Health Status and Portfolio Choice: Causality or Heterogeneity?

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Abstract

This paper explores the role of unobserved individual characteristics in the correlation between health and portfolio choice, from which a causal effect of health has been commonly suggested in previous studies based on cross-sectional variations. Our strategy focuses on comparing the OLS estimates with the results from panel-data methods. To make a robust inference on health effects, we construct four different indices to capture various dimensions of an individual’s health. The OLS results first present strong cross-sectional correlations between health and levels of various asset types, \(^2\) as well as between health and share of risky assets. \(^3\) Further, all these correlations are robust to the four constructed health measures and to the usage of lagged health variables. In sharp contrast, all the cross-sectional correlations between health and levels of various assets disappear in the fixed-effects (FE) model, highlighting the role of heterogeneity. However, the correlation between health and portfolio choice remains strong for at least two health indices in the FE model, suggesting that some health shocks motivate a safer portfolio – a result consistent with the prediction made by the background risks theory (Heaton and Lucas, 2000). Finally, further examinations indicate that the remarkable differences between the OLS and the FE estimates cannot be reconciled by measurement errors or sample attrition.

Key words: Health, Portfolio Choice, Heterogeneity, Causality

JEL Classification: G11, I1

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\(^2\) These include total assets, financial assets, non-financial assets, and risky assets.
\(^3\) We use two measures of risky assets holding – the incidence of holding risky assets and the proportion of risky assets in financial assets.
I. Introduction

The 1990s witnessed a remarkable growth in household wealth in many countries, high- and middle-income alike. As these assets constitute considerable resources in financial markets, discussions on attempts to understand households’ decisions on savings and portfolio choices have become prominent. In the past years, a large body of literature has examined various determinants of household wealth and portfolio choices. One recent development in this literature explores how health status is correlated with an individual’s financial management, mainly focusing on risky assets holding and portfolio choice. However, while a number of studies suggest that negative health shocks are associated with less risky financial management, the causality is less clearly identified, mainly because these studies are mostly conducted using the OLS method or the random-effects (RE) approach. In the OLS model, there may exist unobserved ‘third factors’ that drive the correlations. An example of such unobserved factors, as used in Hurd and Kapteyn (2003), is the subjective time preference across people that could plausibly cause variations in both health investment and assets holding, leading to correlations between the two over a long period. With regard to the RE model, a common threat to its validity is the strong assumption that the individual intercepts in the regression are random and uncorrelated with each explanatory variable in any time period.

The aim of this paper, therefore, is to reassess the causal relationship of the health-portfolio choice nexus after introducing a proper control for unobserved individual characteristics. Using a unique longitudinal data set that traces elderly (aged 60 or over) respondents for a relatively long period of time, we are able to tackle the heterogeneity

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4 In the US context, for example, per capita household wealth increased by 43.7% from 1989 to 2001, while financial wealth increased even more drastically in the same period, by 51.1% (Wolff, 2004).
5 RE estimates fail to be consistent if this assumption does not hold.
issue by exploiting variations in portfolio choices in the time dimension. More specifically, in order to assess the impact of heterogeneity, our analyses focus on comparing the OLS estimates and random-effect (RE) estimates with the results from the fixed-effects (FE) model.\textsuperscript{6}

Unlike most previous studies that draw inferences from estimated health effects based on just one health measure, in this paper we employ multiple health indices with each featuring some specific aspects of an individual health. Four different health indices are constructed based separately on (1) physical functions (PF); (2) chronic conditions (CC); (3) heart attack and stroke history (HASH); and (4) work-related health limitations (WRL). Using these measures, we are able to examine whether the health-assets nexus is robust to various dimensions of health.

Our empirical work produces multiple interesting findings. First, consistent with previous studies using the OLS method, our OLS results suggest a significantly positive correlation between health and the \textit{levels} of household total assets, financial assets, non-financial assets, the share of financial assets, and the share of risky assets\textsuperscript{7}. These correlations are robust to all the four health indices, and remain strong when we instead use lagged health measures. Second, in sharp contrast to the OLS results, the correlations between health and total assets, financial assets, and non-financial assets all disappear in the FE model. While further examination suggest that sample selection and measurement errors have a relatively limited influxes, the dramatic the dramatic differences between the OLS estimates and the FE estimates imply an influential role for heterogeneity. The

\textsuperscript{6} The hypothesis for comparing the OLS estimates and the FE estimates is that these two methods should present similar estimates of health effects on portfolio choice if heterogeneity bears no significant influence on the OLS estimates. Also, we implement the Hausman-Wu test on the hypothesis that the RE estimates are consistent.

\textsuperscript{7} In this paper, we categorize equities and mutual funds as risky assets.
results therefore suggest that the health-wealth correlations implied by cross-sectional variations could be misleading. Third, the coefficient estimates of the PF and the HASH on the probability of holding risky assets and on the share of risky assets remain statistically significant in the FE model. Moreover, these FE estimates are fairly close to the corresponding OLS figures. However, using the other two health measures (the CC and the WRL) does not produce any significant FE estimates. One possible argument that can reconcile the uneven FE estimates of health is that, compared with the CC or the WRL, adverse shocks on the PF and the HASH are more relevant of changes in the background risks\(^8\), prompting larger adjustments in portfolio choices. Fourth, the results from Hausman-Wu tests mostly reject the hypothesis that the RE estimates are consistent, so the FE model is preferred in these cases. Finally, our results underline the importance of using multiple health measures, as any single measure could be narrowly representative as other health dimensions are excluded.

The rest of the paper is organized as follows. In the next section, we provide a brief literature review, followed by an introduction of the data set as well as detailed definitions of the four health indices in Section 3. In Section 4, we graphically demonstrate the unconditional correlations between these health measures and various assets (and asset shares). We then present the identification strategies, followed by the corresponding regression results in Section 5. Finally, Section 6 concludes this paper.

\(^8\) See Eeckhoudt et al. (1996) for more details on the background risk. The rationale underlining the theory is that individuals’ decisions under uncertainty are usually made in the presence of various risks, some of which are exogenous, such as unpredictable weather changes, health shocks, or public insurance programs that are not directly under individuals’ control, for example. The “background risks” refers to the whole set of exogenous risks. The main implication of the theory is that individuals facing higher background risk tend to reduce risk-taking behaviors, acting as if they are more risk-averse.
II. Previous literature

Investors’ health status may affect their portfolio choices through multiple channels. Edward (2007), for example, suggests three possibilities. First, increments in background risks caused by adverse health shocks induce less risk-taking financial investment. Second, negative shocks in health reduce planning horizon and increase survival risk, but as the two effects work in opposite directions, the joint effect is ambiguous. Third, negative health shocks change marginal utility of current consumption relative to future consumption, leading to changes in financial decisions.

There is a growing literature that examines how negative health shocks are associated with asset holdings or portfolio choice. For example, Rosen and Wu (2004) and Berkowitz and Qiu (2006) both present a positive correlation between health and risky portfolio choice, using the random-effects model. Berkowitz and Qiu (2006) additionally show that the channel between health shock and portfolio choice is financial wealth change and they claim that health deterioration causes a decline in financial assets, which in turn leads to less risky asset holding. Further, Coile and Milligan (2006) document sharp declines in various assets after retirement, and their results suggest that health shocks play an important role in those declines of assets. Nonetheless, while their

Note that while these two studies use the same survey data – the US Health and Retirement Survey, they adopt different health measures in their analyses. Rosen and Wu (2004) employ the self-reported health status (SRHS) as the sole health measure. The SRHS refers to a self-assessment of health on a 1 to 5 scale, with 1 representing excellent health and 5 representing poor health. The results show that better SRHS is associated with both total wealth and financial assets holding and portfolio choices of the household. Berkowitz and Qiu (2006) use an indicator of newly-developed severe health conditions, including a heart problem, stroke, cancer or malignant tumor, lung disease and diabetes. Their RE results present a stronger health effect on financial assets than on non-financial assets. Also, the health effect on financial portfolio choice becomes insignificant after controlling for financial wealth of household. Accordingly, they conclude that negative health shocks cast significantly negative effects on financial wealth, and consequently make the household restructure their financial assets holdings.
results present a negative effect of chronic health shocks on risky assets holding\textsuperscript{10}, they find no such an effect on the \textit{share} of risky assets\textsuperscript{11}. Finally, instead of using traditional health measures, Edwards (2007) employs the self-assessed probability of future health events to proxy the health risk faced by an individual. He finds that a lower health risk is associated with a more risky investment, and the link is strongest for the elderly.

In a larger picture, the existing literature on the correlation of health and total assets is much more developed\textsuperscript{12}. Recent studies concentrate on identifying the causality direction between health and various measures of social-economic status (SES), mainly referring to income and wealth. These studies confront the endogeneity using approaches such as the instrumental variables method (Ettner, 1996; Meer et al., 2003; Lindahl, 2005), the Granger test (Adams et al, 2003), or institutional comparisons (Hurd and Kapteyn, 2003). While these attempts show a complex association between health and SES, the direction of causality found is more likely that health shocks lead to changes in income, rather than the reverse (Cutler et al., 2005).

Despite the increasing interest in the health effect on portfolio choices, very little has been done to address the concern about the heterogeneity. While some studies employ the RE model (Rosen and Wu, 2004 and Berkowitz and Qiu, 2006), the legitimacy of their results crucially depends on the assumption that the unobserved heterogeneity is uncorrelated with any covariate. One further attempt to address this issue is made by Rosen and Wu (2004), who control for the following four factors separately in their regression analysis – risk attitude, planning horizon, bequest motive, and entitlement to health insurance. Their results suggest that the estimated health effect is robust to

\textsuperscript{10} In their paper, assets that are categorized into the group of risky assets include IRAs, stocks, and bonds.  
\textsuperscript{11} The share refer to the proportion of risky assets out of total assets  
\textsuperscript{12} Please refer to Smith (1999) for a survey of earlier literature.
specifications with or without controlling for these characteristics. This method, however, cannot completely rule out the possibility that many other unobservable characteristics, such as time preference and innate ability, would also possibly induce the cross-sectional and intertemporal correlation. This paper, therefore, aims to further explore this issue using alternative methodologies, hoping to deal with the issue by exploiting the FE model in order to control for heterogeneity.

III. Data

The data used in this paper are from wave 1 and wave 2 of the US *New Beneficiary Survey* (NBS), conducted in 1982 and 1991, respectively. The NBS is a nationally representative household survey using samples randomly selected from the Social Security Administration's Master Beneficiary Record. The representative samples are all new Social Security beneficiaries who received their first retired-worker’s, disabled-worker’s, wife’s, or widow's cash benefit from mid-1980 to mid-1981. In this paper we focus on individuals who are 60 years old or over so that our results are more comparable to findings from previous studies that exploit the U.S. Health and Retirement Study (HRS).

There are at least two unique advantages of using the NBS to examine the correlation between health and assets holdings. First, the two waves of the survey span

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13 The NBS also contains a representative sampling of persons aged 65 and over who were entitled to Medicare benefits but who had not yet received Social Security cash benefits as of July 1982.
14 The NBS separately sampled from strata of retired-worker men aged 62, aged 63-64, aged 65, and aged 66 or older, and from strata of retired-worker women aged 62, aged 63-64, aged 65, and aged 66 or older. The NBS separately sampled strata of disabled-worker men and of disabled-worker women. The NBS also separately sampled from strata of women first receiving cash benefits solely as wives, as widows, as divorced wives, and as surviving divorced wives. In addition, insured workers entitled to Medicare but not receiving benefits by July, 1982, were eligible for sample selection.
15 Examples are Rosen and Wu (2003), Wu (2003), and Berkowitz and Qiu (2006).
16 The HRS is a nationally representative panel that follows across time approximately 7,000 households with a primary respondent between the ages of 51 and 61 in 1991-92 period.
over nine years, allowing room for broad variations in health status and assets for the elderly in the time dimension. Second, the questionnaires concerning the subjects of health and various assets are highly consistent in these two waves. While more questions are imposed in the 1991 survey, the 1982 questionnaires regarding health and wealth virtually remain unchanged in the second wave. The consistency in questionnaire designs is of substantial importance for applying panel-data methods.

A. Measurement of health status

Unlike most previous studies that employ only one health measure, in this paper we construct four health indices, each of which is designed to capture a specific aspect of an individual’s health status. Multiple health measures enable us to draw a more general inference about how portfolio choice and decisions on asset selection are correlated with health. The four measures are separately constructed based on physical function limitations (PF), chronic conditions (CC), history of heart attack and stroke (HASH), and limitations on work ability (WRL), respectively.

The PF indicates an individual’s ability to carry out a list of various physical activities.\(^{17}\) In principle, PF provides a relatively objective measure of health, compared to some other self-reported health conditions,\(^{18}\) as some physical limitations can be

\(^{17}\) In the context of NBS, there are six questions measuring the degree of difficulty to (1) walk for a quarter mile; (2) walk flight of stairs; (3) stoop, crouch, or kneel; (4) stand for a long period; (5) sit for a long period; and (6) lift or carry a weight of 25 pounds. For each question, respondents are required to assess the degree of difficulty in the corresponding physical function on scale from 1 (no difficulty) to 4 (completely unable to do).

\(^{18}\) One example is the self-reported health status (SRHS) that is measured by respondents’ self-assessment, usually on a scale of one (excellent) to four or five (poor), on their general health conditions compared to that of other people of your age. The SRHS is commonly criticized as being endogenous, as it is possible that the unemployed, for example, report poor health to justify their absence of work.
observed during the interview.\(^{19}\) However, the PF index has its own limitations and the major one being that it neglects health risk of people who have chronic diseases, such as diabetes, but do not have any obvious physical symptoms or limitations.

To reduce the multi-dimensional responses to six questions into one single measure, we apply the following formula to quantify these functions and obtain a numerical value:

\[
PF_i = 1 - \frac{1}{24} \sum_{j=1}^{6} (pf_{ij} - 1)
\]

where \(pf_{ij}\) refers to the value of individual \(i\)'s response to question \(j\). It is important to note that Equation (1) normalizes the value of index PF between 0 and 1, with 0 indicating the greatest limitation in these functions.

Similar to the PF, the Chronic Conditions (CC) index also involves multiple indicators as it is composed of responses to five questions asking about chronic conditions.\(^{20}\) One benefit of the CC as a health measure is that chronic conditions are expected to have long-term impacts on individual health, presumably leading to more adverse shocks on income compared to temporary health conditions. However, in the context of the NBS, a disadvantage of CC is that respondents are required to answer only ‘yes’ or ‘no’ to each of the five questions. As a result, for those who report having a

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\(^{19}\) Another advantage of PF is that it captures functional difficulties in a monotonic (increasing) way, so it improves upon the Body Mass Index that presents a “U-shaped” relationship with health outcomes, like mortality (See Costa 1996, 1998).

\(^{20}\) These include (1) nervous system (such as multiple sclerosis, cerebral palsy, epilepsy, or any other condition affecting the nervous system); (2) paralysis; (3) lung and respiratory system (Respiratory conditions refer to asthma, emphysema or any other condition affecting the lungs or respiratory system, including work-related respiratory conditions such as silicosis or pneumoconiosis); (4) digestive system (gallbladder, stomach, kidney or liver trouble, diabetes, and any other condition affecting digestive system); and (5) malignant tumors or growth.
certain chronic condition, we do not have information to distinguish those with only minor conditions from the very frail ones.

Again, to reduce the dimensions of five dichotomous variables to one sole variable, we apply the following formula which is similar to Equation (1):

$$CC_i = 1 - \frac{\sum_{j=1}^{5} (cc_j^i - 1)}{5}$$  \hspace{1cm} (2)

The third health measure is a dichotomous variable that identifies people who have experienced heart attack or stroke at least once before the survey (heart attack or stroke history, HASH). In general, the HASH has an advantage over the CC as it represents more acute health shocks than most chronic conditions. But as a dichotomous variable, the HASH shares a limitation with the CC – for those who report no experience of heart attack or stroke, we are not able to distinguish their health status.

The last health measure index is based on a series of questions about self-assessed health limitations that keep respondents from working or restrict the hours they work (work-related health limitations, WRL).\(^{21}\) On the positive side, the WRL index captures the ability to work, so it is in principle highly correlated with income variations for working population.\(^{22}\) As for its disadvantage, a potential concern about WRL is that, as pointed out by Bound et al. (1999), a person’s decision on labor supply may determines his/her sense of health. For example, a respondent may report poor health in order to justify his/her absence in labor participation and the resultant lower income and wealth. This raises the question of endogeneity in measuring health in terms of WRL, leading to a

\(^{21}\) The WRL involve questions regarding health conditions that (1) limit work to pay; (2) limit work at home; and (3) keep from working in general.

\(^{22}\) This correlation is considered limited for the retired population.
spurious health-wealth nexus. Using the same method to simplify the multi-dimensions of PF and CC, we generate the single-variable index of WRL by applying a formula analogous to Equation (1).

B. Measurement of assets

In this study, we follow the conventional categorizations of assets used in the literature. The total assets are comprised of two components – financial and non-financial. The non-financial assets refer to current values of real estates (home residence, lands, and other properties) and business assets (ownership of businesses, professional practices, and farms). As for the financial assets, we adopt a four-way classification scheme, which includes safe assets (checking and saving accounts, money market funds, CDs, government savings bonds and T-bills), bonds (corporate, municipal, foreign bonds and bond funds), risky assets (stocks and mutual funds), and retirement accounts (individual retirement accounts and Keogh accounts). In addition to the levels of assets, we further explore health effects on (1) the share of financial assets within total assets, (2) the share of risk assets within financial assets, and (3) the incidence of risky asset holdings.

IV. Graphical Analysis

In this section, we graphically present the unconditional correlations between health indices and various assets (and asset share), using 1982 and 1991 data from the NBS. In these graphic analyses, we separate male and female beneficiaries, although the results based on pooled data are analogous.

23 The empirical results in this paper are robust to wider definition of risky assets that incorporate all bonds (corporate bonds, municipal bonds, foreign bonds, bond funds, and government bonds).
Figure 1.1 displays the correlation between the PF (x-axis) and (a) total assets, (b) financial assets, (c) non-financial assets, (d) risky assets, (e) ratio of financial assets to total assets, and (f) ratio of risky assets to financial assets. In each graph, a fitted curve is graphed by carrying out a locally weighted regression of y variable on x variable, using 1982 data (solid curve), 1991 data (bar curve), and 1991 data using lagged PF in 1982 (dotted curve), respectively. We start with graph (a), where the positive slope of the fitted curves suggests a positive correlation between total assets and the PF. For year 1982, the average level of total assets owned by people who reported no limitations on physical functions (i.e., PF=1) is over $150,000, which is roughly three times larger than the average total assets for individuals reporting extreme difficulties (i.e., PF=0). The gap is fairly substantial, compared to the average total assets in 1982 – around $130,000.

Further, in graph 1.1a, there are two features that are worth mentioning. First, the 1991 data present a similarly positive correlation. This suggests that the cross-sectional PF-assets nexus is fairly time-persistent, despite the loss of 35 percent of observations between the two waves of the survey. Second, as the 1991-lag curve (dotted curve) follows an almost identical path of the 1991 curve, adopting the lagged PF does not much change the PF-assets correlation.

Moving to graphs (b), (c), and (d), these show that the PF is positively correlated with financial assets, non-financial assets, and risky assets, respectively. Further, as suggested by graphs (e) and (f), one unit change in the PF is also correlated with

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24 Practically, this is implemented by using the “lowess” command in STATA with bandwidth of 1.
25 In terms of magnitude, a change from 0 to 1 in PF is associated with increases of around $60,000 in financial assets, $90,000 in non-financial assets, and $30,000 in risky assets, all considered substantial changes compared to the average values listed in Table 1.
significant changes in the financial assets share (of total assets) and the risky assets share (of financial assets).

Turning to the next two pages, Figures 1.2 and 1.3 tell much the same story about the correlations between various types of asset (and shares of assets) and the other two health indices – CC and WRL. Using either health measure, the positive correlation remains strong for most assets (and shares of assets), and for both years 1982 and 1991 (using either contemporary health or lagged health). The consistency in the patterns of health-wealth correlation across different health indices enhances our confidence in the legitimacy of these health indices.\textsuperscript{26}

Insert Figure 2 here.

In order to take a preliminary look at the correlation of health and assets after individual heterogeneity is netted out, in Figure 2 we plot changes in health against changes in assets (and shares of assets) from 1982 to 1991. The key hypothesis here is that, if health and assets (or shares of assets) are causally linked, we should observe that a deterioration in health is linked with lower levels of assets (or lower shares of assets). However, the graphs in Figure 2 do not support such a causality implication. Instead, the positive correlations that are commonly observed in Figure 1 all disappear in Figure 2.\textsuperscript{27}

Although the comparison between Figure 1 and Figure 2 is based on unconditional plotting without controlling for other factors, the abrupt differences between the cross-sectional correlations and the first-difference correlations of health and assets imply that unobserved individual characteristics may play an essential role in driving the cross-sectional correlations.

\textsuperscript{26} We ignore the graphic analysis based on the HASH, as it is a dichotomous index.

\textsuperscript{27} Note that the graphs (a) to (d)
V. Results

Our primary objective is to investigate whether the cross-sectional correlations between health and wealth and between health and portfolio are driven by unobserved individual characteristics. We focus on comparing the OLS model, which falls short in controlling for unobserved individual characteristics, with the FE model where these characteristics are netted out, assuming they are time-consistent.

The OLS model is specified as follows:

$$ W_{it} = \beta_0 + \beta_1 \cdot h_{it} + \gamma \cdot X_{it} + \lambda \cdot Z_{it} + \varepsilon_{it} $$

(3)

where $W_{it}$ refers to the level of an asset type or the share of risky assets held by household $i$ at time $t$; $h_{it}$ denotes health status of individuals at time $t$; $X_{it}$ include individual characteristics such as age, age squared, gender, marital status, years of schooling, ethnicity; $Z_{it}$ refer to household characteristics such as demographic composition, number of children, and household location; and finally, $\varepsilon_{it}$ represents the error term that includes all unobservable factors. For expositional clarity, we will not repeat most of the obvious caveats with every table, but they must be born in mind.

In the fixed-effects model specified in the following equation, we assume that $\varepsilon_{it}$ in Equation (3) is composed of two elements – $v_i$ and $u_{it}$:

$$ W_{it} = \beta_0 + \beta_1 \cdot h_{it} + \gamma \cdot X_{it} + \lambda \cdot Z_{it} + v_i + u_{it} $$

(4)

28 We also control for entitlement of health insurance, which is considered important in determining risk attitude. In addition, we impose number of children into the regressions, as it obviously affects bequest motive. Finally, for regressions of financial assets share or risky assets share, we also impose total assets as a regressor.
The individual specific component, denoted by $v_i$, is assumed to be time-independent but correlated with the covariates in Equation (3). Other unobservable factors in the error term, denoted by $u_t$, are considered uncorrelated with any regressors.

It is important to note that replacing the regressors with lagged variables ($h_{i,t-k}$, $X_{i,t-k}$, or $Z_{i,t-k}$) might not correct the bias due to the correlation between $v_i$ and the covariates in Equation (3). For example, it is plausible that some unobserved characteristics can form early in life, thus leading to correlations between $v_i$ and the lagged regressors.

The regression analysis in this paper focuses on comparing the fixed-effects (FE) results based on Equation (4) and the OLS results from Equation (3). This comparison provides a chance to investigate the effect of unobserved characteristics on cross-sectional health-wealth and health-portfolio correlations. If the effect of heterogeneity is substantial, we should observe a significant difference between results from these two models.

### A. Descriptive statistics

Insert Table 1 here.

Table 1 summarizes the descriptive statistics of the 1982 full sample, the 1982 panel-balanced sample, the attrited observations, and the 1991 full sample. Between the two waves of the survey, about one third of observations dropped out of the sample. Among the attrited, close to 69% were due to death (Antonovics, 2000). As a result, there is a concern about non-random selectivity due to the attrition. Further, compared to the 1982...
panel-balanced observations in column 2 of Table 1 (Panel B), those who dropped out of the sample (column 3) were less healthy, in terms of all the four health indices, and less wealthy, in terms of all types of assets. While these disparities raise a concern about the selection bias due to the attrition, we adopt a straightforward strategy to weight the impact – comparing the 1982 OLS estimates based on all 1982 observations and those based on the panel-balanced observations. As shown in next section, the two samples present virtually the same health-assets correlations, implying a limited impact from the attrition.

**B. The OLS results – using the PF as an example**

In this section, we apply the OLS regression model as specified in Equation (3) to the whole 1982 sample, the panel-balanced observations in 1982, and the full 1991 sample, separately. The results are summarized in columns 1 to 3 of Table 2, respectively. As a start, we focus on the regressions of total assets on the PF.

Insert Table 2 here.

In column 1, the estimated coefficient of the PF is 36.3, which is significantly different from zero. As the PF has been normalized on a scale of 0 to 1, an estimate of 36.3 implies that a change in PF from the extreme difficulties to no physical limitations is associated with an increase of $36,300 in total assets. Compared to the sample mean value of total assets (around $130,000), the magnitude is rather substantial. The positive PF-assets correlation remains strong in column 2, where we implement the same estimation but this time based on the 1982 panel-balanced observations. The estimate – $36,200 – is fairly close to the estimate based on the full 1982 sample. The resemblance
between these two OLS estimates corroborates the graphical comparison illustrated in Figure 1.1a, which demonstrates a limited effect of the sample attrition on the health-assets correlation.

The significantly positive coefficient of the PF is robust to the estimation using the 1991 sample. As shown in the last column, the estimate is $53,900, which is even stronger than the two estimates based on the 1982 observations. These results echo a number of previous studies that typically find a positive health-wealth nexus, mostly using cross-sectional methodologies.30

Estimates of other covariates also exhibit sensible correlations with total assets. First, the age effect on accumulated wealth is negative and convex31. This decreasing pattern of total assets is consistent with the findings from Coeli and Milligan (2006), who show that older US households reduce their ownership of most asset classes as they age. Second, the coefficient of years of schooling suggests a considerable effect of education on wealth accumulation. Taking 1982 full sample as an example, the effect is $14,500 per year of schooling, roughly accounting for 11 percent of the average total assets held. Third, the ethnicity appears to be an important determinant of the relationship between total assets and PF. Throughout all three columns, the estimated coefficient is higher for White than for American natives, Asians and Pacific Islanders, and further higher than Black. Again, this outcome echoes the findings from previous studies, such as Blau and Graham (1990); Wolff (1998); and Hurst et al. (1998), which all present considerable racial differences in household wealth accumulation.

30 For a survey of this literature, please refer to Goldman (2001).
31 Note the coefficient of the squared term is significantly positive.
C. Comprehensive analyses

We now turn to the regression analysis using all the four health indices and all types of asset (and shares of assets). We focus on comparing the OLS results with the FE estimates based on models specified by Equation (3) and (4), respectively. The rationale behind these comparisons is that if heterogeneity does not matter, estimates from the OLS model and the FE model should present a similar pattern of the health-assets and health-portfolio choice correlations.

Table 3 summarizes the regression results from these two models. For expositional simplicity, we report only the coefficients of health variables. Coefficients in Table 3 are categorized into four panels – Panel A to D. These panels summarize coefficients of the four health indices in regressions of different classes and shares of assets using OLS model based on 1982 full sample (Panel A); 1982 panel-balanced sample (Panel B); 1991 sample (Panel C); and 1991 sample with lagged health measures (Panel D).

C.1 OLS results

We start with column 1 of Panel A, where we list the estimates of the PF using solely the 1982 sample. The first coefficient suggests that an improvement from 0 to 1 in PF is associated with an increase of $36,273 in total assets, which is quite evenly broken down to an increase of $17,272 in financial assets and a rise of $19,001 in non-financial assets. Also, these two coefficients are both significantly positive.32 Further moving down in

32 While these two estimates are relatively similar, they imply two diverse percentage changes as the average level of non-financial assets is almost twice the average value of financial assets. To be specific, the two estimates correspond to a 38 percent change in financial assets and a 22 percent change in non-financial assets, respectively.
column 1, the next two estimates are marginal effects imputed from coefficients of a Tobit regression censored at zero value of risky assets, and from a Probit estimation based on holding a positive value of risky assets. The Tobit estimate is $21,730, a strikingly high estimate, especially compared to the mean value of risky assets held by this sample – around $9,800. As for the Probit estimate, a value of 0.102 implies that a change in PF from 0 to 1 is related to a 10.2 percent increase in the incidence of holding positive amount of risky assets.

The next two coefficients in column 1 were estimated using regressions of two shares of assets – share of financial assets in total assets, and share of risky assets in financial assets. The two significant estimates of the PF index suggest that an improvement in PF is associated with a higher share of financial assets and a higher share of risky assets. In terms of magnitude, the estimate on the risky assets share is 2.7%, which accounts for approximately half of the average proportion of risky assets holding – around 6%.

In column 2, the estimates show a very similar pattern of significance as shown in the first column. One difference is that a unit change in the CC (from extreme conditions to no chronic conditions) is associated with larger changes in assets and shares, compared to a unit change in the PF. For the WRL, as described in column (4), the health-assets correlation is similarly evident. Finally, the correlation is somewhat weaker for the HASH, as some coefficients appear insignificant.

Analogous to our earlier discussion on Table 2 which shows little difference between results based on the 1982 full sample and those based on the 1982 panel-balanced sample, we can only discern negligible differences between estimates in Panel
A and those in Panel B, which are obtained using the panel-balanced sample in 1982. Almost all estimates are fairly close to the corresponding figures in Panel A, although the \( t \) statistics are slightly smaller. These results, again, underline the similarity between these two samples, implying that the attrition might not seriously bias the estimates when the panel-balanced sample is exploited.

As demonstrated in Panel C, estimates based on the 1991 data tell much the same story. The only major difference is that the coefficients of financial assets share were dramatically lower and become insignificant (and some even negative) for all the four health indices. This suggests that, from 1982 to 1991, the respondents’ decisions on financial asset holdings become less responsive to health shocks.\(^{33}\)

In the Panel D of Table 3 we list the estimates from regressions of 1991 assets (and shares of assets) on 1982 health indices. Our goal is to compare these estimates with the FE estimates, as this helps advance our understanding of the legitimacy of using lagged health to address the problem of mutual causality. One limitation of this approach is that some unobserved individual characteristics, such as the subjective time rate of discount, can be time consistent and induce a correlation between health and assets over a long period of lifetime. Consistent with this doubt, estimates in this panel suggest that regressions based on lagged health indices do not produce outcomes that much differ from those based on contemporary health indices.\(^{34}\)

\(^{33}\) While this is an interesting phenomenon, the reason for this shift is unclear and further examinations are needed to shed more light on it.

\(^{34}\) These estimates suggest that, compared to the estimates based on the 1991 health measures, most of the health-wealth and health-assets correlations remain obvious, though some estimates are smaller and some others are somewhat larger than their 1991 counterparts. Taking WRL as an example, the coefficients on the levels of the four asset classes are highly similar to the corresponding coefficients using 1991 health indices. However, the Probit estimate is 25.4\%, roughly four times larger than the 1991 estimate (6\%). Likewise, the coefficients of WRL on the two measures of risky assets share are also much larger. Nonetheless, we do not find larger estimates of lagged PF, with the only exception for the coefficient of
C.2 Fixed-effects results and random-effects results

We report the results from the FE model in Panel A of Table 4. Compared to the OLS estimates shown in Table 3, the differences are striking. Taking the estimates of the WRL, when compared to 1982 results, all coefficients reduce remarkably, with some even turning negative. Also, none of the FE estimates are statistically significant. This suggests that the strong WRL-wealth and WRL-portfolio choice correlations found in the OLS model of WRL virtually disappear after individual fixed effects are controlled for. This finding is corroborated by the estimates of the CC in column 2, where we no longer find any significant estimates, as opposed to the significant OLS figures based on 1982 or 1991 cross-sectional data.

Insert Table 4 here.

However, the other two health indices – the PF (column 1) and the HASH (column 3) present similar health-assets correlations, but a very different story about risky assets holding. First, similar to the cases of CC and WRL, the coefficients of the PF and the HASH on total assets, financial assets, and non-financial assets all reduce remarkably and turn insignificant. Second, the coefficients of risky assets share and the Probit estimate of risky assets holding both remain significant. Moreover, the estimates of the risky assets share – 0.021 for the PF and 0.012 for the HASH – are relatively close to the corresponding OLS estimates based on the 1982 full sample (0.027 for the PF and 0.010 for the HASH).

To sum up, we can draw the following two implications from the comparisons of the FE estimates and the OLS estimates. First, the strong cross-sectional correlations financial assets share. As for the other two health measures, we find that most estimates of the CC do not differ much from the 1991 health coefficients, but the estimates of the HASH are generally smaller and some turn insignificant.
(either using concurrent or lagged health) between health and assets \textit{levels} cease to exist in the FE model. Second, the correlations between health and risky assets holding are sensitive to different health indices – some aspects of health (PF and HASH) are better than other health aspects (CC and WRL) in predicting risk-taking financial decisions.

Finally, we have also applied the random-effects (RE) model as a comparison with the FE model. The results are displayed in Panel B of Table 4. In contrast to the FE estimates, the random-effects results clearly suggest significant correlations between health and assets and between health and risky portfolio, presenting a similar pattern to that exhibited in the 1982 OLS estimations. These RE estimates are also similar to the RE results reported in Rosen and Wu (2004) and Berkowitz and Qiu (2006). Though not shown in the table, we have conducted the Hausman-Wu specification tests for each pair of FE and RE regressions. The corresponding test results suggest that the difference between the RE and the FE estimates is significant for almost all the regressions,\(^{35}\) indicating that the results of the RE model are not reliable and we thus prefer the FE results.

\textbf{D. Interpretations}

\textbf{D.1 Background risks}

One of the main findings from the fixed-effects model is that there are insignificant health effects on assets levels, in contrast to the significant health effects on risky assets holding, based on the PF and the HASH. One possible argument that might reconcile this disparity lies in the background risks theory, which states that an increment to the

\(^{35}\) One important exception is the coefficient of the HASH in the regression of financial assets share.
background risks will lead to less risk-taking behaviors.\footnote{For studies that explore the impacts of the background risks, please refer to Heaton and Lucas (2000), Cocco et al. (2005), and Palia et al. (2007).} If adverse health shocks increase the background risks, this will lead to less risky financial management, such as safer portfolio choice. Thus, the significantly positive health effects on the share of risky assets found in this paper are consistent with the prediction of the background risks theory. Also, our findings of the significant FE estimates of health effect corroborate the results from some recent studies, such as Rosen and Wu (2004) and Edward (2007), which suggest that individual health plays an important role in determining portfolio choice.

The next question to be answered is why the FE health estimates on risky assets holding (either incidence or share) are not significant based on the other two health indices – CC and WRL. According to the background risks argument, our conjecture on the reason for the differential FE estimates across these health measures is that different aspects of health might be related to future health risk to different degrees. That said, it is possible that deteriorations in chronic conditions and work-related limitations might not influence one’s future health risk and thus financial investment behavior as much as adverse shocks on physical functions or new experiences of heart attacks or strokes. Further examination, however, is required to shed more light on the explanatory power of this argument. Nonetheless, our results highlight the importance of employing multiple health measures, as any single measure could be limited in its representativeness of an individual’s health status.

It is also important to explain why variations of the FP and the HASH can predict changes in risky assets holding, but cannot as much predict changes in the \textit{levels} of assets.
One possible explanation could be the limited private income sources faced by the older population, who instead heavily rely on income from public programs. As a result, they might not be able to adjust total assets in response to health changes. At the same time, most of the medical expenses due to adverse health shocks are covered by health insurance, exempting the elderly from the immediate need to sell their properties to finance the expenses. Finally, our findings of the limited health effects on total assets are consistent, though not perfectly, with findings of some studies that find little or no causal effect of income or wealth on health improvements of older individuals (Ettner, 1996; Hurd and Kapteyn, 2001; Meer et al., 2003; Adams et al, 2003; Frijters et al., 2005).

Our results also suggest that it is unlikely that health affects portfolio choice through changes in financial wealth – a major finding of Berkowitz and Qiu (2006) – as they show that none of the four health measures appear to have a significant influence on financial wealth. Instead, our results favor an alternative explanation: that the changes of physical function or sudden severe health shocks shift investment from risky financial assets toward other financial assets, but keep constant the total financial assets.

D.2 Measurement errors

One common argument for the differences between the OLS results and the FE results lie in measurement errors in the independent variables of interest (health measures in this paper). However, it is unlikely, especially in the case of the HASH and the PF, that the measurement errors play a dominating role in driving the differences between the two groups of estimates. Take the HASH estimates in Table 4: while all other FE estimates reduce to be statistically insignificant, the Probit estimate (0.21) for risky assets holding and the coefficient for the share of risky assets (0.12) remain large and significant. This
contradicts the hypothesis that measurement errors is the primary factor that attenuate the FE estimates of HASH on total assets, financial assets, and non-financial assets to be lower than the OLS counterparts. If this is so, then the same measurement errors should also attenuate the two significant FE estimates and make them as much proportionally lower than the OLS figures, which do not occur. The same argument can also apply to the case of PF. While the estimated FE coefficients of total assets, financial assets, and non-financial assets are all lower than the OLS estimates by around 50 to 60 percent and all turn insignificant, the FE estimate of risky assets share is 0.021, which remains significant and is smaller than the 1982 OLS estimate by only around 22 percent. However, with regard to the other two health measures, as the contradiction does not exist, it is difficult to assess the influence of measurement errors.

VI. Conclusions

While recent studies have presented evidence suggesting that negative health shocks are associated with less accumulated wealth as well as less risky portfolio choice, the causality is less clearly identified. One concern about the causal implications drawn in these studies lies in unobserved individual characteristics that might cause spurious effects of health on assets and portfolio choice, as most of these studies employ the OLS method or the random-effects model. Therefore, the main objective of this paper has been to assess this concern, using a unique longitudinal data that allow for the fixed-effects model. Also, we have constructed four health indices to capture various dimensions of an

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37 In Appendix A, we further illustrate this point using an econometric model.
individual’s health status. These enable us to make inferences on the health-assets and health-portfolio choice correlations from a broader health perspective.

The principal findings of our empirical work can be summarized as follows. Firstly, the OLS results show that poorer health is significantly associated with lower levels of total assets, financial assets, non-financial assets, share of financial assets, and share of risky assets. These health-assets and health-portfolio choice correlations are highly robust to all the four health indices, and remain strong when we instead use lagged health measures. Secondly, the correlations between health and levels of different wealth types virtually disappear in the FE model, highlighting the possibility that both the cross-sectional and the intertemporal health-wealth correlations are driven by heterogeneity. Further, the sharp contrast between the OLS and the FE estimates cannot be reconciled by either attrition or measurement errors. Thirdly, the FE estimates of the health effect on risky assets share and on the incidence of holding risky assets remain significant for two health measures – the PF and the HASH, and the estimates are relatively close to the corresponding OLS estimates. But the FE estimates of the other two health measures – CC and WRL – are not significant.

Altogether, our results suggest that the correlations between health and levels of assets based on cross-sectional variations could be misleading, as it is plausible that they are driven by unobserved individual characteristics. We can only speculate as to the minor responsiveness of wealth to changes in health. It may be that health conditions no longer determine the wealth accumulation process of the elderly, possibly because their income mainly comes from government programs and most of their medical expenses due to health conditions are covered by insurance.
As for the health effect on risky assets holding, our FE results based on the indices of PF and HASH suggest that adverse health shocks discourage demand for risky assets. This finding is consistent with the primary prediction of the background risks theory, which is commonly used by previous studies to account for the health effect on portfolio choice. However, we should keep in mind that the significant health effect is not robust to the other two health indices. Our speculation as to the discrepancy in these health effects is that deteriorations in some dimensions of health status, such as the onset of heart attacks or strokes and adverse shocks in physical functions, increase future health risk more than some other health dimensions do.

The empirical findings also suggest that it is unlikely that health deteriorations discourage risky assets holding through reductions in financial wealth, as none of the four health measures appears to have a significant influence on financial wealth. Alternatively, our results indicate that adverse health shocks might shift investment from risky financial assets toward other financial assets, but keep constant the total financial assets.

Results of our analyses do not shed much light on the health-assets correlations for younger generations. It is likely that the correlations are more complex than for the elderly as health is believed to be a more important determinant of an individual’s productivity and labor market outcomes at working ages. Thus, further study using samples of younger individuals will contribute to our further understanding about how health is associated with decisions on savings, financial assets holdings and portfolio decisions.
References


Appendix

We start with rewriting Equation (4) by taking the first difference, and it reduces to:

\[ W_{it} - W_{i,t-1} = \beta_1 \cdot (h_{it} - h_{i,t-1}) + \gamma \cdot (X_{it} - X_{i,t-1}) + \lambda \cdot (Z_{it} - Z_{i,t-1}) + (u_{it} - u_{i,t-1}) \]  

(5)

While Equation (5) differences out the unobserved heterogeneity, it might introduce the concern about measurement errors, which lead to the attenuation bias. In the case of this paper, if health indices are poorly-measured, the estimates of health effect will be biased toward zero. While the attenuation bias applies to both Equation (3) and Equation (5), the problem might, but not necessarily, be more serious in Equation (5) as the measurement errors could be enlarged after taking the first difference of the originally poorly-measured health. To illustrate this, assume that the unobserved true health is \( h^* \), and \( h^* = h + m \), where \( h \) and \( m \) refer to a measure of health and measurement errors, respectively. Accordingly, the OLS estimate of \( \beta_1 \) from Equation (3) is inconsistent since

\[ \text{plim} \hat{\beta}_1 = \beta_1 \left( \frac{\sigma_{h}^2}{\sigma_{h}^2 + \sigma_{m}^2} \right), \]  

(6)

where \( \sigma_{h}^2 \) and \( \sigma_{m}^2 \) represent the variance of \( h \) and the variance of \( m \), respectively. Note that the degree of inconsistency depends on the value of \( \sigma_{m}^2 \) relative to the value of \( \sigma_{h}^2 \).

Intuitively, a large \( \sigma_{m}^2 \) implies that substantial noise is imposed into the regression along with the health measure. The noise then reduces the correlation between the true health and \( W_{it} \), leading to an attenuated estimate of \( \beta_1 \).

Similarly, the counterpart description of the probability limit of \( \hat{\beta}_1 \) from Equation (5) is
\[ \text{plim } \tilde{\beta}_i = \beta_i \left( \frac{\sigma^2_{\Delta h}}{\sigma^2_{\Delta h} + \sigma^2_{\Delta m}} \right) \]  

(7)

where \( \Delta h \) and \( \Delta m \) refer to changes in health and measurement errors from 1982 to 1991, respectively, and \( \sigma^2_{\Delta h} \) and \( \sigma^2_{\Delta m} \) are the corresponding variances. Again, similar to Equation (6), the extent of attenuation is determined by the values of \( \sigma^2_{\Delta h} \) and \( \sigma^2_{\Delta m} \). Compared to Equation (6), whether or not the attenuation bias in \( \tilde{\beta}_i \) is larger than that in \( \beta_i \) is generally ambiguous. But there is room for this possibility, especially when \( \sigma^2_{\Delta h} \) is small and \( \sigma^2_{\Delta m} \) is large. This possibility makes it complex to compare the FE results and the OLS results, as detailed in the preceding section. For example, when we find a smaller FE estimate of health effect than the estimated OLS effect, it is difficult to distinguish whether it is because the OLS estimate is biased up due to heterogeneity, or because FE estimate is biased down as a result of greater measurement errors in health in the FE model.
Table 1
Descriptive Statistics of Samples

This table contains two panels – A and B. Panel A reports the summary statistics of individual and household demographic variables. Panel B presents the statistics of various assets and the four health indices. To help evaluate the effect of attrition of observations, all statistics are calculated using four different samples, including 1982 total observations, 1982 panel-balanced sample, attrited observations, and 1991 total observations of the NBS. Numbers in parentheses are standard deviations.

<table>
<thead>
<tr>
<th>Panel A : Descriptive statistics of demographic variables</th>
<th>(1) 1982 all observations</th>
<th>(2) 1982 panel-balanced observations</th>
<th>(3) 1982 attrited observations</th>
<th>(4) 1991 all observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male (%)</td>
<td>51.2</td>
<td>48.8</td>
<td>55.3</td>
<td>48.8</td>
</tr>
<tr>
<td>Months of age</td>
<td>786 (27.6)</td>
<td>785 (26.1)</td>
<td>788 (30.5)</td>
<td>888 (27.1)</td>
</tr>
<tr>
<td>Marital status (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>67.1</td>
<td>69.4</td>
<td>63.0</td>
<td>57.2</td>
</tr>
<tr>
<td>Widow/Widower</td>
<td>18.9</td>
<td>17.3</td>
<td>21.9</td>
<td>29.8</td>
</tr>
<tr>
<td>separated</td>
<td>1.6</td>
<td>1.5</td>
<td>1.7</td>
<td>1.1</td>
</tr>
<tr>
<td>divorced</td>
<td>7.8</td>
<td>7.5</td>
<td>8.3</td>
<td>7.5</td>
</tr>
<tr>
<td>never married</td>
<td>4.6</td>
<td>4.4</td>
<td>5.1</td>
<td>4.4</td>
</tr>
<tr>
<td>Years of schooling</td>
<td>11.3 (3.4)</td>
<td>11.4 (3.4)</td>
<td>11.1 (3.3)</td>
<td>11.4 (3.4)</td>
</tr>
<tr>
<td>Race (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>American Indian or Alaskan native</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>Asians or Pacific Islander</td>
<td>0.4</td>
<td>0.4</td>
<td>0.5</td>
<td>0.4</td>
</tr>
<tr>
<td>Black</td>
<td>8.8</td>
<td>8.5</td>
<td>9.4</td>
<td>8.5</td>
</tr>
<tr>
<td>White</td>
<td>89.3</td>
<td>89.7</td>
<td>88.6</td>
<td>89.7</td>
</tr>
<tr>
<td>Others</td>
<td>1.0</td>
<td>0.9</td>
<td>1.2</td>
<td>0.9</td>
</tr>
<tr>
<td>Household size</td>
<td>2.1 (0.92)</td>
<td>2.1 (0.93)</td>
<td>2.1 (0.91)</td>
<td>0.9 (0.84)</td>
</tr>
<tr>
<td>Insurance coverage (%)</td>
<td>0.92 (0.28)</td>
<td>0.92 (0.28)</td>
<td>0.92 (0.28)</td>
<td>0.99 (0.07)</td>
</tr>
<tr>
<td>Total number of children</td>
<td>2.5 (2.02)</td>
<td>2.60 (2.02)</td>
<td>2.42 (2.03)</td>
<td>2.59 (2.01)</td>
</tr>
<tr>
<td>Observations</td>
<td>15,188</td>
<td>9,798</td>
<td>5,390</td>
<td>9,798</td>
</tr>
</tbody>
</table>
Table 1 (continued)

Panel B: Descriptive statistics of assets and health indices

<table>
<thead>
<tr>
<th></th>
<th>(1) 1982 all observations</th>
<th>(2) 1982 panel-balanced observations</th>
<th>(3) 1982 attrited observations</th>
<th>(4) 1991 all observations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Assets ($1,000)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total assets</td>
<td>130.2 (381.1)</td>
<td>139.4 (423.9)</td>
<td>110.7 (268.1)</td>
<td>118.0 (319.2)</td>
</tr>
<tr>
<td>Financial</td>
<td>45.4 (184.1)</td>
<td>49.3 (212.5)</td>
<td>37.0 (99.7)</td>
<td>52.0 (234.3)</td>
</tr>
<tr>
<td>Non-financial</td>
<td>84.9 (296.3)</td>
<td>90.1 (326.2)</td>
<td>73.8 (219.9)</td>
<td>66.0 (156.5)</td>
</tr>
<tr>
<td>Risky assets</td>
<td>9.8 (123.6)</td>
<td>11.2 (146.6)</td>
<td>6.7 (45.5)</td>
<td>17.3 (163.3)</td>
</tr>
<tr>
<td>Financial assets share (%)</td>
<td>0.36 (0.34)</td>
<td>0.35 (0.33)</td>
<td>0.36 (0.36)</td>
<td>0.42 (0.40)</td>
</tr>
<tr>
<td>Risky assets share (%)</td>
<td>0.06 (0.18)</td>
<td>0.07 (0.18)</td>
<td>0.06 (0.17)</td>
<td>0.09 (0.21)</td>
</tr>
<tr>
<td><strong>Health indices</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical functions (PF)</td>
<td>0.79 (0.29)</td>
<td>0.81 (0.27)</td>
<td>0.74 (0.31)</td>
<td>0.79 (0.26)</td>
</tr>
<tr>
<td>Chronic conditions (CC)</td>
<td>0.92 (0.13)</td>
<td>0.93 (0.12)</td>
<td>0.90 (0.14)</td>
<td>0.91 (0.13)</td>
</tr>
<tr>
<td>Heart attacks or stroke history (HASH)</td>
<td>0.87 (0.33)</td>
<td>0.90 (0.30)</td>
<td>0.83 (0.38)</td>
<td>0.81 (0.39)</td>
</tr>
<tr>
<td>Work-related limitations (WRL)</td>
<td>0.73 (0.39)</td>
<td>0.76 (0.37)</td>
<td>0.66 (0.42)</td>
<td>0.70 (0.40)</td>
</tr>
<tr>
<td>Observations</td>
<td>15,188</td>
<td>9,798</td>
<td>5,390</td>
<td>9,798</td>
</tr>
</tbody>
</table>

**Notes:**

a. Values of assets in 1991 have been deflated using 1982-based CPI.
b. The total assets are comprised of two components – financial and non-financial assets. The non-financial assets contain current values of real estates (home residence, lands, and other properties) and business assets (ownership of businesses, professional practices, and farms). The financial assets include safe assets (checking and saving accounts, money market funds, CDs, government savings bonds and T-bills), bonds (corporate, municipal, foreign bonds and bond funds), risky assets (stocks and mutual funds), and retirement accounts (individual retirement account and Keogh accounts). The financial assets share refers to the proportion of financial assets within total assets. The share of risky assets is defined as the proportion of risk assets within financial assets.
c. The physical function (PF) index is constructed based on six questions measuring the degree of difficulty to carry out (1) walk for a quarter mile, (2) walk flight of stairs, (3) stoop, crouch, or kneel, (4) stand for a long period, (5) sit for a long period, and (6) lift or carry a weight of 25 pounds. The Chronic Conditions (CC) index also involves multiple indicators as responses to five questions asking about chronic conditions, including (1) nervous system; (2) paralysis; (3) lung and respiratory system; (4) digestive system; and (5) malignant tumors or growth. The index of HASH is a dichotomous variable that indicates people who have experienced heart attack or stroke at least once before the survey. Finally, the WRL index is based on a three questions about self-assessed health limitations that keep respondents from working or restrict their hours on paid work, house work, or work in general.

Table 2  
Estimating the Effect of Physical Functions (PF) Index on Total Assets Using Various Samples (OLS model)

This table reports the regression results from the OLS model described in Equation (3), which examines how total assets are associated with the Physical Function (PF) Index, which we construct using the process detailed in Section 2. Regressions are conducted based on three different samples – (i) the whole sample in 1982; (ii) the whole sample in 1991; and (iii) the panel-balanced sample in 1982, which is composed of those households in the 1982 sample that survive to 1991 survey. Numbers in parentheses are t values. *, and ** indicate that the t-statistics is significant at the 5% and 1% significance level, respectively.

<table>
<thead>
<tr>
<th>Dependent Variable: total assets</th>
<th>1982 all</th>
<th>1982 balanced</th>
<th>1991 all</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>41.4 (6.4)**</td>
<td>48.6 (5.4)**</td>
<td>39.5 (5.4)**</td>
</tr>
<tr>
<td>Months of age</td>
<td>-8.0 (-2.4)*</td>
<td>-16.9 (-3.0)**</td>
<td>-9.6 (-2.5)**</td>
</tr>
<tr>
<td>Months of age^2</td>
<td>0.006 (2.9)**</td>
<td>0.012 (3.4)**</td>
<td>0.006 (2.8)**</td>
</tr>
<tr>
<td>Marital Status (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Widow/Widower</td>
<td>36.0 (0.1)</td>
<td>50.6 (0.1)</td>
<td>22.6 (0.6)</td>
</tr>
<tr>
<td>separated</td>
<td>43.7 (0.1)</td>
<td>57.4 (0.1)</td>
<td>4.5 (0.1)</td>
</tr>
<tr>
<td>divorced</td>
<td>6.2 (0.0)</td>
<td>5.8 (0.0)</td>
<td>-22.3 (-0.6)</td>
</tr>
<tr>
<td>never married</td>
<td>14.1 (0.0)</td>
<td>13.7 (0.0)</td>
<td>-5.3 (-0.1)</td>
</tr>
<tr>
<td>Years of schooling</td>
<td>14.5 (14.9)**</td>
<td>15.4 (11.4)**</td>
<td>14.7 (13.9)**</td>
</tr>
<tr>
<td>Race (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>American Indian or Alaskan native</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Asian or Pacific Islander</td>
<td>14.5 (0.2)</td>
<td>5.6 (0.1)</td>
<td>79.2 (1.1)</td>
</tr>
<tr>
<td>Black</td>
<td>-10.3 (-0.2)</td>
<td>-26.7 (-0.4)</td>
<td>6.2 (0.1)</td>
</tr>
<tr>
<td>White</td>
<td>47.4 (0.9)</td>
<td>34.0 (0.5)</td>
<td>52.5 (0.3)</td>
</tr>
<tr>
<td>Others</td>
<td>56.4 (0.6)</td>
<td>22.6 (0.3)</td>
<td>61.4 (1.0)</td>
</tr>
<tr>
<td>Household size</td>
<td>-3.5 (-0.5)</td>
<td>-3.6 (-0.3)</td>
<td>2.3 (0.2)</td>
</tr>
<tr>
<td>Insurance coverage (%)</td>
<td>5.4 (0.5)</td>
<td>-2.2 (-0.1)</td>
<td>40.5 (0.9)</td>
</tr>
<tr>
<td>Total number of children</td>
<td>2.4 (1.5)</td>
<td>2.0 (0.9)</td>
<td>0.7 (0.4)</td>
</tr>
<tr>
<td>Physical functions (PF)</td>
<td>36.3 (3.2)**</td>
<td>36.2 (2.2)**</td>
<td>53.9 (4.1)**</td>
</tr>
<tr>
<td>Observations</td>
<td>15,188</td>
<td>9,798</td>
<td>9,798</td>
</tr>
</tbody>
</table>

Notes:

a. All regressions also include household location dummies as covariates.
b. For definitions of total assets and the physical function (PF) index, please refer to notes of Table 1.

Table 3
OLS Estimations of the Health Effects on Assets and Shares of Assets
Using the NBS DATA

This table reports the comprehensive results from estimating the OLS model described in Equation (3), exploring the correlations of various assets and assets shares with all the four health indices – physical functions, chronic conditions, heart attack or stroke history and work-related. The dependent variables include total assets, financial assets, non-financial assets, share of financial assets, the incident of holding risky assets, and share of risky assets. Regressions are conducted based on four different samples – (1) the full sample in 1982; (2) and the panel-balanced sample in 1982, which is composed of those households in the 1982 sample that survive to 1991 survey; (3) the full sample in 1991; and (4) Regressions of 1992 sample using lagged health measures from 1982. Numbers in parentheses are z values for Tobit estimates, and t values for all other estimates. *, and ** indicate that the t-statistics is significant at the 5% and 1% significance level, respectively.

<table>
<thead>
<tr>
<th>Dependent variables:</th>
<th>(1) Physical Functions (PF)</th>
<th>(2) Chronic Conditions (CC)</th>
<th>(3) Heart Attack or Stroke History (HASH)</th>
<th>(4) Work-related Limitations (WRL)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A: 1982 full sample</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total assets</td>
<td>36,273 (3.2)</td>
<td>80,610 (3.3)</td>
<td>10,870 (1.2)</td>
<td>41,885 (5.1)</td>
</tr>
<tr>
<td>Financial assets</td>
<td>17,272 (3.2)</td>
<td>32,929 (2.8)</td>
<td>9,652 (2.1)</td>
<td>15,170 (3.8)</td>
</tr>
<tr>
<td>Non-financial assets</td>
<td>19,001 (2.2)</td>
<td>47,682 (2.5)</td>
<td>1,217 (0.2)</td>
<td>26,715 (4.2)</td>
</tr>
<tr>
<td>Risky assets (Tobit estimates)</td>
<td>21,730 (12.6)</td>
<td>29,274 (8.1)</td>
<td>5,882 (6.0)</td>
<td>15,649 (12.3)</td>
</tr>
<tr>
<td>Risky assets (Probit estimates)</td>
<td>0.102 (7.5)</td>
<td>0.139 (5.0)</td>
<td>0.021 (2.2)</td>
<td>0.063 (6.8)</td>
</tr>
<tr>
<td>Financial assets share</td>
<td>0.043 (4.4)</td>
<td>0.038 (1.8)</td>
<td>0.001 (0.1)</td>
<td>0.021 (2.8)</td>
</tr>
<tr>
<td>Risky assets share of financial assets</td>
<td>0.027 (5.3)</td>
<td>0.049 (4.5)</td>
<td>0.010 (2.4)</td>
<td>0.019 (5.2)</td>
</tr>
<tr>
<td><strong>Panel B: 1982 panel-balanced sample</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total assets</td>
<td>36,185 (2.2)</td>
<td>97,021 (2.7)</td>
<td>17,448 (1.3)</td>
<td>42,264 (3.6)</td>
</tr>
<tr>
<td>Financial assets</td>
<td>17,874 (2.1)</td>
<td>37,212 (2.1)</td>
<td>9,443 (1.3)</td>
<td>15,112 (2.5)</td>
</tr>
<tr>
<td>Non-financial assets</td>
<td>18,311 (1.4)</td>
<td>59,810 (2.2)</td>
<td>8,004 (0.7)</td>
<td>27,153 (2.9)</td>
</tr>
<tr>
<td>Risky assets (Tobit estimates)</td>
<td>26,499 (9.4)</td>
<td>32,582 (5.7)</td>
<td>5,534 (3.4)</td>
<td>18,764 (9.4)</td>
</tr>
<tr>
<td>Risky assets (Probit estimates)</td>
<td>0.520 (6.0)</td>
<td>0.619 (3.7)</td>
<td>0.063 (1.1)</td>
<td>0.303 (5.3)</td>
</tr>
<tr>
<td>Financial assets share</td>
<td>0.045 (3.5)</td>
<td>0.025 (0.9)</td>
<td>-0.003 (-0.3)</td>
<td>0.015 (1.6)</td>
</tr>
<tr>
<td>Risky assets share of financial assets</td>
<td>0.031 (4.6)</td>
<td>0.049 (3.3)</td>
<td>0.008 (1.4)</td>
<td>0.023 (4.7)</td>
</tr>
<tr>
<td><strong>Panel C: 1991 full sample</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total assets</td>
<td>53,915 (4.1)</td>
<td>92,025 (3.9)</td>
<td>16,288 (2.1)</td>
<td>36,568 (4.5)</td>
</tr>
<tr>
<td>Financial assets</td>
<td>24,946 (2.5)</td>
<td>38,685 (2.2)</td>
<td>11,994 (2.0)</td>
<td>15,652 (2.5)</td>
</tr>
<tr>
<td>Non-financial assets</td>
<td>28,969 (4.5)</td>
<td>53,339 (4.6)</td>
<td>4,293 (1.1)</td>
<td>20,916 (5.2)</td>
</tr>
<tr>
<td>Risky assets (Tobit estimates)</td>
<td>28,805 (7.8)</td>
<td>33,972 (5.5)</td>
<td>5,982 (3.4)</td>
<td>15,345 (7.2)</td>
</tr>
<tr>
<td>Risky assets (Probit estimates)</td>
<td>0.129 (6.0)</td>
<td>0.172 (4.6)</td>
<td>0.015 (1.2)</td>
<td>0.060 (4.7)</td>
</tr>
<tr>
<td>Financial assets share</td>
<td>0.010 (0.6)</td>
<td>-0.037 (-1.3)</td>
<td>0.006 (0.7)</td>
<td>-0.009 (-0.9)</td>
</tr>
<tr>
<td>Risky assets share of financial assets</td>
<td>0.041 (4.9)</td>
<td>0.044 (2.9)</td>
<td>0.007 (1.4)</td>
<td>0.015 (2.9)</td>
</tr>
</tbody>
</table>
Table 3 (continued)

<table>
<thead>
<tr>
<th>Dependent Variables:</th>
<th>(1) Physical Functions (PF)</th>
<th>(2) Chronic Conditions (CC)</th>
<th>(3) Heart Attack or Stroke History (HASH)</th>
<th>(4) Work-related Limitations (WRL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panel D: Regressions based on 1992 sample using lagged health measures from 1982</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total assets</td>
<td>29,582 (2.4) *</td>
<td>80,754 (3.0) **</td>
<td>13,881 (1.3)</td>
<td>36,096 (4.1) **</td>
</tr>
<tr>
<td>Financial assets</td>
<td>16,405 (1.8)</td>
<td>36,122 (1.8)</td>
<td>6,049 (0.8)</td>
<td>19,094 (2.9) **</td>
</tr>
<tr>
<td>Non-financial assets</td>
<td>13,176 (2.2) *</td>
<td>44,631 (3.4) **</td>
<td>7,833 (1.5)</td>
<td>17,002 (3.9) **</td>
</tr>
<tr>
<td>Risky assets (Tobit estimates)</td>
<td>21,629 (6.5) **</td>
<td>36,811 (5.2) **</td>
<td>7,743 (3.7) **</td>
<td>21,503 (8.8) **</td>
</tr>
<tr>
<td>Risky assets (Probit estimates)</td>
<td>0.199 (2.7) **</td>
<td>0.504 (3.3) **</td>
<td>0.098 (1.7)</td>
<td>0.254 (4.8) **</td>
</tr>
<tr>
<td>Financial assets share</td>
<td>0.031 (2.0) *</td>
<td>0.018 (0.6)</td>
<td>0.000 (0.0)</td>
<td>-0.001 (-0.1)</td>
</tr>
<tr>
<td>Risky assets share of financial assets</td>
<td>0.014 (1.8)</td>
<td>0.040 (2.4) *</td>
<td>0.008 (1.2)</td>
<td>0.026 (4.6) **</td>
</tr>
</tbody>
</table>

Notes:

a. In each regression, regressors include age, age squared, gender, marital status, years of schooling, ethnicity, household size, household demographic composition, entitlement of health insurance, number of children, and household locations. For regressions of financial assets share or risky assets share, we also control for total assets in the regressions. However, for expositional simplicity, in this table we only report estimates of health indices. Estimates of other covariates are not reported here but available upon request.

b. For definitions of assets, assets shares, and the health indices, please refer to notes of Table 1.

Table 4  
Estimating the Health Effects on Assets and Shares of Assets Using the Fixed-Effects (FE) and the Random-Effects (RE) Model

This table reports the comprehensive results from estimating the FE and RE models described in Equation (4), exploring the correlations of various assets and assets shares with all the four health indices – physical functions, chronic conditions, heart attack or stroke history and work-related. The dependent variables include total assets, financial assets, non-financial assets, share of financial assets, the incident of holding risky assets, and share of risky assets. Numbers in parentheses are t values. *, and ** indicate that the t-statistics is significant at the 5% and 1% significance level, respectively.

<table>
<thead>
<tr>
<th>Dependent Variables:</th>
<th>(1) Physical Functions (PF)</th>
<th>(2) Chronic Conditions (CC)</th>
<th>(3) Heart Attack or Stroke History (HASH)</th>
<th>(4) Work-related Limitations (WRL)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A Fixed-effects Model</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total assets</td>
<td>16,559 (1.1)</td>
<td>18,395 (0.8)</td>
<td>-2,486 (-0.3)</td>
<td>3,807 (0.5)</td>
</tr>
<tr>
<td>Financial assets</td>
<td>6,687 (0.7)</td>
<td>4,433 (0.3)</td>
<td>4,938 (0.9)</td>
<td>-3,595 (-0.7)</td>
</tr>
<tr>
<td>Non-financial assets</td>
<td>9,872 (0.7)</td>
<td>13,961 (0.7)</td>
<td>-7,423 (-1.0)</td>
<td>7,403 (1.0)</td>
</tr>
<tr>
<td>Risky assets (Tobit estimates)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Risky assets (Probit estimates)</td>
<td>0.058 (3.0)**</td>
<td>0.008 (0.3)</td>
<td>0.021 (1.8)</td>
<td>0.006 (0.6)</td>
</tr>
<tr>
<td>Financial assets share</td>
<td>-0.017 (-1.0)</td>
<td>-0.038 (-1.3)</td>
<td>-0.006 (-0.6)</td>
<td>-0.006 (-0.6)</td>
</tr>
<tr>
<td>Risky assets share of financial assets</td>
<td>0.021 (2.1)*</td>
<td>-0.019 (-0.6)</td>
<td>0.012 (2.1)*</td>
<td>-0.004 (-0.7)</td>
</tr>
</tbody>
</table>

| **Panel B Random-effects Model** |                            |                             |                                        |                                  |
| Total assets         | 75,398 (11.8)**            | 85,320 (6.7)**              | 13,274 (2.9)**                        | 53,440 (11.8)**                  |
| Financial assets     | 35,833 (10.0)**            | 41,359 (5.8)**              | 8,739 (3.4)**                         | 24,554 (9.6)**                  |
| Non-financial assets | 43182 (9.2)**              | 55,770 (6.0)**              | 6,336 (1.9)                           | 35,336 (10.6)**                  |
| Risky assets (Tobit estimates) | --                       | --                          | --                                     | --                               |
| Risky assets (Probit estimates) | 0.14 (17.8)**              | 0.148 (9.3)**               | 0.029 (5.1)**                         | 0.087 (15.4)**                   |
| Financial assets share | 0.078 (10.1)**            | 0.036 (2.2)*                | 0.009 (1.6)                           | 0.038 (6.7)**                     |
| Risky assets share of financial assets | 0.046 (12.3)**            | 0.048 (6.4)**               | 0.010 (3.7)**                         | 0.028 (10.4)**                   |

**Notes:**

a. In each regression, regressors include age, age squared, gender, marital status, years of schooling, ethnicity, household size, household demographic composition, entitlement of health insurance, number of children, and household locations. For regressions of financial assets share or risky assets share, we also control for total assets in the regressions. However, for expositional simplicity, in this table we only report estimates of health indices. Estimates of other covariates are not reported here but available upon request.

b. For definitions of assets, assets shares, and the health indices, please refer to notes of Table 1.

Figure 1
Unconditional Correlation between Health Indices and Assets (and Shares of Assets)
Using the NBS Data

(1.1) Physical functions (PF)

(a) Total assets

(b) Financial assets

(c) Non-financial assets

(d) Risky assets

(e) Financial assets share

(f) Risky assets share
Figure 1 (continued)

(1.2) Chronic conditions (CC)

(a) Total assets

(b) Financial assets

(c) Non-financial assets

(d) Risky assets

(e) Financial assets share

(f) Risky assets share
Figure 1 (continued)

(1.3) Work-related limitations (WRL)

(a) Total assets

(b) Financial assets

(c) Non-financial assets

(d) Risky assets

(e) Financial assets share

(f) Risky assets share

Notes:
1. Each fitted curve is graphed by carrying out a locally weighted regression of y variable on x variable with bandwidth of 1.
2. Values of assets in 1991 have been deflated using 1982-based CPI.
3. For definitions of assets, assets shares, and the health indices, please refer to notes of Table 1b.

Figure 2
Unconditional Correlations between Changes in Health Indices and Changes in Assets (and Shares of Assets)

(2.1) Physical functions (PF)

(a) Total assets
(b) Financial assets
(c) Non-financial assets
(d) Risky assets
(e) Financial assets share
(f) Risky assets share
(2.2) Chronic conditions (CC)

(a) Total assets

(b) Financial assets

(c) Non-financial assets

(d) Risky assets

(e) Financial assets share

(f) Risky assets share
(2.3) Work-related limitations (WRL)

(a) Total assets

(b) Financial assets

(c) Non-financial assets

(d) Risky assets

(e) Financial assets share

(f) Risky assets share

Notes:
1. In each graph, the line is drawn by carrying out a linear regression of y variable on x variable.
2. Values of assets in 1991 have been deflated using 1982-based CPI.
3. For definitions of assets, assets shares, and the health indices, please refer to notes of Table 1b.