function is a standard CRRA utility function for healthy individuals. The term $\gamma_0 S$ allows the level of utility to vary with health while leaving the shape of the utility function unchanged. On the other hand, the term $\gamma_1 S$ does affect the marginal utility of consumption and therefore captures health state dependence. In the two-period model, individuals optimize lifetime income in two periods. Moreover, their health status, denoted by S, is binary. It is assumed that individuals are healthy (S =0) in the first period and have a probability p of experiencing an adverse health shock (S =1) in the second period. Even though the health shock is unanticipated, the individual is aware of his chances to fall ill. It is assumed that the individual does not know the future health status in period 1 and allocates lifetime income over first- and second period consumption. The model assumes that an individual maximizes expected utility subject to a lifetime budget constraint:

$$\max E\left[U(C_1, C_2, S)\right] \tag{7}$$

subject to

$$Y = C_1 + \frac{1}{1+r} C_2, \tag{8}$$

where Y denotes lifetime income. Combining the budget constraint and the lifetime utility function results in the following expected utility as a function of C_2:

$$E[U(C_2)] = \frac{1}{1-\alpha}\left(Y - \frac{C_2}{(1+r)}\right)^{1-\alpha} + \frac{1}{1+\delta}\left(\gamma_0 p + \frac{1}{1-\alpha}(1 - p\gamma_1) C_2^{1-\alpha}\right). \tag{9}$$

Maximizing expected utility with respect to C_2 results in the following optimal level of consumption in the second period:

$$C_2 = \frac{\left(\frac{(1+p\gamma_1)(1+r)}{1+\delta}\right)^{\alpha}}{1 + \left(\frac{(1+p\gamma_1)(1+r)}{1+\delta}\right)^{\alpha} / (1+r)} Y = cY, \tag{10}$$

where c is implicitly defined. From this is can be concluded that optimal second-period consumption is proportional to lifetime income and independent of the realization of a health shock, $C_2 = cY$. Substituting the optimal level of second-period consumption into the second-period utility function yields indirect utility, $v(Y, S)$, in the second period for the healthy state and the sick state, respectively:

$$v(Y,0) = \left(\frac{1}{1-\alpha}\right)^{1-\alpha} \tag{11}$$

and

$$v(Y,1) = \gamma_0 + \frac{1+\gamma_1}{1-\alpha}(cY)^{1-\alpha}. \tag{12}$$

From the indirect utility functions, the following non-linear regression can be derived:

$$v = \beta_1 S \cdot Y^{\beta_2} + \beta_3 S + \beta_4 Y^{\beta_2}, \tag{13}$$

where

$$\beta_1 = (\tfrac{c^{1-\alpha}}{1-\alpha})\gamma_1,\ \beta_2 = 1-\alpha,\ \beta_3 = \gamma_0, \text{ and } \beta_4 = \tfrac{c^{1-\alpha}}{1-\alpha}. \tag{14}$$

In the indirect utility function, the estimate of β_1, which is the coefficient on the interaction term between permanent income and health state, measures the incremental income gradient of utility in the sick state relative to the healthy state. The coefficient β_4 measures the income gradient of utility in the healthy state. Since the main variable of interest is γ_1, which indicates the health state dependence parameter, the ratio of β_1 and β_4 needs to be estimated. This provides a direct measure of health state dependence. In line with Finkelstein et al. (2008), the coefficient of relevant risk aversion is assumed to be 1 ($\alpha = 1$). In this case, following L'Hôpital's rule, equation (13) can be written as follows:

$$v = \beta_1 S \cdot ln\,(Y) + \beta_3 S + \beta_4 ln\,(Y). \tag{15}$$

Taking the ratio of the incremental income gradient of utility in the sick state relative to the healthy state (β_1) to the income gradient of utility in the healthy state (β_4) yields:

$$\frac{\beta_1}{\beta_4} = \frac{(\frac{c^{1-\alpha}}{1-\alpha})\gamma_1}{\frac{c^{1-\alpha}}{1-\alpha}} = \gamma_1. \tag{16}$$

Hence, the ratio (β_1/β_4) directly estimates the health state dependence parameter.

3.2 Empirical model

The indirect utility function is operationalized by running a random-effects regression following the approach developed by Mundlak (1978). Here this paper deviates from the method used by Finkelstein et al. (2008). They first run a fixed-effects model including a variable capturing the individual fixed effects, which absorbs any direct effect of lifetime income and any other time-invariant characteristics on utility. One of these effects absorbed is the parameter capturing the effect of lifetime income on utility in the healthy state (β_4). Since this parameter is used to determine the magnitude of the health state dependence, they run an auxiliary regression of the estimated fixed effects on lifetime income and demographic controls. In order to determine the standard errors, p-values and confidence intervals for the parameter indicating state dependence (β_1/β_4), they bootstrap the sample at the individual level. However, this paper argues that this estimate of the health state dependence parameter is inconsistent. The fixed effect is estimated on only a measure of lifetime income ($\ln(\bar{Y}_i)$) and the variable indicating demographic controls (X_{it}). In order to consistently estimate this parameter, one should also include the individual specific average of health state (S_{it}) and the interaction of this term with lifetime income ($\bar{S}_i \cdot \log(\bar{Y}_i)$). By not including these terms, they incorrectly make the assumption that both regressors S_{it} and $S_{it} \cdot \log(\bar{Y}_i)$ are independent of the individual fixed effects. Hence, the parameter β_4 is estimated inconsistently. In order to address this problem, this research deviates from this method by directly measuring the model and deviating from the fixed effects approach. Essentially, the fixed effects model concentrates on differences within individuals. One of the benefits of using this approach is that it allows for arbitrary correlation between unobserved individual effects and the explanatory variables. However, any time-invariant variables incorporated in the regression will be eliminated since its impact will be subsumed by the fixed effects. Another method that does allow to measure the impact of time-invariant variables is the random effects approach. Consistency of the random effects estimator however does require the assumption that all regressors included in the model are uncorrelated with the unobserved individual effect. Even though this assumption is more palatable when using panel data compared to using a cross-section, in many applications it is felt that unobserved heterogeneity is correlated to observed regressors. Several authors have suggested modifications of the random effects model that would at least partly overcome its deficit. One of the approaches, which is used in this paper, is one developed by Mundlak (1978). He parameterizes the individual fixed effects as a linear function of the average time-varying explanatory variables over time and includes a random individual specific effect. This unobserved individual effect is assumed to be uncorrelated with the explanatory variables. Mundlak makes the following assumption:

$$E\{c_i|X_i) = \bar{x}_i'\gamma \tag{17}$$

where $\bar{x}_i'$ identifies the mean of all the explanatory variables included in the model. The assumption can be written as:

$$c_i = \bar{x}_i'\gamma + w_i. \tag{18}$$

In the above equation, w_i is an unobserved individual effect which is assumed to be uncorrelated with the explanatory variables. Mundlak (1978) states that by applying this approach, the individual means are picking up the correlation between observed individual characteristics and the individual unobserved effects. The advantage of this approach is that it allows to preserve the specification of the random effects model but that it does not require the unrealistic assumption that the explanatory variables and the unobserved individual effects are uncorrelated. Mundlak (1978) has proven that the coefficients are the same as the ones obtained from the fixed effects model in case of linear models. Following this approach, the following model is run:

$$\begin{aligned} UProxy_{it} = g(&\beta_1 S_{it} \cdot \log(\bar{Y}_i) + \beta_3 S_{it} + \beta_4 \log(\bar{Y}_i) + \Psi_1 X_{it} + \Psi_2 \bar{X}_i + \Psi_3 \bar{S}_i \\ &+ \Psi_4 \bar{S}_i \cdot \log(\bar{Y}_i) + \eta_i + \varepsilon_{it}). \end{aligned} \tag{19}$$

S_{it} and $\bar{Y}_i$ indicate health status and lifetime income respectively, X_{it} is a vector of time constant and time varying variables of individual *i* in period *t*, η_i is an individual specific effects and ε_{it} is the error term which is assumed to be distributed as standard normal with mean zero and variance one. The function that determines the type of regression is denoted as $g(.)$. In line with the baseline specification of Finkelstein et al. (2008), it is assumed that the function $g(.)$ is linear. Finally, β_1, β_3 , β_4 , Ψ_1 , Ψ_2 , Ψ_3 and Ψ_4 are coefficients to be estimated. The coefficient β_1 indicates the additional marginal utility of lifetime income when being in the unhealthy state relative to being in the healthy state. Since it is assumed that consumption in the second period is proportional to lifetime income, and consumption is the unhealthy state is predetermined, the marginal utility of lifetime income is the same as the marginal utility of consumption. The equation is measured using de-meaned values of $\bar{Y}_i$ so that coefficient β_3 directly describes the relation between an individuals' change in sickness and change in utility at the sample average level of lifetime income. The empirical estimate of the ratio (β_1/β_4) gives the proportional change in marginal utility of lifetime income resulting from experiencing an adverse health shock. This ratio hence measures health state dependence.

It was argued before that the method of Finkelstein (2008) is inconsistent. By using their method, one incorrectly assumes that $\Psi_3 = 0$ and $\Psi_4 = 0$.

3.3 Potential threats to validity

This paper measures health state dependence by looking at the within individual changes in financial wellbeing as a result of an adverse health shock. For ease of exposition, several assumptions have been made. This section discusses the underlying assumptions and identifies other threats that could violate the validity of the results.

3.3.1 Underlying assumptions and potential threats

Firstly, the assumption was made that consumption in the sick state is predetermined. In line with Finkelstein et al. (2008) and Kools and Knoef (2017), the sample is limited to individuals aged 65 years and older and earning less than 2000 euros per month. However, consumption would not be predetermined if health has a mechanical effect on the resources available to consume. These mechanical effects could be caused by changes in labor income, out-of-pocket (OOP) medical expenses, household production and changes in mortality risk. Since this research limits the sample to individuals aged 65 and older, changes in labor income are accounted for. Furthermore, concerning the OOP medical expenditures, this research has assumed that health insurance within Europe is universal and that individuals are fully insured. Consequently, in case of an adverse health shock, they do not experience large increases in medical expenditures. However, each country within the sample has different policies concerning health insurance and therefore the amount of OOP medical expenses differs. For example, in the Netherlands significant increases in OOP medical expenditures for long-term care occurred between 2009 and 2017 (Van Ooijen et al., 2018). In case individuals have a health insurance in which a large part of the medical costs needs to be covered by themselves, an adverse health shock could significantly increase their expenditures. This would bias results towards positive health state dependence. Kools and Knoef (2017) test whether OOP medical expenditures influence their findings and state that it does not drive their results. In their research, Van Ooijen et al. (2018) state similar conclusions. They find that even though medical expenditures increase after an adverse health shock, they do not seem to drive the decline in non-medical expenditures. Moreover, in case the mortality risk of individuals changes, the assumption regarding predetermined consumption could not be valid. Changing mortality risk affects the amount of wealth an individual has per remaining year. As a result, financial wellbeing may change while the marginal utility of consumption is not affected, leading to a negative bias. However, in case individuals have a bequest motive, this bias would be weakened. Even though the years remaining for individuals to spend their wealth has decreased, this would not change their spending pattern since this money would be used to leave a bequest. Moreover, consumption would not be predetermined if individuals are able to re-allocate consumption in response to their state dependent preferences. This could be the case when health shocks are anticipated or informal insurance is provided, and adjustments can be made to the spending pattern before the actual health shock occurs. Hence, the health shock would not affect financial wellbeing, biasing towards zero state dependence.

Another assumption regards the coefficient of relative risk aversion. This research assumes a coefficient or relative risk aversion of 1 (α). However, as was mentioned before, there is no consensus reached on what the exact coefficient of relative risk aversion is and a wide variety of coefficients have been used in literature. In their paper, Finkelstein et al. (2008) test the validity of their results by running the regression with different coefficients of relative risk aversion that are commonly used ($\alpha = 0.5, 2,3,5 \text{ and } 10$). They find that the results are generally robust in statistical significance and magnitude. Therefore, this research assumes using $\alpha = 1$ is an appropriate assumption.

Thirdly, this paper assumes $g(.)$ to be a linear function. Misspecification of the mapping can cause incorrect inference of the true magnitude of state dependence (Finkelstein et al., 2013). In order to investigate whether the results of their findings were sensitive to the mapping chosen, Finkelstein et al. (2008) estimated the model to different assumptions and estimates of $g(.)$. In order to check for robustness of the model, section 6.2 provides results of the model using different functional forms.

Fourthly, in contrast to Finkelstein et al. (2008) who uses social wellbeing as a proxy for utility, this research uses financial satisfaction. An adverse health shock can influence overall utility through diverse channels. It can affect utility through a lower health satisfaction, through changes leisure satisfaction or through financial satisfaction (Kools and Knoef, 2017). Since this research intends to measure the marginal utility of consumption, financial satisfaction is chosen as a proxy for utility. This way it is not necessary to filter out other direct and indirect relations between health and wellbeing that are not related to consumption. Even though financial satisfaction only partly captures overall utility, the advantages outweigh this limitation.

An issue that remains in this research regards measurement error. It is important to recognize this since much of the data used in this research is based on self-reported information from survey questionnaires. It is well documented that individuals are highly sensitive to the way questions in a survey are presented. Factors like framing, wording, social desirability or question order affect responses which can result in measurement errors (Bertrand et al., 2010). Moreover, the way a person interprets certain scales within questionnaires depends on individual characteristics. People have different scales and benchmarks to evaluate themselves, which makes it hard to compare surveys. In general, a way to account for these unobserved individual effects on reporting style is to look at the effect of within individual health changes on financial satisfaction instead of comparing individuals with different levels of health to each other. Since this research investigates within individual changes in health states, this threat is partly accounted for. However, this solution does require the assumption that answering styles within individuals are fixed over time, which does not necessarily need to be the case[2]. Angelini et al. (2014) find that health affects reporting styles. They state that individuals in poor health tend to evaluate life satisfaction more negatively than individuals in good health. On the other hand, there is growing evidence that measures of self-reported wellbeing are meaningful, and that self-reported happiness does correlate with objective life circumstances (Frey and Stutzer, 2002).

Another threat that is identified regards the assumptions that conditional on the explanatory variables in the model, there are no omitted determinants of utility that are correlated with one of the other explanatory variables. In the case a cross-section was used, it would be reasonable to assume that there are person-specific characteristics not controlled for in the model that are correlated with utility, health and lifetime income. However, in the model used, the unobserved individual effects are assumed to be captured by the parameter η_i, which specifies individual specific effects. Even though the model uses panel data, omitted variable bias could still be a problem if health changes within individuals vary across individuals of different lifetime income in a way that is correlated with utility (Finkelstein et al., 2008). Certain socioeconomic factors like family background, education and time preference may influence both health and financial satisfaction. This can make it difficult to establish causal relationships. For example, an individual who is very impatient may both have difficulties making ends meet and may be less healthy as a result of bad habits like smoking and drinking alcohol. In the same way there could be certain unobserved characteristics influencing both lifetime income and financial wellbeing such as the level of optimism one exhibits. The model controls for several of these factors, however there could still be variables that are not considered. Leaving these factors out of the model could result in omitted variable bias.

Lastly, a potential threat identified concerns reverse causality. There are two channels through which reverse causality could run. Firstly, individuals who express a lower level of financial satisfaction might experience stress from not being able to make ends meet. This level of stress could eventually lead to more severe health problems in the long run and could affect the ability to perform activities of daily living at old age. Secondly, reverse causality could arise when individuals who express difficulties with making ends meet are also unable to pay for measures that could prevents illness, like specific medicines or vitamins. Moreover, they might be unable to afford a healthy lifestyle. However, since this research focusses on European countries in which customary medical expenditures are often paid for by health insurance companies and the government, it is not expected that this reverse causality will significantly influence results.

[2] Appendix B presents a robustness check to test for biases in reporting due to time-varying optimism or pessimism.

4 Data

To estimate the model, this paper uses the Survey of Health, Ageing, and Retirement in Europe (SHARE). This is a multidisciplinary database of microdata on health, socio-economic status and social and family networks of individuals. The data in this database is selected by face-to-face computer aided personal interviews (CAPI), and in addition a self-completion drop-off part is added including questions that require more privacy. Furthermore, personal interviews are conducted to execute physical tests. In order to compare results between countries, SHARE uses a principle of ex-ante harmonization. This entails making one common generic questionnaire which is translated into the national languages using an internet-based translation tool which is processed automatically in a common CAPI instrument. Since some variables vary greatly between countries, for example variables regarding education, country-specific measurements are introduced and ex-post harmonization was required. Selected household members serve as a family, financial or household respondent. Depending on the various modules, one of the type of respondents answers the question. For the generated variables, the information is stored for all respondents. The CAPI questionnaire is divided into eighteen modules ranging from questions on health to questions related to financial wealth. The SHARE target population consists of all persons aged 50 years and over at the time of sampling who have their regular domicile in the respective SHARE country. The data is collected through 6 different waves. Data for the first wave was collected in 2004, the second wave in 2007, the third in 2008/2009, the fourth in 2011, fifth in 2013 and finally the sixth wave in 2015. Since the third wave focuses on people's life histories and collects retrospective information, this paper excludes this wave in the analysis. Moreover, some significant irregularities regarding the total household income in the second wave were observed that could not be explained and deviated significantly from the other waves. Since total household income is one of the main variables in the model, it was decided to drop the second wave from the panel. Furthermore, the Netherlands did not participate in the regular sixth SHARE wave, but instead conducted a Mixed Mode Experiment. In contrast to the regular SHARE interview, which is face-to-face, the Dutch interviews were collected using a self-administered online survey (CAWI) and a small part through telephone interviewing (CATI). Although the questionnaire was based on the regular SHARE interview, many adaptations are required in order to compare the data. Since the different mode of data collection may result in different survey outcomes, it was decided to not include the Mixed Mode Experiment in the model.

Like other household surveys, SHARE suffers from the problem of item non-response. One option to deal with this problem would be to not use any observations with missing values. However, besides the fact that missing data is highly prevalent in household surveys and hence leaving these observations out would significantly reduce the data sample, taking this approach would also imply making another assumption. One would be assuming that the observations containing missing values are not in any way different from those without missing values

(Christelis, 2011). This assumption entails the acceptance that all the missing values are completely random, hence that the mechanism that generates the missing data is uncorrelated with any other variables in the survey. Since a violation of this assumption would make the analysis biased and inconsistent, imputations can be used in order to correct for the missing data (Christelis, 2011). The SHARE dataset provides an imputation database of each wave including five imputations of the missing values. This paper uses the first set of imputations to measure the model. The remainder of this section further elaborates on the data used in order to run the regressions and do the analyses.

4.1 Sample Selection

This paper considers retired individuals in ten European Countries from 2004 till 2015. These countries include Germany, Austria, Sweden, the Netherlands, Spain, Italy, France, Denmark, Switzerland and Belgium. In accordance with the method used by Kools and Knoef (2017), the sample consists of households in which the individuals are aged 65 or older and where annual household income from a job or from self-employment is less than 2000 euros. Focusing on this population group makes sure that health shocks do not have a direct effect on income. Since SHARE only considers individuals living independently, persons living in a nursing home from the start they participate in the survey are excluded. Moreover, households with more than 2 household members are also removed from the sample. The baseline sample consists of 61,883 observations. This paper includes in X_{it} covariates for individual characteristics that might be correlated with changes in utility and health. In line with Finkelstein et al. (2008), these demographics include household size, age squared, gender and a dummy variable for wave[3]. Additionally, a dummy variable for country, a dummy variable for level of education and a dummy variable indicating whether the individual owns a house are included. As research has found that household wealth plays a major part in explaining the retirement savings puzzle, this might be important to consider (Suari-Andreu et al., 2018).
Table 1 presents descriptive statistics. In the sample, the average household consist of 1.7 individuals and 56 percent is male. The average age is approximately 75 years and 73 percent of the sample is home owner. Within the sample, 18 percent of individuals has an education level of college or more, and their average numeracy score is 3.30 on a scale from one to five.

[3] In their research, Finkelstein et al. (2008) also include a variable indicating race.

Table 1: Descriptive statistics

	mean	sd	min	max	N
Demographics					
Lifetime income ('000)	35.57	46.22	0	5037	61883
Household size	1.69	0.46	1	2	61883
Age	74.96	6.98	65	104	61883
Male	0.56	0.50	0	1	61883
Home owner	0.73	0.45	0	1	61883
High education level	0.18	0.39	0	1	61883
Numeracy	3.30	1.11	1	5	61883
Health measure					
ADL	0.15	0.36	0	1	61883
Utility proxy					
Financial wellbeing	3.09	0.91	1	4	61883

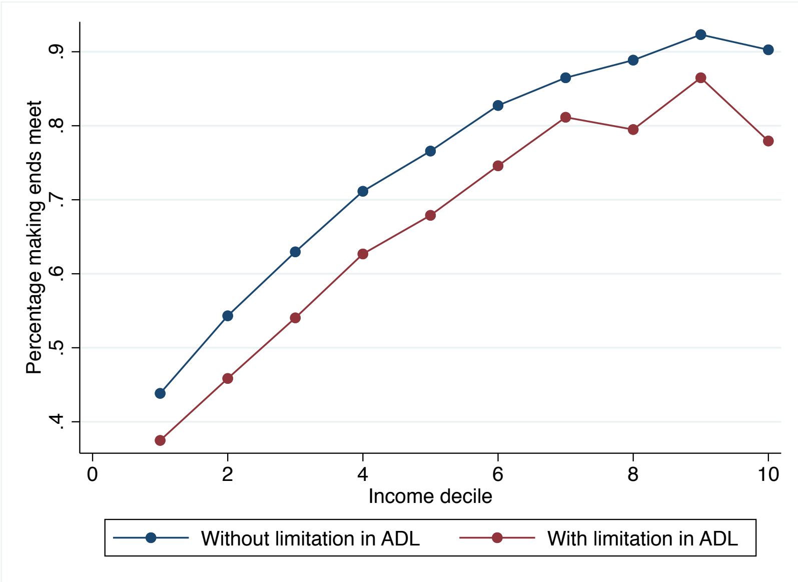
A respondent is considered highly educated with an ISCED level of five of higher. An individual is considered to be unhealthy when having more than one limitation in activities of daily living (ADL).

4.2 Utility

The dependent variable used in this research is utility. As this is a very broad concept which is hard to measure, many researchers debate on which utility proxy is best. Overall wellbeing is often used as a proxy and can be defined as a weighted combination of domain satisfactions such as health satisfaction, leisure satisfaction, and financial satisfaction (Van Praag and Ferrer-I Carbonnel, 2004). Finkelstein et al. (2008) choose this as a proxy and use the response to the question: “Much of the time during the past week I was happy. (Would you say yes or no?)”. In order to isolate the effects of health through financial satisfaction, they introduce an interaction term between a change in health and permanent income. However, research has suggested several limitations of using subjective wellbeing as a proxy for utility. One of the objections often stated is that there are systematic differences between hypothetical choices and predicted happiness (Benjamin et al., 2012). This implies that even though respondents' predictions regarding social wellbeing are a powerful predictor of their choices, other factors are identified that help explain the choices made. Moreover, Angelini et al. (2014) found that life satisfaction is highly heterogeneous across similar countries. Their research state that this phenomenon can be explained by the different scales and benchmarks that people use to evaluate themselves. These findings imply that using this self-reported happiness as a proxy for subjective wellbeing can bias results as it is hard to compare between different countries. Therefore, other measures have been suggested to serve as a proxy for utility. One of these variables is financial wellbeing. In their research, Kools and Knoef (2017) use this measure and state that it is advantageous since it circumvents having to filter out other direct and indirect relations between health and wellbeing that are not related to consumption. Another advantage of using financial wellbeing is that the subjective component is smaller compared to using subjective wellbeing. This is advantageous since one of the main variables in this paper is health, which is often comprised of a subjective component. The measures range from being partly subjective like limitations in activities of daily living, to highly subjective like life satisfaction. When both the dependent variable as well as one of the independent variables have a subjective component, errors may be correlated and therefore bias the results.

In correspondence with Kools and Knoef (2017), this paper uses financial wellbeing as a proxy for utility. The SHARE questionnaire includes a question regarding the level of financial satisfaction of the respondents. The question is as follows: "Thinking of your household's total monthly income, would you say that your household is able to make ends meet?'. Respondents can choose between four categories in order to indicate the level of financial satisfaction. These categories are (1) with great difficulty, (2) with some difficulty, (3) fairly easily, and (4) easily. As was shown in Table 1, the average individual in the sample scores 3.09. Figure 1 represents financial satisfaction across health and income. For interpretation purposes, the y-axis represents the percentage of individuals who reported that they can fairly easily or easily make ends meet. The two different lines indicate the group of individuals who reported to experience more than 1 limitation in activities of daily living, and the group of individuals who do experience 1 or less limitations. From the graph it can be concluded that, as was expected, individuals who have a higher income can more easily make ends meet. Moreover, conditional on income, individuals without ADL limitations have less difficulties making ends meet. The figure illustrates that mean utility drops slightly more after an adverse health shock for those with higher lifetime incomes than those in lower income groups. Hence, since the gradient of utility with respect to lifetime income becomes lower when health deteriorates, this suggests there is evidence of negative health state dependence.

Figure 1: Financial satisfaction across health and income

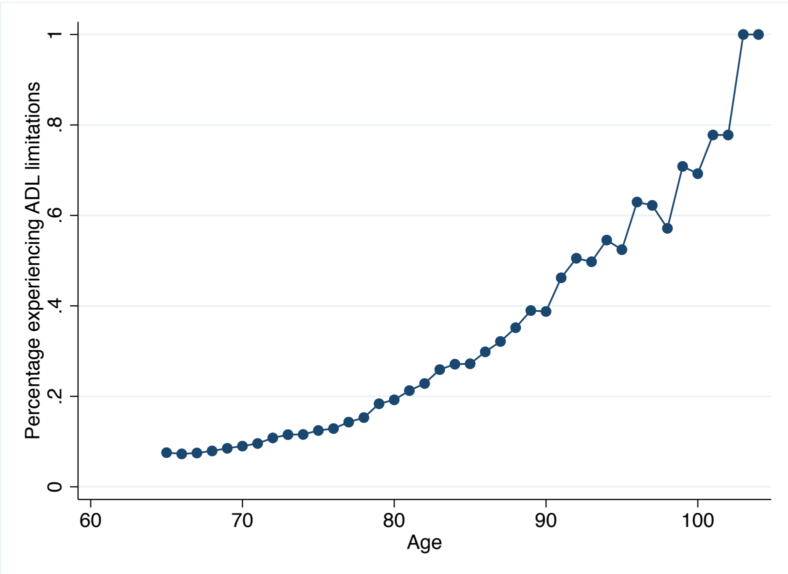


4.3 Health

In order to determine the effect of health on the marginal utility of consumption, data needs to be collected in order to measure health status. Since the dataset includes many measures of health, a choice should be made to asses which health measure covers the wide concept of 'health status' best. Kools and Knoef (2017) use the limitations in activities of daily living (ADL) as their main health measure. The SHARE dataset includes a question in which respondents are asked whether they experience any difficulties with the listed activities because of physical, mental, emotional or memory problem. They are asked to exclude any difficulties that are expected to last less than three months. These 15 different activities listed can be categorized into six categories including dressing, bathing/showering, getting in or out of bed, walking, eating and using the toilet. In line with Kools and Knoef (2017), this paper identifies individuals to be limited when they have one or more problems with ADL. Figure 2 presents the prevalence of limitations in activities of daily living at different ages. The graph illustrates that as individuals age, they experience more difficulties with activities of daily life.

There are two advantages of using ADL as a proxy for health. The first advantage regards the fact that this measure is relatively objective. As was mentioned before, since the dependent variable is partly subjective, using a subjective measure for one of the variables can lead to spurious results due to correlated measurement error (Finkelstein et al., 2008). Using ADL as a proxy for health limits this bias since, compared to other health measures, this proxy is more objective. Whether an individual experiences physical limitation to perform certain activities is less dependent on one's personal perspective than other measures like self-perceived health status. Another argument in favor of ADL as a proxy for health in the baseline model is that this variable measures physical limitations, and that these physical limitations are assumed to be a mediating factor between health and consumption (Kools and Knoef, 2017). It directly measures the impact of an adverse health shock on everyday life. For other health indicators that measure a range of different illnesses, like number of chronic diseases, it is harder to indicate how these different diseases impact everyday life. As a result, estimated results are hard to interpret. In the sample used in this paper, 15 percent experience more than one limitation is ADL.

Figure 2: Prevalence of limitations in activities of daily living at different ages



4.4 Income and assets

The SHARE dataset contains data on income, assets and housing wealth. As an indicator of lifetime income, this paper uses the imputation of total household net income provided by SHARE. This measure is obtained by aggregating several individual income components at the household level. These components include earnings from employment and self-employment, income from the other household member, various pension and sickness related payments, regular payments from private transfers and income from rent and interest.

In order to formulate a measure of lifetime income, the average of each individual over all the waves is calculated[4]. Since elderly households may be spending down their accumulated financial savings, common practice in research is to control for this by taking account of net financial assets (Finkelstein et al., 2008). In order to see whether this influences the results, five

[4] Since the model controls for household size, it was chosen not to use the OECD equivalence scale to equivalize to a one-person household.

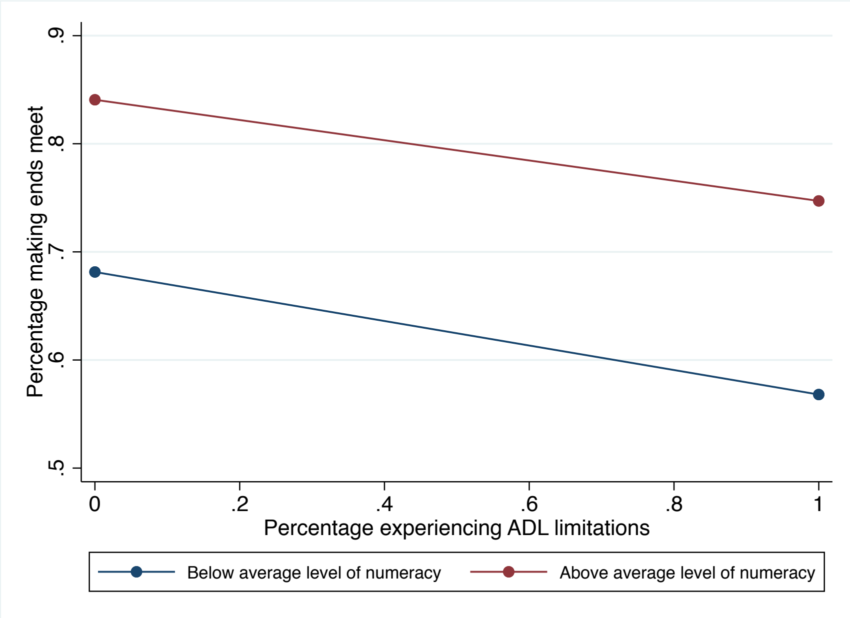
percent of net financial assets was aggregated to total household net income. However, since this did not significantly influenced results, this measure is not included in the baseline model[5]. For the selected sample, the average net household income is €34.286 per year and the median is €24.011. Since the median is substantially lower than the average, net household income is right skewed. Apparently, there are some individuals within the sample with a very high level of income. Moreover, the average lifetime income within the sample is €35.566 per year with a median of € 25.943.

4.5 Numeracy

As this paper also intends to investigate the effect of numeracy on the level of health state dependence, data on this topic needs to be included. As part of the SHARE questionnaire, respondents are asked to answer four numeric questions[6]. These answers are aggregated and translated into a score ranging from one till five, which is included in the model. This research defines someone to be numerate if the score that person received in the numeracy test is more than the average in the sample. Figure 3 presents financial satisfaction across numeracy and health. In a similar vein as Figure 1, the y-axis represents the percentage of individuals who reported that they can fairly easily or easily make ends meet. The graph illustrates that individuals who experience more physical limitations find is harder to make ends meet. Moreover, conditional on the health status of the individual, people with a higher level of numeracy experience a higher level of financial wellbeing. This could indicate that numeracy does influence the interaction between financial wellbeing and health status.

[5] Appendix C reports estimates when using net household income plus 5 percent of net financial assets as a measure of lifetime income.
[6] Please refer to Appendix A for the exact wording of the questions.

Figure 3: Financial satisfaction across numeracy and health



5 Main results

5.1 Baseline Results

Column (1) of Table 2 presents the baseline estimation results of equation (19). The coefficient β_3 is negative and significant at a one percent level. This implies that when individuals experience an adverse health shock, it will result in deteriorating financial wellbeing. Moreover, the coefficient estimating the relation between lifetime income and financial wellbeing, β_4, is positive and significant. Hence suggesting that utility increases when income is higher. These finding indicate that the chosen utility proxy is sensible. Since $\bar{Y}$ is demeaned, the coefficient $\beta_3$of -0.0617 (s.e = 0.015) indicates that for an individual with average lifetime income, the utility level of a person with at least 2 ADL limitations is 0.0617 units lower than that of the other persons. This finding is identified within-person using variation in the health status over time. The coefficient β_4 has a value of 0.342 (s.e.= 0.010), which indicates that a 10 percent increase in lifetime income would result in the average level of utility to increase by 0.034 units. This is a rational finding since having more income directly results in being better able to make ends meet. However, as was mentioned by Finkelstein et al. (2008), who use a similar model, this coefficient is based on a cross-sectional comparison of financial wellbeing for individuals with different levels of lifetime income. There could be other characteristics of individuals with high levels of lifetime income that are as well determinants of financial wellbeing. Hence, β_4 could indicate a combination of effects and therefore one should be cautious when interpreting the causal effect of lifetime income on financial wellbeing. Moreover, Table 2 presents an estimate of β_1, which is the coefficient related to the interaction between health and lifetime income, one of the main variables of interest in the model. This coefficient is estimated to be -0.0545 (s.e. = 0.0206) and is significant at a one percent level. From this it can be concluded that the marginal utility of lifetime income declines as health deteriorates. Hence the model implies negative state dependence: the marginal utility of consumption is higher in a state of good health than in a state of bad health.

Panel B of Table 2 reports the percentage change in marginal utility for a one unit increase in ADL limitations, and the percentage change in marginal utility for a one standard deviation increase in ADL limitations. This second term in included in order to be able to compare the results of different kind of proxies for health status. By using the standard deviation change, both the scale and the severity of the adverse health shock can be taken into account. The ratio of (β_1/β_4) is estimated to be -0.159. This implies that when an individual who is healthy experiences an adverse health shock, the marginal utility declines with 15.9 percent. Correspondingly, the ratio $(\sigma\beta_1/\beta_4)$ gives a value of -0.030, which indicates that a one standard deviation increase in the probability of being limited in activities of daily living is associated with a 3 percent decline in marginal utility for an individual who was healthy before.

In order to compare results, the model of Finkelstein et al. (2008) was imitated to measure health state dependence[7]. The results indicated almost the same parameters β_1 and β_4, and therefore the same level of health state dependence. However, it should be pointed out that estimated equation (19) is much simpler and does not involve bootstrapping.

Looking at the other parameters in the model, several observations can be noticed. Firstly, the coefficient related to household size is positive and significant at a five percent level. This indicates that if individuals switch from renting a home to buying one, they experience less difficulties with making ends meet. Secondly, the size of the household has a positive effect on being able to make ends meet. Since this model only includes household with 1 or 2 persons, this implies that singles express lower levels of financial satisfaction. Another variable that is controlled for in the model is the level of education. The coefficient related to this covariate is positive and significant. Hence, from this it can be inferred that within the sample, individuals who have an education level of college or higher can more easily make ends meet. Interestingly, gender does not seem to influence financial wellbeing.

[7] This method involved running a fixed effects regression to find estimates for β_1 and β_3, and an additional auxiliary regression to find estimates for β_4.

Table 2: Estimated magnitude of state dependent utility

	(1) Baseline
B. Estimation Results	
Health x ln($\bar{Y}$); β_1	-0.0545***
	(0.0206)
Health; β_3	-0.0617***
	(0.0150)
ln($\bar{Y}$); β_4	0.342***
	(0.0100)
Household size	0.0527**
	(0.0232)
Age squared	3.37e-05***
	(1.27e-05)
Male	-0.00444
	(0.00790)
Home owner	0.0595***
	(0.0194)
High education	0.195***
	(0.0119)
Constant	2.649***
	(0.0383)
Observations	61,883
Number of individuals	32,813
B. Interpretation	
Health state dependence parameter (β_1/β_4)	-0.159
	(0.0604)
($\sigma\beta_1/\beta_4$)	-0.030
	(0.0114)

Estimated using a linear random effects model with Mundlak specifications and clustered standard errors. Panel A reports coefficients β_1, β_3 and β_4 from estimated equation (19). Besides the covariates shown in the table, dummies for country and wave, and Mundlak terms are included. Panel A and B: Robust standard errors in parentheses. The within-standard deviation change in health (σ) is 0.189.*** p<0.01, ** p<0.05, * p<0.1.

5.2 Numeracy

The effect of numeracy is not included in the baseline model. However, since research has shown that financial literacy is positively related to retirement planning and the development of a savings plan, this paper investigates whether it influences health state dependence (Suari-Andreu et al., 2017). The direction of this effect is expected to be positive as more financially literate people are better able to save part of their earnings as a buffer in case of unexpected shocks. Hence, they are less compelled to change their consumption behavior in case of an adverse health shock. When including a measure for numeracy in the model, the coefficient indicating the effect on financial satisfaction was positive yet insignificant. Hence, there seems to be a positive association between numeracy and the level of financial wellbeing. In order to investigate whether this relation is affected by the level of education, the model was run excluding the variable indicating level of education. This did not significantly influence results. To further explore the association between level of numeracy, financial wellbeing and health state dependence, the sample was split. Table 3 presents the results. In column (2), estimates are presented when the sample is limited to individuals who have a higher than average level of numeracy within the full sample used in this research. When only considering this limited sample, the estimate for β_1 is negative but not significant, implying that there does not seem to be health state dependence. However, column (3) illustrates different results for the limited sample based on individuals with a lower than average level of numeracy. The coefficient β_1 is estimated to be -0.0607 and is significant at a one percent level. Moreover, the ratio indicating health state dependence is -0.177. When a healthy individual with a lower than average numeracy level experiences an adverse health shock, the marginal utility declines with 17.7 percent, which is higher than the 15.9 percent found in the baseline model. Hence, individuals with a lower level of numeracy appear to show a higher level of negative health state dependence. In case this group experiences an adverse health shock, the utility they derive from lifetime income decreases more than for individuals with a higher level of numeracy. It could be the case that individuals with a low level of numeracy experience negative health shock as a greater setback than individuals who are more financially literate. They might have saved less during their lifetime and consequently have less money to deal with potential consequences of the health shock. Therefore, their wealth is more severely affected. To conclude, as was expected, numeracy positively influences health state dependence.

Table 3: Results on analysis numeracy

	(1) Baseline	(2) High Numeracy	(3) Low Numeracy
A. Estimation Results			
Health x $\ln(\bar{Y})$; β_1	-0.0545***	-0.0210	-0.0607**
	(0.0206)	(0.0348)	(0.0275)
Health; β_3	-0.0617***	-0.0510**	-0.0708***
	(0.0150)	(0.0220)	(0.0219)
$\ln(\bar{Y})$; β_4	0.342***	0.322***	0.343***
	(0.0100)	(0.0137)	(0.0141)
Numeracy		-0.0168	0.0244
		(0.0237)	(0.0191)
Household size	0.0527**	0.0529	0.0539*
	(0.0232)	(0.0333)	(0.0316)
Age squared	3.37e-05***	9.70e-06	6.88e-05***
	(1.27e-05)	(1.88e-05)	(1.75e-05)
Male	-0.00444	-0.00636	0.0324***
	(0.00790)	(0.0110)	(0.0113)
Home owner	0.0595***	0.0187	0.0862***
	(0.0194)	(0.0262)	(0.0280)
High education	0.195***	0.146***	0.185***
	(0.0119)	(0.0159)	(0.0195)
Constant	2.649***	2.507***	2.381***
	(0.0383)	(0.0762)	(0.0586)
Observations	61,883	28,017	33,820
Number of individuals	32,813	14,989	18,938
B. Interpretation			
Health state dependence parameter (β_1/β_4)	-0.159	-0.065	-0.177
	(0.0604)	(0.1082)	(0.0807)
$(\sigma\beta_1/\beta_4)$	-0.030	-0.010	-0.035
	(0.0114)	(0.0177)	(0.0162)

Estimated using a linear random effects model with Mundlak specifications and clustered standard errors. Panel A reports coefficients β_1, β_3 and β_4 from estimated equation (19). Besides the covariates shown in the table, dummies for country and wave, and Mundlak terms are included. Panel A and B: Robust standard errors in parentheses. The within-standard deviation change in health (σ) is 0.189. *** p<0.01, ** p<0.05, * p<0.1.

6 Robustness checks

A large number of robustness tests have been performed on the baseline results from column (1) of Table 2. Firstly, it was investigated whether the health state dependence parameter is sensitive to alternative health measures. Secondly, analyses have been performed to see whether the functional form affects results. Thirdly, different utility proxies have been tested. Lastly, some other additional analyses are presented. In this and all other tables, Column 1 replicates the baseline results from Table (2). Subsequent columns report results for a specified change to the baseline model. In order to facilitate comparability of the implied health state dependence, the ratio (β_1/β_4), is presented at the bottom of each column. Moreover, the implied percent change in marginal utility for healthy individuals associated with a one-standard-deviation decline in health is provided $(\sigma\beta_1/\beta_4)$. In this way, estimates can be compared in a scale-free way.

6.1 Alternative health measures

In order to improve understanding of the mechanisms underlying health state dependence, the model is re-estimated using several other health measures. Data is used on instrumental activities of daily living (IADL), the number of chronic diseases and self-perceive health status. Table 4 presents the summary statistics for the various health measures[8].

Table 4: Summary statistics for health variables

	N	mean	sd	min	max
Limitation in ADL	61,883	0.15	0.36	0	1
Limitation in IADL	61,883	0.23	0.42	0	1
Number of chronic diseases	61,883	2.04	1.59	0	13
Self-perceived health	61,853	0.78	0.41	0	1

The results of the regressions can be found in Table 5. Firstly, the model is run including a measure that indicates having problems with instrumental activities of daily living. In contrast to ADL limitations, IADL limitations are slightly milder, occur earlier in life and are therefore more prevalent. This statement is supported by Table 3, which shows that the mean of limitations of IADL is higher than for ADL. The SHARE survey includes a question in which the respondents are given a list of 15 activities and are asked to state if they have any difficulty

[8] Please refer to Appendix D for figures illustrating the prevalence of the various health measures as age progresses.

with these activities because of a physical, mental, emotional or memory problems. Examples of these activities are shopping for groceries, taking medications and making telephone calls. In line with the method used before, individuals are defined as limited when they state that they have more than one limitation in IADL. Column (2) of Table 5 shows the estimated results from the regression with IADL as a measure of health. Even though coefficient β_3 is significant and has the same sign as in the baseline regression, the coefficient β_1 ,that indicates health state dependence, in insignificant. Hence this implies that when people experience an adverse health shock measured as an increase in limitations with instrumental activities of daily living, this does not significantly affect their marginal utility of consumption.
Moreover, a measure of self-perceived health could be used as a proxy for health status. One of the questions asked in the SHARE questionnaire is as follows: 'Would you say your health is…". Respondents can answer by choosing either one of the categories (1) excellent, (2) very good, (3) good, (4) fair, or (5) poor. This paper defines a person to have a low level of self-perceived health if the individual reported lower than a good level of self-perceived health. As this measure is highly subjective, errors may be correlated and therefore could bias the results. However, as the measure of financial wellbeing has subjective as well as objective components, this paper does include this measure as a robustness check. Column (3) of Table 5 provides the results of the regression including self-perceived health. As with the measure used in the previous analysis, no health state dependence is found.
Another candidate that is often used in research to measure health status is the number of chronic diseases. Finkelstein et al. (2008) include this measure in their baseline model. They considered seven diseases that are frequently used in research[9]. These particular diseases are chosen because they are considered not to be subjective, again preventing the occurrence of correlated measurement error. In line with this reasoning, this paper also uses the number of chronic diseases as one of the methods to measure health status. The SHARE questionnaire defines chronic diseases as those that has troubled an individual over a period of time or is likely to affect one over a period of time. The questionnaire contains a question where respondents are shown a list of 20 chronic diseases and are asked to state the amount of diseases that the doctor has told them they have. Kools and Knoef (2017) select seven different chronic diseases to construct a measure. However, this paper decided to include all the listed chronic diseases. Colum (4) in Table 5 reports the results. As was expected, the parameter $\beta_4$is negative and significant. Having more chronic diseases negatively influences financial wellbeing. However, since β_1 is positive but insignificant, no health state dependence is found.
From these analyses it can be concluded that the health state dependence parameter is very sensitive to the health measure chosen.

[9] These diseases include hypertension, diabetes, cancer, heath disease, chronic lung disease, stroke and arthritis.

Table 5: Results for alternative health measures

	(1) Baseline	(2) Limitations in IADL	(3) Self-perceived health	(4) Number of chronic diseases
A. Estimation Results				
Health x $\ln(\bar{Y})$; β_1	-0.0545***	-0.0172	0.0258	0.00285
	(0.0206)	(0.0171)	(0.0171)	(0.00492)
Health; β_3	-0.0617***	-0.0580***	-0.0444***	-0.00815**
	(0.0150)	(0.0126)	(0.0115)	(0.00362)
$\ln(\bar{Y})$; β_4	0.342***	0.328***	0.264***	0.316***
	(0.0100)	(0.0103)	(0.0135)	(0.0122)
Household size	0.0527**	0.0534**	0.0544**	0.0538**
	(0.0232)	(0.0232)	(0.0232)	(0.0232)
Age squared	3.37e-05***	4.06e-05***	3.29e-05***	2.06e-05
	(1.27e-05)	(1.27e-05)	(1.27e-05)	(1.26e-05)
Male	-0.00444	0.00828	-0.00434	0.00221
	(0.00790)	(0.00792)	(0.00790)	(0.00789)
Home owner	0.0595***	0.0599***	0.0600***	0.0600***
	(0.0194)	(0.0194)	(0.0194)	(0.0194)
High education	0.195***	0.192***	0.183***	0.194***
	(0.0119)	(0.0119)	(0.0119)	(0.0118)
Constant	2.649***	2.632***	2.820***	2.742***
	(0.0383)	(0.0382)	(0.0384)	(0.0380)
Observations	61,883	61,883	61,853	61,883
Number of individuals	32,813	32,813	32,799	32,813
B. Interpretation				
Health state dependence parameter (β_1/β_4)	-0.159	-0.053	0.098	0.009
	(0.0604)	(0.0522)	(0.0649)	(0.0156)
($\sigma\beta_1/\beta_4$)	-0.030	-0.012	0.021	0.007
	(0.0114)	(0.0116)	(0.0137)	(0.0116)

Estimated using a linear random effects model with Mundlak specifications and clustered standard errors. Panel A reports coefficients β_1, β_3 and β_4 from estimated equation (19). Besides the covariates shown in the table, dummies for country and wave, and Mundlak terms are included. Panel A and B: Robust standard errors in parentheses. The within-standard deviation change in health (σ) is 0.189 for the baseline, 0.222 for limitations in IADL, 0.212 for self-perceived health and 0.747 for number of chronic diseases. *** p<0.01, ** p<0.05, * p<0.1.

6.2 Choice of Functional form

A second set of robustness tests investigates whether the functional form of the model has a large impact on the size of the coefficients. The baseline regression is provided in column (1), which was the random effects approach with Mundlak specifications. To test for robustness, an OLS regression, a fixed effects regression and an ordered probit model are run [10]. In line with the research by Mundlak (1987), it was found that the coefficients when using a fixed effects model are similar to the baseline model. Minor differences can be observed between the coefficients, however they do not affect size and significance. Moreover, an ordinary least squares (OLS) is run. Both the sign and the significance level of the estimated coefficients are comparable to the baseline model and the estimated health state dependence parameters are very similar (-0.159 compared to -0.148). Additionally, the model is estimated using an ordered probit model. Column (2) of Table 6 presents the results. The table indicates that changing the functional form does not significantly affect size and level of significance of the coefficient found in the baseline model. From this it can be concluded that the results found in the model are not sensitive to the choice of the functional form.

[10] Please refer to Appendix B for the exact estimates of these regressions and other robustness checks.

Table 6: Robustness functional form

	(1) Baseline	(2) Ordered probit
A. Estimation Results		
Health x $\ln(\bar{Y})$; β_1	-0.0545***	-0.0703**
	(0.0206)	(0.0293)
Health; β_3	-0.0617***	-0.0888***
	(0.0150)	(0.0218)
$\ln(\bar{Y})$; β_4	0.342***	0.520***
	(0.0100)	(0.0152)
Household size	0.0527**	0.0691**
	(0.0232)	(0.0319)
Age squared	3.37e-05***	4.65e-05***
	(1.27e-05)	(1.77e-05)
Male	-0.00444	-0.00991
	(0.00790)	(0.0116)
Home owner	0.0595***	0.0785***
	(0.0194)	(0.0272)
High education	0.195***	0.283***
	(0.0119)	(0.0186)
Constant	2.649***	
	(0.0383)	
Observations	61,883	61,883
Number of individuals	32,813	
B. Interpretation		
Health state dependence parameter (β_1/β_4)	-0.159	-0.135
	(0.0604)	(0.056)
($\sigma\beta_1/\beta_4$)	-0.030	-0.026
	(0.0114)	(0.0107)

Estimated using a linear random effects model with Mundlak specifications and clustered standard errors. Panel A reports coefficients β_1, β_3 and β_4 from estimated equation (19). Besides the covariates shown in the table, dummies for country and wave, and Mundlak terms are included. Panel A and B: Robust standard errors in parentheses. The within-standard deviation change in health (σ) is 0.189 for the baseline and 0.189 for column (2). *** p<0.01, ** p<0.05, * p<0.1.

6.3 Choice of utility proxy

To further test for robustness, health state dependence is re-estimated using different proxies for utility. The SHARE database includes the EURO-D scale, a measure which has been validated by an earlier cross-European study of depression prevalence (Prince et al., 1998). This variable has a 12-point scale in which 0 indicates that the individual is not depressed, while 12 indicates that an individual experiences a severe form of depression. The second column of Table 7 presents the results when measuring the model with this proxy for utility[11]. The variable has desirable properties for a utility proxy since it decreases in number of diseases ($\beta_3 < 0$) and increasing in lifetime income ($\beta_4 > 0$). However, the sign of β_1 is positive, indicating positive health state dependence. Moreover, the estimate of the ratio (β_1/β_4) is 1.646, which indicates that when a healthy individual experiences an adverse health shock, the marginal utility increases with 165 percent. This result seems to be implausible.

Furthermore, it was stated before that subjective wellbeing is often used as a proxy for utility. Finkelstein et al. (2008) use the answer to the question: "Much of the time during the past week I was happy. (Would you say yes or no?)". In a similar vein, the SHARE questionnaire includes a question concerning life satisfaction. Respondents are asked the following question: "On a scale from 0 to 10 where 0 means completely dissatisfied and 10 means completely satisfied, how satisfied are you with your life?". Column 3 presents the results when the model is estimated using life satisfaction as a proxy for utility. Since the answering style of the life satisfaction question was different in the questionnaire of wave 1, this wave is dropped for this part of the analysis. The results are presented in column (3) of Table 7. Again, this proxy for utility seems sensible since it decreases in number of diseases ($\beta_3 < 0$) and increasing in lifetime income ($\beta_4 > 0$). However, the value of β_1 is not significant and therefore no conclusions can be drawn regarding health state dependence.

These results indicate that the results on the health state parameter are very sensitive to the choice of utility proxy.

[11] In order to find proper results, the variable was recoded such that 12 corresponds to higher utility.

Table 7: Alternative utility proxies

	(1) Baseline	(2) Depression	(3) Life satisfaction
A. Estimation Results			
Health x $\ln(\bar{Y})$; β_1	-0.0545***	0.166***	0.0631
	(0.0206)	(0.0574)	(0.0478)
Health; β_3	-0.0617***	-0.613***	-0.245***
	(0.0150)	(0.0406)	(0.0341)
$\ln(\bar{Y})$; β_4	0.342***	0.101***	0.214***
	(0.0100)	(0.0191)	(0.0158)
Household size	0.0527**	0.439***	0.280***
	(0.0232)	(0.0598)	(0.0578)
Age squared	3.37e-05***	-0.000345***	-0.000191***
	(1.27e-05)	(3.30e-05)	(4.02e-05)
Male	-0.00444	-0.701***	0.00571
	(0.00790)	(0.0208)	(0.0168)
Home owner	0.0595***	0.0960**	0.0121
	(0.0194)	(0.0479)	(0.0432)
High education	0.195***	0.224***	0.103***
	(0.0119)	(0.0290)	(0.0234)
Constant	2.649***	10.64***	7.467***
	(0.0383)	(0.100)	(0.0807)
Observations	61,883	59,834	52,732
Number of individuals	32,813	32,139	28,148
B. Interpretation			
Health state dependence parameter (β_1/β_4)	-0.159	1.646	0.294
	(0.0604)	(0.6446)	(0.2244)
($\sigma\beta_1/\beta_4$)	-0.030	0.300	0.053
	(0.0114)	(0.1176)	(0.0406)

Estimated using a linear random effects model with Mundlak specifications and clustered standard errors. Panel A reports coefficients β_1, β_3 and β_4 from estimated equation (19). Besides the covariates shown in the table, dummies for country and wave, and Mundlak terms are included. Panel A and B: Robust standard errors in parentheses. The within-standard deviation change in health (σ) is 0.189 for the baseline, 0.182 for column (2) and 0.181 for column (3). *** p<0.01, ** p<0.05, * p<0.1.

6.4 Additional sensitivity analyses

In line with the working paper of Finkelstein et al. (2008), several additional analyses have been done. A full set of results from these additional sensitivity analyses are presented in Appendix C. The main results are briefly summarized in this section. It is found that the results are not sensitive to excluding the demographic controls (X_{it}). Moreover, research has suggested that individuals partly adapt to disability (Oswald and Powdthavee, 2007). They state that an adverse health shock has a larger effect on utility in the short run than in the long run. If this 'habituation effect' is indeed present, it could be the case that this would also influence the marginal utility. Estimated results show that the marginal utility after a negative health shock does not appear to diminish over time and therefore no evidence is found of a habituation effect. Lastly, estimates could be confounded by correlations in health changes within a couple and the health of one's spouse could influence an individuals' own marginal utility. Therefore, the regression was run when restricting the sample to singles. Results do not significantly change when only considering singles.

7 Conclusion

This paper investigates the effect of health on marginal utility of consumption for the elderly population in Europe. A method is used that is based on the approach of Finkelstein et al. (2008) and includes Mundlak (1978) variables to account for correlated unobserved heterogeneity. Even though similar parameters and health state dependence were found when imitating the method adopted by Finkelstein et al. (2008), the approach used in this paper is simpler and does not involve bootstrapping. In line with Kools and Knoef (2017), financial wellbeing is used as the primary proxy for utility instead of overall wellbeing. As was argued before, using this utility proxy is advantageous since it is not needed to control for direct and indirect effects of health on subjective wellbeing that are unrelated to consumption. Moreover, it results in lower correlated measurement error.

The model is implemented using four waves of panel data from the Survey of Health, Ageing and Retirement in Europe (SHARE). The baseline results show that when an individual who is healthy experiences an adverse health shock, the marginal utility declines with 15.9 percent. Correspondingly, the point estimate of the baseline specification indicates that, relative to marginal utility of consumption when the individual had no limitations in activities of daily living (ADL), a one-standard deviation increase in an individuals' limitations in ADL is associated with a 3 percent decline in marginal utility. Evidence is provided that results are robust against a range of alternative specifications. Moreover, a similar approach as Finkelstein et al. (2008) based on overall wellbeing and number of chronic diseases was applied. Contrasting to the baseline results, when using overall wellbeing as a proxy for utility and when using number of chronic diseases as a measure for health, no health state dependence was observed. This is at odds with the findings of Finkelstein et al. (2008), who found negative health state dependence. Unfortunately, this indicates that the findings are very sensitive to the chosen proxy for utility and the choice of health measure.

Another part of the analysis concerns the effect of numeracy. Results indicate that there is a positive association between numeracy and health state dependence. For the group of individuals within the sample with a higher than average level of numeracy, no health state dependence was found. On the other hand, individuals with a lower level of numeracy appear to show a higher level of negative health state dependence. The ratio indicating health state dependence for this group is -0.177. When a healthy individual with a lower than average numeracy level experiences an adverse health shock, the marginal utility declines with 17.7 percent, which is higher than the 15.9 percent found in the baseline model. Hence, individuals with a lower level of numeracy appear to show a higher level of negative health state dependence. In case this group experiences an adverse health shock, the utility they derive from lifetime income decreases more than for individuals with a higher level of numeracy. Hence, as was expected, numeracy positively influences health state dependence.

Health state dependence has several consequences for economics questions such as the optimal savings rate and the optimal level of health insurance. Negative health state dependence suggests that, compared to assuming no health state dependence, individuals receive less utility from consumption when experiencing a negative health shock. As was mentioned in the introduction, the trend of global population ageing has resulted in many high-income countries undertaking reforms in their pension systems by raising the statutory pensionable age, reducing benefits or increasing contribution rates. Moreover, many countries have proposed or are implementing reforms that make long-term care insurance less generous. If it is indeed the case that negative health state dependence is observed, the findings of this research would support these trends in policy changes. Since health deteriorates with age, negative health state dependence implies that the ageing population receives less utility from consumption. Consequently, this results in lower levels of optimal health care insurance and optimal saving rates. Moreover, the observation that numeracy positively influences health state dependence could have implications for government policies. Since no health state dependence was found for individuals with a high level of numeracy, a government stepping back and handing over responsibilities to citizens has less implications for this group. On the other hand, it was found that individuals with a lower level of numeracy experience a higher decline in marginal utility of consumption when their health deteriorates. Individuals with lower levels of numeracy, who already find it harder to make ends meet, will even experience more difficulties when governments hand over responsibilities to citizens. Hence, governments could consider providing funded financial education to raise their level of financial literacy and consequently lower the negative implications that an adverse health shock might have on their marginal utility.

Even though many robustness tests have been done, it should be noted that the findings reported in this paper are sensitive to various assumptions. Beside the choice of the proxies for health and utility, other assumptions that were made that might have influenced the results. An example is the chosen parameter for relative risk aversion. Furthermore, in the model we assume that individuals are rational and do not procrastinate. In future research, this could be improved by for example considering hyperbolic discounting. As was noted before, even though this paper argues in favor of financial satisfaction as a proxy for utility, this measure does not perfectly represent utility. More research could be done to find a more ideal measure. The findings done in this paper raise several questions for further research. This research assumes that all the countries in the samples have similar (long-term) health care systems. It would, however, be very interesting to investigate whether there are differences in level of health state dependence between countries within Europe. Due to a lack of data, it was not possible to do these analyses for each country separately. However, by considering each country separately, differences in countries health insurance policies could be taken into account. Additionally, countries with a more generous health care system could be taken apart to see whether health state dependence in these countries differs. Moreover, it was found that the health state dependence parameter is very sensitive to the chosen utility proxy and the chosen measure for health. This could be due to correlated measurement error. Further research needs to be done to explain this observation. Lastly, besides financial literacy, the level of knowledge regarding health could impact health state dependence. Developing a questionnaire to test for health literacy could be interesting. If it would be found that low levels of health literacy negatively influences health state dependence, governments could intervene by providing information regarding health and how this can influence daily life.

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Appendices

Appendix A SHARE Questions numeracy

Next, I would like to ask you some questions which assess how people use numbers in everyday life.

1. If the chance of getting a disease is 10 per cent, how many people out of 1000 (one thousand) would be expected to get the disease?
    a. 100
    b. 10
    c. 90
    d. 900
    e. Other answer

2. In a sale, a shop is selling all items at half price. Before the sale, a sofa costs 300. How much will it cost in the sale?
    a. 150
    b. 600
    c. Other answer

3. A second-hand car dealer is selling a car for 6000. This is a two-thirds of what it costs new. How much did the car cost new?
    a. 9000
    b. 4000
    c. 8000
    d. 12000
    e. 18000
    f. Other answer

4. Let's say you have 2000 in a savings account. The account earns ten percent interest each year. How much would you have in the account at the end of two years?
    a. 2420
    b. 2040
    c. 2100
    d. 2200
    e. 2400
    f. Other answer

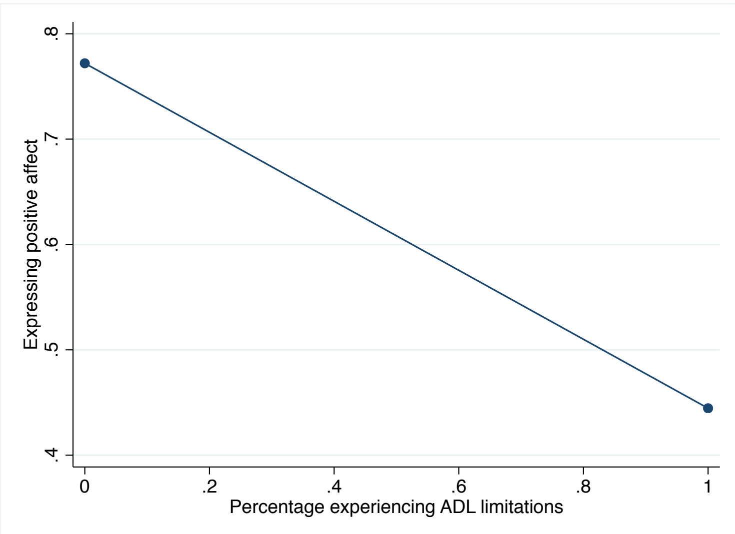
Appendix B Additional Robustness checks

This section presents supplementary material for the robustness test performed in section 6. Firstly, differential item functioning is discussed. Moreover, estimates discussed in section 6.2 regarding the functional form are presented.

B.1 Differential item functioning

Biases in reporting may be due to time-varying optimism or pessimism. Kools and Knoef (2017) included measures of positive and negative affect to the regressions by using questions from the EURO-D depression scale. This research also performs an analysis to test for biases in reporting. Two variables are generated to represent both positive and negative affect. In line with Dewey and Prince (2005), this research defines clinically significant depression as a EURO-D score greater than three. This cut point has been validated by previous research against a variety of clinically relevant indicators. Individuals with a level higher than three, would likely be diagnosed as suffering from a depressive disorder, for which therapeutic intervention would be indicated. The dummy for negative affect is constructed by including all responses that are higher than the average level of depression in the sample. In the same manner, the dummy for positive affect represents the respondents who expressed a lower than average level of depression. As shown in figure B1, individuals with ADL limitations tend to experience fewer positive feelings.

Figure B1: Positive affect and ADL limitations



Results are presented in column (2) of Table B2. It can be observed that when including the measure of positive affect to the regression, the estimated health state dependence is still negative and significant at a one percent level. Therefore, it can be concluded that reporting error in ability to make ends meet does not seem to drive results.

Table B2: Additional Robustness checks

	(1) Baseline	(2) PA/NA	(3) Fixed effects	(4) OLS
B. Estimation Results				
Health x $\ln(\bar{Y})$; β_1	-0.0545***	-0.0555***	-0.0536***	-0.0546***
	(0.0206)	(0.0211)	(0.0206)	(0.0206)
Health; β_3	-0.0617***	-0.0444***	-0.0626***	-0.0618***
	(0.0150)	(0.0153)	(0.0150)	(0.0150)
$\ln(\bar{Y})$; β_4	0.342***	0.342***		0.367***
	(0.0100)	(0.0100)		(0.00976)
Household size	0.0527**	0.0472**	0.0544**	0.0525**
	(0.0232)	(0.0237)	(0.0232)	(0.0232)
Age squared	3.37e-05***	4.49e-05***	0.000173*	3.33e-05***
	(1.27e-05)	(1.28e-05)	(9.92e-05)	(1.28e-05)
Male	-0.00444	0.0139*		-0.00887
	(0.00790)	(0.00798)		(0.00809)
Home owner	0.0595***	0.0582***	0.0597***	0.0597***
	(0.0194)	(0.0198)	(0.0194)	(0.0194)
High education	0.195***	0.188***		0.176***
	(0.0119)	(0.0119)		(0.0121)
Positive affect		0.167***		
		(0.00813)		
Constant	2.649***	2.495***	2.015***	2.684***
	(0.0383)	(0.0392)	(0.453)	(0.0389)
Observations	61,883	59,834	61,883	61,883
R-squared			0.018	0.253
Number of individuals	32,813	32,139	32,813	
B. Interpretation				
Health state dependence parameter (β_1/β_4)	-0.159	-0.162		-0.149
	(0.0604)	.061717		(0 .0563)
($\sigma\beta_1/\beta_4$)	-0.030	(-0.0296)		-0.028
	(0.0114)	(0.0112)		(0.0106)

Estimated using a linear random effects model with Mundlak specifications and clustered standard errors. Panel A reports coefficients β_1, β_3 and β_4 from estimated equation (19). Besides the covariates shown in the table, dummies for country and wave, and Mundlak terms are included. Panel A and B: Robust standard errors in parentheses. The within-standard deviation change in health (σ) is 0.189 for the baseline, 0.182 for column (2) and 0.189 for column (4). *** p<0.01, ** p<0.05, * p<0.1

Appendix C Additional sensitivity analyses

This section elaborates on the additional sensitivity analyses presented in section 6.4. Table C1 reports estimated results discussed in that section. Firstly, the baseline estimate is run without including the demographic variables. Column (2) of table C1 shows that the results are not sensitive to excluding the demographic controls (X_{it}). The coefficient β_1 is still negative and significant. Moreover, research has suggested that individuals partly adapt to disability (Oswald and Powdthavee, 2007). They state that an adverse health shock has a larger effect on utility in the short run than in the long run. If this 'habituation effect' is indeed present, it could be the case that this would also influence the marginal utility. In order to test this, a two-year lag of the baseline health measure is included in the model as well as an interaction term with lifetime income. Column (3) shows that the coefficient of lifetime income with the lagged variable of health is negative but insignificant. Therefore, it can be concluded that the decline in marginal utility does not seem to diminish over time after an individual has experienced an adverse health shock. Column (4) of table C1 provides the results of the regression in which an alternative measure of lifetime income is considered. Since elderly households may be spending down their accumulated financial savings, common practice in research is to control for this by taking account of net financial assets (Finkelstein et al., 2008). Hence, in order to see whether this influences the result, five percent of net financial assets is aggregated to total household net income. The results show that this change has no significant influence on the measure of state dependence. The fifth column shows the results of the regression when only including singles. The data shows that when the sample is restricted to individuals who are single, the point estimate of state dependence(β_1) is still negative. However, since this is based on just a small part of the original sample (18,913 observations), the estimate is no longer statistically significant.

Table C1: Additional sensitivity analyses

	(1) Baseline	(2) No Covariates	(3) Habituation effect	(4) Lifetime income (incl.assets)	(5) Singles
A. Estimation Results					
Health x $\ln(\bar{Y})$; β_1	-0.0545***	-0.0613***	-0.0763**	-0.0545***	-0.0507
	(0.0206)	(0.0207)	(0.0382)	(0.0206)	(0.0387)
Health; β_3	-0.0617***	-0.0153	-0.0413	0.130*	-0.0789**
	(0.0150)	(0.0149)	(0.0279)	(0.0700)	(0.0324)
$\ln(\bar{Y})$; β_4	0.342***	0.451***	0.432***	0.342***	0.338***
	(0.0100)	(0.00792)	(0.0143)	(0.0100)	(0.0185)
Household size	0.0527**		0.0366	0.0527**	
	(0.0232)		(0.0423)	(0.0232)	
Age squared	3.37e-05***		4.32e-05	3.37e-05***	8.94e-05***
	(1.27e-05)		(3.46e-05)	(1.27e-05)	(2.24e-05)
Male	-0.00444		-0.0239**	-0.00444	-0.149***
	(0.00790)		(0.0117)	(0.00790)	(0.0164)
Home owner	0.0595***		0.0188	0.0595***	0.00252
	(0.0194)		(0.0314)	(0.0194)	(0.0347)
High education	0.195***		0.108***	0.195***	0.192***
	(0.0119)		(0.0173)	(0.0119)	(0.0232)
Second lag health			-0.00289		
			(0.0293)		
Second lag health x $\ln(\bar{Y})$			-0.0650		
			(0.0405)		
Constant	2.649***	3.200***	3.052***	1.442***	2.706***
	(0.0383)	(0.00439)	(0.0556)	(0.0432)	(0.0740)
Observations	61,883	61,883	23,822	61,883	18,913
Number of individuals	32,813	32,813	16,486	32,813	10,424
B. Interpretation					
Health state dependence parameter (β_1/β_4)	-0.159	-0.136	-0.177	-0.159	-0.150
	(0.0604)	(0.0459)	(0.0886)	(0.0604)	(0.1147)
($\sigma\beta_1/\beta_4$)	-0.030	-0.026	-0.027	-0.030	-0.030
	(0.0114)	(0.0087)	(0.0133)	(0.0114)	(0.023)

Estimated using a linear random effects model with Mundlak specifications and clustered standard errors. Panel A reports coefficients β_1, β_3 and β_4 from estimated equation (19). Besides the covariates shown in the table, dummies for country and wave, and Mundlak terms are included. Panel A and B: Robust standard errors in parentheses. The within-standard deviation change in health (σ) is 0.189 for the baseline, 0.189 for column (2), 0.151 for column (3), 0.189 for column (4) and 0.200 for column (5). *** p<0.01, ** p<0.05, * p<0.1.

Appendix D Prevalence health measures at different ages

These figures illustrate the prevalence of the health measures used at different ages.

Figure D1: Prevalence health measures at various ages