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The effects of health shocks on risk preferences: Do personality traits matter?

Abstract

Older individuals hold a disproportionate amount of total wealth, and are particularly vulnerable to shocks to health. Accordingly, there is a interest in understanding the extent to which health detriments influence financial choices and portfolio holdings within this group of society. A separate strand of literature has recently focused on the role of non-cognitive skills, and in particular personality traits, in shaping attitudes towards risk. We combine these literatures to explore the extent to which unantici pated shocks to health display heterogeneous impacts on preferences towards financial risk via portfolio investments and stock market participation. We find that health shocks have a negative effect on the level of risk at the household level when men, but not women, experience the shock. Moreover, there appears to be heterogeneity in the response by personality trait. Households where men display dominant traits for neuroticism, extraversion and openness to experience tend to be most affected in investment decisions following a health shock. The household becomes less risk tolerant when the level of neuroticism or openness increases, and more risk tolerant when the level of extroversion of the man increases.

1. Introduction

There has been recent interest in how health impacts financial portfolio holdings and preferences over financial risk. Health deteriorates with age and people who experience health shocks the most tend to be elderly. Since the elderly also control a "disproportionate amount of total wealth" (Rosen and Wu 2004), shocks to health which cause changes in risk preferences among this group may lead to revised portfolio decisions and, as a consequence, impact financial markets. Changes in risk preferences due to health shocks are also relevant in the light of reforms of pension systems which have occurred over the past few decades across many countries, such as Canada, Australia, the US and the UK, where it is expected that the share of private pension wealth will become increasingly important and that households will have more responsibility for financial decisions with respect to their pensions (Munnell 2006). Pension income is, therefore, expected to become more reliant on financial assets and decisions about investments (Lindeboom an Melnychuk 2015). Should health shocks affect financial choices, they might be expected to lead to changes in pension income and economic wellbeing. A separate literature has focused on the influence of non-cognitive skills such as personality traits on financial risk preferences and have shown these to vary across traits. For example, stock market participation has been found to be positively related to conscientiousness (Goldfayn-Frank 2018) and openness to experience (Brown and Taylor 2014), and negatively related to agreeableness (Bucciol and Zarri 2017; Goldfayn-Frank 2018) and extraversion (Brown and Taylor 2014). Using objective measures of stock market participation and percentage of risky assets in portfolio on older couples (aged 50 years and above) within households from the US Health and Retirement Study (HRS), we combine these literatures to investigate whether health shocks have heterogeneous effects on financial risk preferences due to personality traits.

Risk preferences are often regarded as exogenous and fixed in economic models. More recently, however, this assumption has been relaxed. For example, changes to risk preferences have been observed due to unexpected shocks caused by natural disasters (Reynaud and Aubert 2013, Cameron and Shah 2015), conflicts and violence (Voors et al. 2012, Callen et al. 2014, Bellucci et al. 2020) or severe financial shocks during early life (Malmendier and Nagel 2011). Recent studies have also investigated changes in risk preference due to life experiences such as losing work (Hetschko and Preuss 2020) or becoming a parent (Görlitz and Tamm 2020). Understanding the determinants of risk-taking behaviours is a key challenges for current research in Economic Psychology (Aytona et al. 2020).

In the literature that has focused on the effects of health and health shocks on preferences over financial risk, often proxied by the share of financial wealth invested in risky assets (bonds and stocks), most studies report that poor general health, poor mental health and health shocks are associated with less risky portfolios, and greater financial risk aversion (Rosen and Wu 2004, Bertowitz and Qiu 2006, Edwards 2008, Coile and Milligan 2009, Bogan and Fertig 2013, Lindeboom and Melnychuk 2015). An additional literature considers the effects of non-cognitive skills on human capital formation and labour market outcomes (e.g. Heckman and Rubinstein 2001, Heckman et al. 2006, Borgahns et al. 2008, Stratton et al. 2018). However, the links between personality traits and traditional economic preferences, such as risk aversion, have rarely been explored (Almlund et al. 2011). The literature that does exploit information on personality traits has tended to focus on the "Big 5" domains (Costa and McCrae 1992): neuroticism, extraversion, conscientiousness, agreeableness and openness to experience (Brown and Taylor 2014, Luik and Steinhardt 2016, Bucciol and Zarri 2017, Goldfayn-Frank 2018).

This paper combines the above two strands of literature to investigate whether health shocks have heterogeneous effects on financial risk preferences, according to personality traits. We focus on acute health conditions, since these conditions (such as stroke, health conditions and cancer) have been found to be more relevant for financial risk preference than chronic conditions (such as arthritis, diabetes, psychological issues, ect.) (Fan and Zao 2009, Bressan et al. 2014, Love and Smith 2010). Further, acute health shocks, at least in terms of their timing, can be thought of as exogenously determined (see for example, Jones et al. 2020). We further focus on households consisting of couples, since previous literature has shown no relevant effects of health on the level of riskiness of portfolios for single occupant households (Love and Smith 2010).

As far as we are aware this study is the first to investigate the presence of heterogeneity by personality traits in the effects of health shocks on risk preferences. Our unit of analysis is the household; however, we allow for the characteristics of each individual to have a separate influence on the portfolio choices of the household (Hurd et al. 2012, Gensowski 2014). Only a small number of studies investigate the influence of personality traits of both spouses on economic outcomes and behaviours of the household (Hurd et al. 2012, Gensowski 2014). A fundamental assumption in our empirical strategy is stability in personality traits over the survey period. We perform robustness checks to provide support for this assumption.

Our empirical analysis suggests that health shocks, on average, have a negative influence on the level of risk tolerance of households when men, but not women, experience a shock. Moreover, the effects of health shocks appear to be heterogeneous according to the personality traits of the individuals. Neuroticism, extroversion and openness to new experiences appear to be the traits for which heterogeneity seems to be most relevant. Understanding the characteristics of individuals and households that lead to changes in preferences over financial risk provides valuable information to better target financial instruments, through for example, improving financial literacy, so that households may achieve their financial goals following a major event including a health shock of a household member.

2. Related literature

Risk preferences have typically been regarded by economists as exogenous and fixed in the framework of the homo-economicus model. "The notion of endogenous, or context-dependent, preferences gnaws at the foundations of standard welfare theory" (Voors et al. 2012). However, in other social sciences, such as psychology, there is little opposition to the concept that large (temporary) shocks can have persistent effects on someone's outlook on life and preferences (Carmil and Breznitz 1991, Tedeschi and Calhoun 2004). As a consequence of this view, more recent studies have begun to relax the assumption that preferences are fixed. For example, studies have considered how shocks via unexpected events caused by natural disasters such as hurricanes, tsunami, floods. (Ecker et al. 2009, Reynaud and Aubert 2013, Ingwersen 2014, Cameron and Shah 2015), exposure to conflicts and violence (Voors et al. 2012, Callen et al. 2014) or severe financial shocks during early life (Malmendier and Nagel 2011) impact attitudes towards risk.

It has been debated whether risk preference vary across domains that make up human life or are fairly stable across those domains. As an example, one may be quite risk-averse about financial decisions but risk-loving with regard to decisions about health. Several studies have provided evidence in favour of the hypothesis that risk preferences are domain specific (Weber et al. 2002, Einav et al. 2012). Other more recent studies claim that a willingness to take risks within a specific domain is highly correlated to risk preferences in other domains (Dohmen et al. 2011). While we focus our attention specifically on risk preferences in the domain of financial choices, we do not exclude the possibility that risk preferences in this domain might be correlated to preferences in other domains, such as occupation or health choices.

Within the literature focused on the effects of health and health shocks on financial risk preferences, beginning with the contributions of Cohn et al. (1975) and Friend and Blume (1975), financial risk tolerance has typically been proxied by the share of financial wealth invested in risky assets (bonds and stocks) and, more generally, household portfolio allocation. With regard to the influence of measures of general health on portfolio allocation Rosen and Wu (2004) and Edwards (2008) find that poor health is associated with less risky portfolios in the HRS study. However, mixed results are reported by Fan and Zhao (2009) and Love and Smith (2010), when using the US Administration's Master Beneficiary Record and the HRS, respectively.[1] Bogan and Fertig (2013) and Lindeboom and Melnychuk (2015) investigate more specifically the influence of mental health on risky asset holdings by using data from the HRS and Survey on Health, Ageing and Retirement in Europe (SHARE), respectively. They report that, in general, mental illness lowers the probability of acquiring risky financial assets and a corresponding reduction in expected financial return. Bressan et al. (2014) cast doubt on the previous results and report that only poor self-assessed health negatively impacts portfolio choice, while other health measures - chronic conditions, limitations in daily activities of life, mental health - have no effect. Berkowitz and Qiu (2006) and Coile and Milligan (2009) both rely on data from the HRS. The former suggests that the effects of health shocks on financial asset allocation is indirect, since it can be due to a financial wealth effect; "a health shock can significantly reduce household total financial assets and lead to a restructuring of the composition of its financial assets" (Berkowitz and Qiu 2006). The latter study suggests that health shocks reduce the share of risky assets in portfolios, and that this effect strengthens with increasing time since the shock. They also report that responses to health shocks are dependent on household physical and mental capacity. Sahm (2012) and Decker and Schmitz (2016) consider a direct measure of financial risk, derived from hypothetical gambles over lifetime income. While the latter report that health shocks significantly increase individual risk aversion, the former fails to find such an effect when considering acute health shocks (heart disease, stroke, cancer or lung disease). Recently, Banks et al. (2020) investigated financial risk tolerance at older ages across 14 European countries using data from SHARE and found that decreased health, among other life events such as widowhood, and retirement, reduces

[1] Love and Smith (2010) report that there is a small negative effect of being in poor health on portfolio riskiness, but this effect is present only for married couples and not for singles. Fan and Zhao (2009) report that the correlation they find among health and the share of risky assets is sensitive to the different health indices they use. In particular physical functions, heart attack and stroke history appear to be better than chronic conditions and work related health limitations in predicting risk taking financial decisions.

risk tolerance in elderly people.

A further strand of literature has considered the influence of non-cognitive skills (personality traits) on financial risk preferences.[2] Beginning with studies in Economics on the predictive power of non-cognitive skills on labour and social outcomes (e.g. Heckman and Rubinstein 2001), a large and growing literature considers the effects of non-cognitive skills on human capital formation and labour market outcomes, such as unemployment, wage gaps, lifetime earnings and financial distress (Heckman et al. 2006, Borgahns et al. 2008, Parise and Peijnenburg 2019). However, the links between personality traits and traditional economic preference, such as risk aversion, remain scarcely explored (Almlund et al. 2011). Below we focus on studies which have proxied personality traits by the "Big five" (henceforth big 5) personality domains; neuroticism, extraversion, conscientiousness, agreeableness and openness to experience (Costa and McCrae 1992). Of the few studies that focus on the influence of these traits on financial market participation through holdings of stocks and shares, results suggest that stock market participation is positively influenced by conscientiousness (Goldfayn-Frank 2018) and openness to experience (Brown and Taylor 2014), and negatively influenced by agreeableness (Bucciol and Zarri 2017, Goldfayn-Frank 2018) and Extraversion (Brown and Taylor 2014).[3][4][5] Other studies have focused on the influence of the big 5 traits on risk preferences directly, and find that the degree of risk tolerance has been reported to be positively influenced by openness to experience (Dohmen et al. 2010) and extraversion (Becker et al. 2012), while negatively influenced by agreeableness (Borghans et al. 2008) and neuroticism

[2]It has been shown that the measurement system of personality traits and risk preferences capture distinct sources of heteroegeneity in life outcomes, and, therefore, risk preferences and personality traits appear to be complementary construct (Almlund et al. 2011, Becker et al. 2012).

[3]The result about Conscientiousness of Goldfayn-Frank (2018), which has been obtained by investigating a sample from the HRS, appear to hold only for older people, who have already retired.

[4]When investigating a sample from the HRS, Luik and Steinhardt (2016) confirm the result obtained by Brown and Taylor (2014) (who used the British Household Panel Survey) about the negative influence of extraversion on stock market participation, but only for immigrant US residents. However, the results of Luik and Steinhardt (2016) suggest that this effect is positive for native US residents. Luik and Steinhardt (2016) suggest that neuroticism has also a positive influence of the stock market participation of US native residents.

[5]Bertoni et al. (2019) have also investigated the influence of the big 5 personality traits on stock market participation of couples made by the elderly individuals by using Wave 7 of the Survey of Health, Ageing and Retirement in Europe (SHARE). However, since they use a cross-section dataset, they only estimate associations.

(Borghans et al. 2008, Becker et al. 2012, Rustichini et al. 2012).

3. Data

We use 11 waves (1992-2008) of the HRS, which is administered every two years by the Institute for Social Research at the University of Michigan. The HRS is a household panel providing longitudinal data on socio-demographic characteristics, health status and household portfolios of older US individuals. The HRS began in 1992 by surveying households with residents aged 51–61. In addition to re-interviewing households every two years, the survey merged with a similar survey of households occupants aged 70 and older ("AHEAD cohort").[6] Both partners in a household are interviewed in the HRS. By the 1998 wave, the HRS represented all US households with occupants over age 50. We focus our attention on households consisting of couples.

The HRS also contains information on specific topics. Of interest to us is the Participant Lifestyle ("Left Behind") module which contains data on personality traits. Since 2006 in each wave questions were asked to a rotating (random) 50% of the full sample. This implies that members of a household complete the module every four years. We use years 2006-2008 and assume that personality traits are fixed during the survey period.[7] This appears reasonable for our sample since evidence suggests that personality traits are stable in later life (e.g. McCrae and Costa 2006, Borghans et al. 2008, Cobb-Clark and Schurer 2012). We discuss further the assumption of stability of personality traits in Section 6.1.

Our outcome variables are stock market participation (a dummy variable equal to 1 if the household holds stocks or bonds, and 0 otherwise), and the percentage of risky assets in the portfolio, defined as the ratio of stocks and bonds to total financial wealth (Bucciol and Zarri 2017). Information on both is collected at the time of interview. Our main regressors of interest are health shocks, personality traits and their interaction.[8] Individuals are considered to have had an acute health shock if,

[6]Individuals in the "AHEAD cohort" were first interviewed in 1993 and then subsequently in 1995, and 1998. They were then interviewed every two years. Therefore, the waves included in the sample are 1992, 1993, 1994, 1995, 1996, 1998, 2000, 2002, 2004, 2006, and 2008.

[7]This follows the approach by Bucciol and Zarri (2017), who also exploits the HRS for their study.

[8]While the focus of our paper is on the interaction of health shocks and personality traits of household couples and how they influence financial decision making, it is plausible that health shocks

compared to the previous wave, they change their answer to the question "Has a doctor ever told you that you have heart problems/ cancer/ stroke", from "No" to "Yes" in the current wave. Accordingly, health shocks are recorded as equal to 1 in the wave first reported and all subsequent waves, and 0 in all waves preceding the shock.[9] This allows us to estimates both the immediate and cumulative impact of a health shock to financial portfolio risk. Personality traits are measured in the HRS on the basis of 26 personality facets, each with a 4-point rating scale (a description of these facets is provided in Appendix Table A1). For each individual, for each big 5 trait we take the average of their responses to the facets related to that trait to derive a continuous score in the range [1,4]. We then follow the procedure set out in Smith et al. (2013), and reparameterise the scores by dividing by 4 to be in the range [0.25, 1] (also see Bucciol and Zarri 2017, and Rustichini et al. 2012).

All models include the following controls: male (1 if male, 0 if female), age (in years), education (dummy = 1 if above the median number of years of schooling), non-white (1 if non-white ethnicity, 0 if white ethnicity), retired (1 if retired, 0 otherwise)[10], no children (1 if the respondents have no children, 0 otherwise[11]), log of total wealth of the household (in US$), income (in US$10,000), pension (in US$10,000) and dummy variables for good health (t-1) and fair or poor health (t-1) (contrasted against excellent or very good health) in the last period.[12]

It is possible that individuals who are deemed risk takers in the health domain, and hence more likely to experience the kind of health shocks considered, may have high financial risk tolerance.[13] In order to account for this potential source of endo-

to extended family members might also impact on the portfolio decision of households. Unfortunately, we are not able to investigate this here as information on health shocks on extended family members is not available in the HRS.

[9]Note that we exclude observations (households) where individuals inconsistently report a health shock across waves. This occurs where, for example, an individual reports the occurrence of a health shock, but at a subsequent wave disputes this. We exclude approximately 0.2%, 0.9% and 0.8% of the responses for the health domains of cancer, heart problems and stroke, respectively

[10]We have considered specification with additional controls for labour supply status, including employed, unemployed, not in labour force etc. However, results remain almost identical to those obtained in this more parsimonious model containing retired versus non-retired.

[11]Children could be dependents or living independently.

[12]We have also considered health insurance status. These are not significant in the model, and the estimates obtained for variables of interest are almost identical to the more parsimonious model estimated. Since their use implies a reduction in sample size we do not include them in our preferred specification.

[13]There is a lack of consensus whether risk preferences are domain specific or not (Weber, 2001,

geneity we include variables capturing health behaviours related to drinking alcohol and smoking (at time t-1), which are often used as proxies for risk preferences in the health domain (Dohmen et al. 2011).

Table 1 presents the mean, standard deviation, minimum and maximum for the variables used in our empirical model for the sample of households. Households are included in the sample where both partners responded to the questionnaire. The descriptive statistics are stratified by gender. P-values for paired t-tests of the null hypothesis of equality of means and proportions across men and women within households are provided in the final column of the table. While, in general, socioeconomic characteristics appear substantively similar, formal tests of differences across partners reveal statistical differences, for instance for income, pension and smoking.

4. Empirical model and estimation strategy

We model stock market participation and the percentage of risky assets in portfolio by estimating nonlinear panel specifications with correlated random effects. The unit of analysis remains the household (i), but we allow for the characteristics of each individual within the couple in the household to have a separate influence on the portfolio choices of the household (Hurd et al. 2012, Gensowski 2014). Given the limited dependent nature of our outcomes, we formulate our basic model for financial risk tolerance in terms of an underlying latent variable as follows:

$$f_{it}^{*} = \gamma h_{ijt} + p_{ij}'\lambda_1 + p_{ik}'\lambda_2 + x_{ijt}'\beta_1 + x_{ikt}'\beta_2 + z_{it}'\theta + \pi_t + \alpha_i + \varepsilon_{it}, \qquad (1)$$

where $i = 1, \ldots, N$, and $t = 1, \ldots, T_i$, index household and time respectively. Financial risk tolerance on a latent scale for household i in wave t is represented by f_{it}^{*}. The indices j and k reference the two individuals within the household couple and we run regressions separately to investigate the impact of health shocks for males and for females. Accordingly, when considering health shocks to males (females), j indexes male (female) characteristics, and k indexes female (male) characteristics for household i. h_{ijt}, represents the health shock for spouse/partner j, and γ is the primary parameter of interest. Since we consider only households formed from couples, $N_j = N_k = N$. p_{ij} and p_{ik} represent vectors of personality traits (from the big 5

2002; Dolmen et al. 2011; Einav, 2012)

Table 1: Summary statistics

	Households Couples Mean	S.D.	Min.	Max.
Stock market participation	0.60	0.49	0.00	1.00
% of risky assets in portfolio	0.41	0.41	0.00	1.00
No children	0.03	0.18	0.00	1.00
Log total wealth	12.40	1.33	0.69	17.51

	Males				Females				¶-value
	Mean	S.D	Min.	Max.	Mean	S.D	Min.	Max.	diff.
Personality traits									
Neuroticism	2.23	0.40	1.00	4.00	2.38	0.44	1.00	4.00	0.000
Extraversion	3.16	0.55	1.00	4.00	3.27	0.54	1.20	4.00	0.000
Agreeableness	3.38	0.50	1.20	4.00	3.65	0.40	1.40	4.00	0.000
Conscientiousness	3.35	0.46	1.20	4.00	3.46	0.44	1.20	4.00	0.000
Openness to experience	2.97	0.53	1.00	4.00	2.97	0.54	1.00	4.00	0.418
Health shock									
Health shock	0.33	0.47	0.00	1.00	0.20	0.40	0.00	1.00	0.00
Control variables									
Age	67.72	8.73	33.0	100.00	64.48	9.16	25.00	95.00	0.000
Education	13.44	2.84	0.00	17.00	13.23	2.33	0.00	17.00	0.001
Non-white	0.08	0.27	0.00	1.00	0.08	0.27	0.00	1.00	0.151
Retired	0.52	0.50	0.00	1.00	0.44	0.50	0.00	1.00	0.000
Self-reported health:									
fair/poor (t-1)	0.32	0.47	0.00	1.00	0.30	0.46	0.00	1.00	0.000
good(t-1)	0.16	0.37	0.00	1.00	0.13	0.34	0.00	1.00	0.219
Income (US$10,000)	2.05	6.72	0.00	652.50	1.23	2.82	0.00	82.50	0.000
Pension (US $10,000)	0.84	2.51	0.00	139.04	0.24	1.33	0.00	126.23	0.000
Drinking	0.63	0.48	0.00	1.00	0.55	0.50	0.00	1.00	0.000
Smoking	0.10	0.30	0.00	1.00	0.09	0.29	0.00	1.00	0.169

Note: NT = 18388 (households, males, females). P-values for paired t tests of the null hypothesis of equality of means or proportions are provided in the final column.

traits) for individuals within the household couple, and x_{ijt} and x_{ikt}, are respective sets of control variables. z'_{it} represent household level characteristics. π_t represents a fixed time trend, α_i is a household-specific and time invariant random component and ε_{it} is an idiosyncratic time varying error term assumed to follow a standard normal distribution. Equation (1) allows us to estimate the influence of health shocks and personality traits on financial risk tolerance, assuming that the effect of a health shock is homogeneous across personality traits. Since the outcome is either binary (stock market participation) or truncated (percentage of risky assets in portfolio) we estimate panel probit and tobit models respectively.

Given we are estimating nonlinear models, the usual panel data fixed effects approach is not feasible due to the incidental parameter problem.[14] While random effects estimation is possible, this fails to account for correlation between the regressors and the household unobserved effect. To allow for the possibility that the observed regressors are correlated with the unobserved random effect, α_i, we follow Mundlak (1978) (also see Wooldridge, 2005), and parameterise the random effect as follows,

$$\alpha_i = \bar{x}'_{ij}\pi_1 + \bar{x}'_{ik}\pi_2 + \bar{z}'_i\pi_3 + \mu_i, \tag{2}$$

where $\bar{x}'_{ij}$ and $\bar{x}'_{ik}$ are averages over the sample period, T_i, of observed regressors for each member of the couple within the household. Similarly, $\bar{z}'_i$ are time averaged household characteristics. μ_i is assumed to be distributed as $N\left(0, \sigma^2_\mu\right)$, independent of the regressors and the idiosyncratic error term (ε_{it}). This parameterisation controls for the correlation between the regressors, x_{it} and z_{it}, and the unobserved household effect, α_i in Equation (1).

To investigate heterogeneity in the effects of health shocks by personality traits we augment Equation (1) to include an interaction term between the health shock and the demeaned measure of the big5 trait as follows:[15]

$$\begin{aligned} f^*_{it} &= \gamma h_{ijt} + p'_{ij}\lambda_1 + h_{ijt}\left(p_{ij} - \bar{p}_j\right)'\phi + p'_{ik}\lambda_2 \\ &+ x'_{ijt}\beta_1 + x'_{ikt}\beta_2 + z'_{it}\theta + \pi_t + \alpha_i + \varepsilon_{it}, \end{aligned} \tag{3}$$

where $(p_{ij} - \bar{p}_j)$ represents the demeaned measure of the big5 personality trait ob-

[14]The number of parameters grows with i and hence α_i cannot be estimated consistently. In turn, due to the model being non-linear, this impacts on the consistency of the key parameters of interest in the model.

[15]Using a demeaned measure of the big5 personality trait, when interacted with a heath shock, is helpful to aid interpretation. Note that each of the big 5 traits are continuous measures with a range between 0.25 and 1, while the health shock is binary. The demeaned specification implies that the coefficients γ, representing the main effect for the health shock, h_{ijt}, is the partial effect of the health shock at the sample average value of the given personality trait (e.g. sample average level of neuroticism) - see Wooldridge (2005) for a detailed explanation. Without demeaning, the interpretation of the main partial effect for the health shock would be when the personality measure is zero. This is not a possible solution given the minimum value each trait can take.

tained by taking the difference between the personality of the individual, and the mean of the personality trait across households for partners j (males or females depending on the sub-sample). α_i is parameterised as in Equation (2).

Table 2: Correlated random effects estimations

	Stock market participation				% risky assets in portfolio			
	Male health shock		Female health shock		Male health shock		Female health shock	
	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
Neuroticism: men	0.068	0.281	0.066	0.281	-0.033	0.085	-0.033	0.085
Extraversion: men	-0.138	0.271	-0.147	0.271	0.000	0.082	-0.003	0.082
Agreeableness: men	-0.239	0.288	-0.225	0.288	-0.100	0.087	-0.095	0.087
Conscientiousness: men	0.707*	0.279	0.706†	0.279	0.190*	0.084	0.189*	0.084
Openness to experience: men	-0.583*	0.274	-0.591*	0.274	-0.228**	0.083	-0.230**	0.083
Neuroticism: women	-0.001	0.257	0.001	0.257	-0.011	0.078	-0.010	0.078
Extraversion: women	-0.245	0.270	-0.254	0.270	-0.012	0.082	-0.016	0.082
Agreeableness: women	0.246	0.345	0.250	0.345	0.100	0.104	0.102	0.104
Conscientiousness: women	0.237	0.289	0.239	0.289	0.074	0.087	0.074	0.087
Openness to experience: women	-0.552*	0.256	-0.554*	0.256	-0.207**	0.078	-0.207**	0.078
Health shock: men	-0.083†	0.044			-0.030*	0.012		
Health shock: women			0.027	0.051			0.008	0.014
AIC	17109.85		17113.17		25019.03		25024.74	
BIC	17414.81		17418.13		25331.81		25337.52	

Note: All models are estimated including the within-individual means of the time-varying regressors (Mundlak,1978) and year effects. The other regressors included in our model are: age, education, retired, self-reported health FAIR/POOR (t-1), self-reported health GOOD (t-1), income, pension, no-children, log of total wealth, drinking and smoking. The entire results for the reported regressions are available upon request. We assume that health shocks have no heterogeneous effects due to the personality traits on financial risk preferences. Statistical significance is denoted by: $^{\dagger}p < 0.1;^{*}p < 0.05;^{**}p < 0.01$. NT = 18388.

5. Results

Table 2 presents the results of estimation of Equation (1), for the health health shock and a personality trait.[16] The effects of health shocks and personality traits on financial risk tolerance are largely in line with previous literature (for example,

[16]Table A2 in the Appendix reports the full set of estimates, as an example, for Stock market participation for Male. The entire results for the other regressions reported in Table 2 are available upon request.

Brown and Taylor 2014, Bucciol and Zarri 2017, Luik and Steinhardt 2016, Goldfayn-Frank 2018). In particular, for men, conscientiousness has a positive and statistically significant influence of risk tolerance, as shown by Goldfayn-Frank (2018) and Bucciol and Zarri (2017). In contrast, agreeableness has a negative influence on risk tolerance, and while it is not statistically significant at conventional levels, it accords with Openness to experience which is negative and statistically significant for both men and women. The latter result, however, does not seem to be in line with previous literature. Brown and Taylor (2014) report a positive influence for this trait, and Bucciol and Zarri (2017) fail to reject the null of no effect. Table 2 shows that when the health shock impacts men there is a negative and statistically significant effect on both stock market participation and the percentage of risky assets in portfolio. The corresponding effect for women is not significant at conventional levels.[17]

Since Table 2 provides results related to non-linear models, the estimated coefficients have only a qualitative interpretation. To provide information about the magnitude of the effect of the health shocks we present average partial effects (APEs) (Wooldridge 2005) in Table 3. APEs are first computed on the full sample, as the average of the partial effects computed for each observation in the sample. The APEs for men are statistically significant and imply a 1.6 percentage point and a 3 percentage point reduction in stock market participation and the percentage of risky assets in portfolio, respectively, suggesting that the impact of this health shock, while not large, is not negligible. Accordingly, risk tolerance is reduced after a male in the household experiences a health shock.

We next explore heterogeneity in the impact of health shocks by personality trait. For each trait, we stratified the sample into two sub-samples, one containing individuals for whom the personality trait is below its sample median level (low level) and the other containing individuals with above medium levels (high level) of the trait.[18] We then estimate Equation (1) using each subsample and again compute APEs for the health shock. The magnitude of a negative effect of a health shock is smaller when the shock affects men with low levels of neuroticism (-0.002 for the probit and -0,009 for

[17] The p-values in Table 2 for the coefficients for health shocks for men for stock market participation and the percentage of risky assets in portfolio are $p = 0.058$ and $p = 0.014$, respectively

[18] The median value does not have a clear *clinical/psychological* meaning in terms of being "high" or "low" for a particular trait. However, as a first approximation, we believe that the median value represents a reasonable cut-off.

the tobit) compared to men with high levels of neuroticism (-0,027 for the probit and 0,046 for the tobit), with the effect being statistically significant in the latter sample. Conversely, the negative effect of the health shocks looks larger in households in the sub-sample with men characterized by low extraversion (-0.027 for the probit and -0,06 for the tobit) than for high extroversion (-0,007 for the probit and - 0,004 for the tobit). The APE is statistically significant only for the former sub-sample. The results appear to be in line with previous literature that has considered the influence of neuroticism and extraversion on direct measures of risk preferences (Borghans et al. 2008, Anderson et al. 2011, Becker et al. 2012, Rustichini et al. 2012). With regard to the other three personality traits, while there are differences in the magnitude of the effects of the health shocks across the sub-samples, these appear much smaller and are not statistically significant at conventional levels.

Table 4 presents results from the estimation of Equation (3) for the health shock and the personality traits. Results for men and women are reported separately. The interaction term between a health shock and a personality trait is statistically significant for neuroticism, extroversion and openness for men who are affected by the shock. None of the terms are statistically significant when considering shocks to women (with the exception of agreeableness, which is significant at the 10% level). [19]

We next compute APEs, and appropriate standard errors, from the results presented in Table 4.[20] Standard errors are obtained through bootstrapping by performing 1000 replications. APEs are computed for different levels of a personality trait (e.g. neuroticism) holding the other four personality traits at their observed levels. Following Bucciol and Zarri (2017), we first consider values at the bottom and the top of the distribution of the personality trait scores. Specifically, we take the observed

[19]We have also tried a specification with age included as a polynomial. The results (available upon request) do not change substantively. In the years 2007-2008 the US was hit by the financial crisis known as the "Great Recession". Since shocks via unexpected events in the external environment might impact attitudes toward risk (see Section 2), as a robustness check we have re-estimated Equation (3) using a sample that excludes 2008, i.e. the year where preferences might be affected by the Great Recession. The results of these estimates, available upon request, replicate the results of Table 4 well, indicating that the effects of the Great Recession do not bias our findings.

[20]Ai and Norton (2003) and Norton (2004) caution about the interpretation of interaction terms in non-linear models. First, although the directly estimated coefficient of the interaction term might be zero the partial effect for an interaction term could be non-zero. Secondly, standard significance tests on the coefficients of the interaction term are not reliable. Thirdly, the interaction effect is conditional on the independent variables and may have different signs for different values of the covariates.

Table 3: Average Partial Effects (APEs) for the health shock

	Full sample		Big 5 < sample median			Big 5 > sample median		
	Coef.	S.E.	N	Coef.	S.E.	N	Coef.	S.E.
				Stock market participation				
Men	$-0.016^{\dagger}$	0.009						
Neuroticism			7602	-0.002	0.014	10786	-0.027^{*}	0.011
Extraversion			8210	-0.027^{*}	0.013	10178	-0.007	0.012
Agreeableness			7387	-0.015	0.013	11001	-0.017	0.011
Conscientiousness			7665	$-0.022^{\dagger}$	0.013	10723	-0.013	0.011
Openness to experience			8551	-0.013	0.012	9837	$-0.021^{\dagger}$	0.012
Women	0.005	0.010						
Neuroticism			5164	-0.009	0.020	13224	0.012	0.012
Extraversion			8911	0.022	0.014	9477	-0.014	0.014
Agreeableness			7752	0.009	0.015	10636	0.002	0.013
Conscientiousness			8693	0.003	0.014	9695	0.006	0.014
Openness to experience			8495	0.021	0.015	9893	-0.006	0.014
				Percentage of risky assets in portfolio				
Men	-0.030^{*}	0.012						
Neuroticism			7602	-0.009	0.020	10786	-0.046^{**}	0.016
Extraversion			8210	-0.060^{**}	0.018	10178	-0.004	0.017
Agreeableness			7387	$-0.032^{\dagger}$	0.018	11001	$-0.028^{\dagger}$	0.016
Conscientiousness			7665	-0.040^{*}	0.020	10723	-0.023	0.016
Openness to experience			8551	$-0.031^{\dagger}$	0.019	9837	$-0.031^{\dagger}$	0.016
Women	0.005	0.010						
Neuroticism			5164	0.008	0.028	13224	0.009	0.017
Extraversion			8911	0.028	0.020	9477	-0.017	0.020
Agreeableness			7752	0.018	0.021	10636	-0.003	0.020
Conscientiousness			8693	0.008	0.021	9695	0.005	0.020
Openness to experience			8495	0.024	0.021	9893	-0.007	0.019

Note: The partial effects for stock market participation indicate the change in the probability of a household of taking part to the stock market due to be the health shock of one of the members of the household. For the percentage of risky assets in the portfolio the partial effects represent the change in the percentage points of risky assets in the portfolio of the household due to the health shock. Statistical significance is denoted by: $^{\dagger}p < 0.1;^{*}p < 0.05;^{**}p < 0.01$. NT = 18388 for full sample.

minimum level (0.25 or 0.3) and maximum level (1) for each of the traits. We also consider values which can unambiguously be considered as "low" (5th percentile of the distribution) and "high" (90th percentile of the distribution). In addition, we also compute the APE at the 25th percentile of the distribution, at the median value, and at the 75th percentile, for each trait. Results, presented in Table 5, suggest that households become less risk tolerant when the level of neuroticism, agreeableness,

Table 4: Correlated random effects with interaction terms

	Stock market participation				% risky assests in portfolio			
	Male		Female		Male		Female	
	Coef.	S.E.	Coef.	S.E.	Coef.	S.e.	Coef.	S.E.
Neuroticism	0.332	0.309	-0.002	0.272	0.026	0.092	0.007	0.082
Extraversion	-0.383	0.298	-0.254	0.285	-0.075	0.089	-0.004	0.086
Agreeableness	-0.132	0.313	0.397	0.363	-0.083	0.093	0.158	0.109
Conscientiousness	0.730*	0.307	0.214	0.306	0.194*	0.092	0.083	0.092
Openness to experience	-0.355	0.299	-0.492†	0.269	-0.169†	0.089	-0.202*	0.081
Health shock (hlth s)	-0.080†	0.044	0.025	0.051	-0.030*	0.012	0.006	0.014
Neuroticism × hlth s	-0.840*	0.409	0.033	0.436	-0.191†	0.115	-0.079	0.123
Extraversion × hlth s	0.798*	0.395	0.014	0.475	0.243*	0.109	-0.061	0.133
Agreeableness × hlth s	-0.392	0.424	-0.771	0.603	-0.062	0.117	-0.280†	0.167
Conscientiousness × hlth s	-0.072	0.405	0.208	0.501	-0.018	0.115	-0.016	0.139
Openness to experience × hlth s	-0.682†	0.375	-0.344	0.430	-0.178†	0.105	-0.030	0.122
AIC	17110.20		17110.20		25020.39		25020.19	
BIC	17454.26		17454.26		25372.07		25372.07	

Note: All models are estimated including the within-individual means of the time-varying regressors (Mundlak 1978) and year effects. The other regressors included in our model are: age, education, retired, self-reported health FAIR/POOR (t-1), self-reported health GOOD (t-1), income, pension, no-children, log of total wealth, drinking and smoking. The entire results for the reported regressions are available upon request. We assume that health shocks have no heterogeneous effects due to the personality traits on financial risk preferences. Statistical significance is denoted by: $^{\dagger}p < 0.1$;$^{*}p < 0.05$;$^{**}p < 0.01$. NT = 18388.

conscientiousness and openness of the male in the household increases as observed by decreasing APEs for increasing levels of these traits. For neuroticism, agreeableness, and openness positive APEs are found when traits are set to their minimum values (and in most cases also when set at the 5th percentile of the distribution), while the APEs are always negative at the 90th percentile of the distribution and at the maximum value. Household risk tolerance generally increases with increasing levels of extroversion. However, the APEs do not follow a constant trend across the distribution of the trait, and results need to be interpreted with caution. Heterogeneity in responses across the levels of the trait appear largest for neuroticism, extroversion and openness (e.g. for stock market participation, the variation in absolute terms is around 12.4, 12 and 10 percentage points between the APEs of the minimum and maximum value, respectively). These three traits are those for which the estimated coefficients of the interaction terms are statistically significant in Table 4.

Table 5: Average Partial Effects (APE) and standard errors for the health shock, MEN

	Min value	5th percentile	25th percentile	median value	75th percentile	90th percentile	Max value
				Stock market participation			
Neuroticism	0.035	0.014	0.004	-0.017	-0.027	-0.037	-0.089
	7.5e-05	3.1e-05	8.5e-06	3.6e-05	5.8e-05	8.0e-05	1.9e-04
Extraversion	-0.100	-0.061	-0.038	-0.014	-0.006	-0.042	0.017
	2.1e-04	1.3e-04	8.1e-05	3.0e-05	1.3e-05	9.2e-05	3.7e-05
Agreeableness	0.026	0.003	-0.008	-0.016	-0.020	-0.024	-0.028
	5.8e-05	7.0e-06	1.8e-05	3.4e-05	4.3e-05	5.1e-05	5.9e-05
Conscientiousness	-0.008	-0.013	-0.015	-0.016	-0.017	-0.017	-0.018
	1.7e-05	2.6e-05	3.1e-05	3.4e-05	3.6e-05	3.7e-05	1.8e-05
Openness to experience	0.048	0.016	-0.002	-0.017	-0.027	-0.036	-0.051
	1.2e-04	3.7e-05	5.5e-06	3.6e-05	5.6e-05	7.6e-05	1.6e-05
				Percentage of risky assets in portfolio			
Neuroticism	0.007	0.001	-0.002	-0.008	-0.011	-0.014	-0.032
	6.7e-05	1.2e-05	1.6e-05	6.9e-05	9.5e-05	1.2e-05	2.5e-04
Extraversion	-0.044	-0.027	-0.017	-0.007	-0.004	-0.008	-0.016
	3.5e-04	2.2e-04	1.4e-05	6.1e-05	6.7e-05	3.3e-05	4.5e-05
Agreeableness	0.001	-0.003	-0.006	-0.008	-0.009	-0.010	-0.011
	3.5e-04	2.2e-06	1.4e-04	6.1e-05	6.7e-05	3.3e-05	4.9e-05
Conscientiousness	-0.007	-0.007	-0.008	-0.008	-0.008	-0.008	-0.008
	1.7e-05	2.6e-05	3.1e-05	3.4e-05	3.6e-05	3.7e-05	1.8e-05
Openness to experience	0.009	0.003	-0.003	-0.008	-0.012	-0.016	-0.023
	1.5e-04	3.2e-05	2.8e-05	7.0e-05	9.7e-05	1.2e-05	1.6e-05

Note: All coefficient estimates in the above table are statistically significant at conventional levels. Standard errors are obtained through bootstrapping by performing 1000 replications. APEs are computed for different levels of a personality trait (e.g. neuroticism) holding the other four personality traits at their observed levels.

5.1. Short to medium-run effects of a health shock

The above estimates capture the cumulative effect of a health shock on outcomes over the remaining period for which an individual is observed in the panel. The period will vary across individuals such that for some respondents the impact of a shock might be estimated over a short time span (one to two waves), while for others this will be greater (up to a maximum of 11 waves in our data). This will depend on both the wave in which a health shock occurs and the total number of waves a respondent is observed within the data. The estimates reported above are averaged across these heterogeneous time periods. In this subsection we explore how a health shock influences financial risk preferences over the short to medium term (up to 4 waves post shock). We do this by considering sub-samples of respondents defined by how many waves of data following a health shock we consider, and estimate Equation 3 separately on each sub-sample. For example, we first consider the response to a health shock at period $t + 1$. This is achieved by ignoring all subsequent waves of data such that the impact of a health shock represents the cumulative effect averaged over waves t and $t + 1$. We then separately consider the cumulative response at $t + 2$ (that is, including responses at t, $t + 1$ and $t + 2$ and ignoring all subsequent waves), and finally at $t + 3$.[21] We estimate the model for the three personality traits that, when interacted with a health shock, influence financial risk choices (neuroticism, extroversion and openness to experiences). This is undertaken for men only.

Coefficient estimates and standard errors are presented in Table 6. Results reported in the final column of the table correspond to our main results reported in Table 4 for ease of comparison. The first three columns report cumulative effects from the health shock up to waves $t + 1$, $t + 2$ and $t + 3$, respectively.

The top panel of the table considers stock market participation. For the interaction between the health shock and neuroticism there is a clear gradient in coefficient effects which decreases in absolute value as the time period from the wave of the shock increases. In the wave following a shock the interaction term is approximately 50% higher (at -1.263) than the corresponding effect when considering all possible remaining waves following the shock (from our main model specification: -0.840). This suggests that the probability of stock market participation reduces by a greater amount immediately following a shock, than in the longer run. This would appear plausible given a likely focus on rehabilitation of health in the immediate and short-run period following a health shock, which is then likely to ease over time. While the effects for the interactions with extroversion are not significant in the short-run, there is similar evidence of a gradient over time. There is some evidence of a gradient for the interaction with openness to experience, with the probability of participation falling at an increasing rate in all but one of the time spans considered.

The bottom panel of the table reports results for the percentage of risky assets in

[21] We only consider the change in outcomes up to the first three waves following the health shock to capture the short-run effect and how this varies from the medium-term effect from our main specification.

portfolio. While there exists a clear gradient for the interaction terms for neuroticism, gradients are less obvious for interactions with extroversion and openness to experience. For the latter two, however, the largest effect is observed in the final column where all data periods following the shock are considered. The pattern for neuroticism follows that observed for stock market participation in that for the percentage of risky assets held in portfolio the coefficients on the interaction terms, while remaining negative, become less so with increasing time from the health shock. Again, this indicates less adversity towards financial risk as individuals adjust or recover from health shocks.

Table 6: Short and longer run effects of a health shock, MEN

	Cumulative effect of health shock using waves from t to			
	$t+1$	$t+2$	$t+3$	All waves
	Stock market participation			
Health shock	-0.065	-0.084†	-0.089†	-0.080†
	0.050	0.047	0.046	0.044
Health shock interacted with:				
Neuroticism	-1.263*	-1.195**	-0.950*	-0.840*
	0.493	0.455	0.435	0.409
Extroversion	0.343	0.506	0.557	0.798
	0.475	0.441	0.422	0.395
Openness to experience	-0.575	-0.588	-0.531	-0.682†
	0.452	0.417	0.398	0.375
	% risky assets in portfolio			
Health shock	-0.020	-0.028*	-0.032*	-0.030*
	0.014	0.013	0.013	0.012
Health shock interacted with:				
Neuroticism	-0.257†	-0.247*	-0.237*	-0.191†
	0.135	0.124	0.119	0.115
Extroversion	0.202	0.196	0.199†	0.243*
	0.130	0.120	0.115	0.109
Openness to experience	-0.128	-0.178	-0.161	-0.178†
	0.125	0.115	0.110	0.105
NT	13945	15332	16452	18388

The above subsamples are formed by ignoring all subsequent waves of data beyond those indicated in the column header. For example, when we consider the cumulative response to $t+2$, waves t, $t+1$ and $t+2$ are used, and all subsequent waves are ignored. Results report coefficients and associated standard errors. Statistical significance is denoted by: $^{\dagger}p < 0.1$;$^{*}p < 0.05$;$^{**}p < 0.01$.

6. Robustness checks

6.1. Stability of personality traits

A fundamental assumption we impose is that personality traits are stable over the survey period. However, there is an ongoing debate about validity of this assumption (see Borghans et at. 2008). The literature distinguishes between two kinds of stability, mean level stability and intra-individual stability. Mean level stability reflects whether or not in a given cohort personality traits increase or decrease over time. Intra-individual stability focuses on changes to personality traits of individuals over time, net from the effect of ageing (Roberts and Delvecchio 2000).

With regard to mean level stability, evidence suggests that the big 5 traits might change over the life cycle, with the majority of changes occurring during adolescence and old age, with greater consistency during middle age (Roberts and Del Vecchio 2000, Borghans et al. 2008, Lucas and Donnellan 2011, Specht et al., 2013).[22] Accordingly, as a given cohort progresses across the lifecycle, mean levels of a given trait may change. Evidence on intra-individual stability suggests that personality is fairly stable in the age range 50-70 years (Roberts and DelVecchio 2000). Changes in personality have been attributed to both genetic and environmental factors (Specht et al. 2013). If changes are solely caused by genetic traits, reverse causality - that is outcomes of interest also affecting personality traits - should not be a concern (Viinikainen and Kokkob 2012). However, for the big 5 traits there are differing views about the possible sources of changes in personality. McCrae and Costa (2008) state that life events have very little effect while Bleidorn et al. (2009) report that the changes in traits can be attributed to both genetic and environmental factors. While there is evidence that some personality traits are affected by shocks in the labour market such as unemployment, adverse employment changes and income related events (Cobb-Clark and Schurer 2012, Anger et al. 2017), personality traits do not appear to be affected by health shocks for individuals in the age range 50-65 (Cobb-Clark and Schurer 2012).

We check for mean level stability by stratifying the sample into younger (50 - 65 years) and older individuals (over 65 years). For each personality trait, we compute -

[22] A meta-analysis of Roberts et al. (2006) shows that after 50-60 people tends to become more agreeable and conscientious and less open to new experience.

by wave and gender - the average level of the personality traits in the two age groups. We then compare, using a chi-squared test, the averages across the two groups for each trait. Overall, personality traits across the two groups appear to be similar, with chi-square tests suggesting no significant differences (results are available on request). Second, in order to account for potential life cycle effects influencing personality traits, we implement the procedure suggested by Nyhus and Pons (2005) and regress each of the big 5 personality trait on age.[23] The resulting residuals are then used as indicators of personality net of life cycle influences and are used in place of the standard indicators in a regression of Equation (3). The results are almost identical to those shown in Table 4 (available on request). This lends further support to the notion that mean level stability of personality traits is likely to hold across the sample.

Addressing intra-individual stability empirically is less straightforward. Since information on personality traits is not routinely collected across all waves, we assume that they remain constant over time. Evidence on intra-individual stability by Roberts and Del Vecchio (2000) and Cobb-Clark and Schurer (2012) suggests this is reasonable for individuals in the age range 50-70 (about 60% and 75% of the sample for men and women in couple households, respectively). However, to test this assumption we replicate the analysis using a subsample of approximately 12,000 observation, consisting of individuals who are less than 70 years of age, and compare the results to those reported for the full sample. Results for the restricted age range are reported in Appendix Table A3. The results are very similar to those reported in Table 4 when using the complete sample. This lends some support to the notion that intra-individual stability of personality traits is likely to hold across the sample.

However, since 2006 in each wave (every two calendar years) the "Left Behind" module of the HRS which contains questions on personality traits has been administered to a rotating (random) 50% of the full sample. Accordingly, for half of our sample repeated observation on personality are available in the years 2006, 2010 and 2014, and for the other half of the sample, in years 2008, 2012 and 2016. The availability of, albeit interrupted, repeated observations allows us to further investigate the stability of personality traits. Following Cobb-Clark and Schurer (2012), in each

[23] In order to run such regression we exploit the variability of personality traits across individuals of different ages, although the personality of each individual is assumed constant over the sample time frame considered.

Table 7: Summary Statistics on the changes over time of the big5 personality traits in the HRS dataset

	1st group				2nd group			
	Changes between				Changes between			
	2006 & 2010		2010 & 2014		2008 & 2012		2012 & 2016	
	Coef.	S.D.	Coef.	S.D.	Coef.	S.D.	Coef.	S.D.
Neuroticism	-0.358	0.533	-0.039	0.515	-0.323	0.539	-0.061	0.489
Extraversion	-0.048	0.427	-0.015	0.432	-0.052	0.433	-0.020	0.434
Agreeableness	-0.015	0.404	-0.036	0.419	-0.037	0.418	-0.020	0.410
Conscientiousness	-0.015	0.393	-0.038	0.401	-0.034	0.401	-0.046	0.397
Openness to experience	-0.062	0.430	-0.039	0.423	-0.062	0.430	-0.033	0.438

Note: In each of the two rotating groups of respondents and for each personality trait, we compute the difference between the level of the personality trait reported in wave t+1 to that reported in wave t. The change in each trait ranges from -3 to 3, since each trait is scored from 1 to 4. The table reports the mean of the differences across the individuals in the two groups together with the standard deviation.

of the two rotating groups of respondents and for each personality trait, we compute the difference between the level of the personality trait reported in wave t+1 to that reported in wave t. Since each trait is scored from 1 to 4, the change in each trait ranges from -3 to 3. Table 7 reports the mean of the differences across the individuals in the two groups together with the standard deviation. The changes in the level of the personality traits is small and below 0.06 in all cases (with the exception of neuroticism in the period 2006-2010 and 2008-2012, where the change is 0.36 and 0.32, respectively). The magnitude of the mean change and standard deviation is comparable to the respective values reported by Cobb-Clark and Schurer (2012) with regards to personality traits in the Household, Income and Labour Dynamics in Australia (HILDA). This provides further evidence in favour of the assumption of stability of personality traits in our sample.

6.2. Attrition bias

Analyses using panel data, such as the HRS, creates the risk that results will be contaminated by bias associated with longitudinal non-response. Individuals drop-out from the panel at each wave and some of these drop-outs might not be random, but instead related to risk tolerance, and health status. For example, survivors who remain in the panel could be more or less risk tolerant on average compared to the sample at wave 1. This issue may lead to attrition bias (Jones et al. 2013). We test for such bias in our data in this section.

We first consider a descriptive analysis of potential attrition. We consider the number of observations available at each wave and the corresponding number of drop-outs and re-joiners/new-entrants between waves. The attrition rate (reported as a percentage) is computed as the number of drop-outs (excluded the re-joiners/new-entrants) between consecutive waves (t-1 and t) to the number of observations at wave t-1. The attrition rate at each wave is less than 6 %, except for the final two waves which are higher at around 15%. Accordingly, while there appears little cause for concern across much of the sample, there may be selective attrition in the final two waves.

As a formal test of non-response bias we use a variable addition test proposed by Verbeek and Nijman (1992). This test works by constructing a variable that reflects the pattern of survey response for each individual respondent. Thus, we create a variable indicating whether an individual at wave t-1 appears at wave t. Survey response should not influence an individuals' risk tolerance. Therefore, the statistical significance of the added variable in the base specification provides a test for attrition bias (Jones et al. 2013). When applied to our data, we fail to reject the hull hypothesis of no effect at conventional levels of statistical significance ($\chi^2_1 = 0.91$, p-value $= 0.34$), suggesting that our analysis is not biased by attrition.

6.3. Cognitive skills

It is likely that cognitive and non-cognitive (such as the big 5 personality traits) abilities are correlated, and also that cognitive abilities might independently influence risk preference (Parise and Peijnenburg 2019, Borghans et al. 2008). To examine the role for cognitive ability in our sample, following previous literature (Parise and Peijnenburg 2019, Bertoni et al. 2019) we estimate a specification that includes a proxy measure of cognitive ability as an additional regressor. We use information from a word recall question that proxies for memory skills as a measure of cognition. The variable is obtained by counting the number of words from a 10 or 20 word list that were recalled correctly. In waves 1 and 2, the word list contained 20 nouns, which could be recalled in any order. In the following waves, the list contained 10 words and respondents were randomly assigned to one of four lists, with a different assignment over four interviews and no overlap with the spouse. [24]

When we include this proxy for cognition, the results remain consistent with the results from the base model (results are available upon request). This suggests that our model is robust to the inclusion of cognitive traits. However, its inclusion leads to a loss of all observations from the first two waves and almost half of the observations in the third wave in the sample. The overall size of the sample available for analysis is reduced to approximately 16,500 observations (compared to our base specification of 18,388 observations). Accordingly, due to the loss of data and it's minimal impact on results, we do not adopt this specification as our main specification.

7. Discussion and conclusion

We investigate whether the impact of health shocks on financial risk preferences varies by personality traits, drawing on data from the HRS. Our empirical analysis suggests that health shocks, on average, have a negative influence on the level of risk tolerance of households when men, but not women, experience a shock. Moreover, the effects of health shocks appear to be heterogeneous according to the personality trait of an individual. Neuroticism, extroversion and openness to new experiences appear to be the traits for which heterogeneity seems to be most relevant. We find evidence that the impact of a health shock by such traits is greater in the short term than in the longer term, particularly for neuroticism. This would appear plausible given the short-run need for rehabilitation and a focus on health improvement, together with dynamic adjustments to subjective life expectancy that likely occurs following a major health shock.

The different results for men and women is likely to be explained by evidence on intra-household financial decision making. Systematic gender differences within households affect financial decision making and responsibilities (Kim et al. 2017, Mader and Schneebaum 2013, Bartley et al. 2005). The traditional division of roles within a household suggests that in the Western world women make more decisions over daily household spending, while men appear to make decisions over larger financial choices (Mader and Schneebaum 2013, Antonides 2011). For example, men often take control of financial decisions that require more specific financial knowledge such

[24] The measure of memory in waves 1 and 2 was rescaled to be consistent the measure in other waves.

as investments, savings and tax returns, whereas women tend to lead on bill paying and short-term planning and spending (Fonseca et al. 2012). This view is further confirmed in descriptive statistics of the HRS sample. When performing the interviews, the HRS staff assess which partner is the most knowledgeable about the household's financial situation (i.e., income sources, assets holdings, medical expenditures, and insurance). The spouse designated by the HRS as the financially knowledgeable partner is then interviewed about the financial choices of the household. Although it cannot be ascertained whether a partner who is designated as the most knowledgeable is also the one who actually takes the financial decisions, this is highly likely. In our HRS sample a male is designated as being the most knowledgeable in 64% of households. This observation lends prima-facie support to our findings that suggests households change their level of financial risk tolerance only in response to a health shock experienced by males. While health shocks may alter a woman's level of risk given a more limited role in financial decision making, this is less likely to affect the household level of risk tolerance. This might also explain why the literature has failed to identify an impact of portfolio decisions following a health shock for single households. In the HRS data we employ, the vast majority of single households consist of women, a large proportion of which are widowers. Assuming that traditional gender roles remain relevant in such households it is plausible that single women are unlikely to take choices that affect their financial portfolio on their own, and instead perhaps delegate to financial advisors, bank officers, other family members (sons, siblings), friends, etc., or simply avoid making such decisions.

It is possible that individuals selectively sort into households based on personality traits. The psychological literature has investigated the extent of similarity versus complementary in the characteristics of partners.[25] Evidence is generally suggestive of positive assortative mating with regards to several socio-economic variables (i.e. education, ethnicity, etc.), with little evidence of complementary mating (Bouchard & Loehlin, 2001; Buss, 1984). With regard to the big5 personality traits, openness and

[25] Assortative mating can be defined as the non-random coupling of individuals based on their resemblance to each other on one or more characteristic (Buss, 1984). "Similarity (or "positive assortment") is established through significant positive correlations between a husband's score and a wife's score on the same characteristic (e.g., between a husband's extraversion and his wife's extraversion); conversely, complementarity (or "negative assortment") is demonstrated when these scores are significantly negatively correlated" (Watson et al. 2004).

contentiousness are traits that are most frequently reported as drivers of assortative mating (Flinn et al. 2018, Mangiavacchi et al. 2018, Lundberg 2012, Watson et al. 2004). However, the level of correlation among couples in personality traits is small, and usually reported to be less than 0.30 (Watson et al. 2004, Mangiavacchi et al. 2018, Flinn et al. 2018). In the HRS sample of couples, the within household correlation between the big5 traits is 0.09 for neuroticism, 0.03 for extroversion, 0.11 for agreeableness, 0.10 for contentiousness and 0.22 for openness. These appear to be in line with other findings in the literature and suggest that personality traits are not strong drivers for assortative mating. Accordingly, we do not believe that assortative mating due to personality traits is a notable source of bias in our empirical results.

Future research on heterogeneous effects of health shocks on financial risk preferences by personality traits would benefit from exploiting direct measures of financial risk preferences (for example, see Borghans et al. 2008, Becker et al. 2012, Rustichini et al. 2012), instead of the indirect measures adopted in the HRS. While the HRS contains a direct measure of risk preference, obtained through the "Experimental Module" of the questionnaire, this relates to the domain of work and employment choices, rather than financial choices. Moreover, the variable is present in a limited number of waves of the HRS, and there is a general lack of overlap between respondents to this question and respondents who were administered the "Left Behind" module and interviewed about personality traits.

This paper provides helpful insights by highlighting ways in which the effects of health shocks on financial risk preferences vary according to the gender of the individual experiencing the health shock and their dominant personality. Protective measures, such as providing information to enhance financial literacy, and/or psychological support tailored towards certain personality traits, and directed towards households that are likely to become less risk tolerant following a health shock may be helpful to ensure these households reach their financial goals and build adequate retirement wealth (Fisher and Yao 2017).

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Appendix

Table A1: Definitions of personality traits

Personality trait	"Facets of personality" (descriptive items)
Neuroticism	reckless, worrying, nervous, not-calm
Extroversion	outgoing, friendly, lively, active, talkative
Agreeableness	helpful, warm, caring, softhearted, sympathetic
Conscientiousness	organized, responsible, hardworking, careless, thorough
Openness to experience	creative, imaginative, intelligent, curious, broad-minded, sophisticated, adventurous

Table A2: Full set of estimated results for Equation (1), Tale 2, Stock market participation, Male

	Stock market participation	
	Male	
	Coef.	S.E. .
Log total wealth	0.544**	0.026
No children	0.290†	0.150
Age: men	-2.813**	0.600
Age: women	0.577	0.579
Education: men	0.132*	0.063
Education: women	0.057	0.061
Non-white: men	-0.122	0.152
Non-white: women	-0.364*	0.157
Retired: men	-0.070	0.044
Retired: women	-0.056	0.041
Self Reported Health, fair/poor(t-1): men	0.041	0.057
Self Reported Health, fair/poor(t-1): women	-0.070	0.064
Self Reported Health, good(t-1): men	0.012	0.039
Self Reported Health, good(t-1): women	-0.028	0.040
Income (US$10,000): men	0.009*	0.004
Income (US$10,000): women	0.001	0.007
Pension (US$10,000): men	0.016*	0.007
Pension (US$10,000): women	0.019	0.015
Drinking: men	0.023	0.050
Drinking: women	0.002	0.049
Smoking: men	0.243**	0.092
Smoking: women	0.070	0.101
Neuroticism: men	0.068	0.281
Neuroticism: women	-0.001	0.257
Extraversion: men	-0.138	0.271
Extraversion: women	-0.245	0.270
Agreeableness: men	-0.239	0.288
Agreeableness: women	0.246	0.345
Conscientiousness: men	0.707*	0.279
Conscientiousness: women	0.237	0.289
Openness to experience: men	-0.583*	0.274
Openness to experience: women	-0.552*	0.256
Health shock: men	-0.083†	0.044

Note: Statistical significance is denoted by: $^{\dagger}p < 0.1; ^{*}p < 0.05; ^{**}p < 0.01$. NT = 18388.

Table A3: Robustness check: Model 3 sample with age $\leq$ 70 years

	Stock market participation				% risky assests in portfolio			
	Male		Female		Male		Female	
	Coef.	S.E.	Coef.	S.E.	Coef.	S.e.	Coef.	S.E.
Neuroticism	0.530	0.347	-0.143	0.309	0.071	0.105	-0.026	0.094
Extraversion	-0.367	0.335	-0.176	0.320	-0.047	0.101	0.023	0.098
Agreeableness	-0.091	0.352	0.225	0.404	-0.106	0.106	0.090	0.123
Conscientiousness	0.866^{*}	0.350	0.530	0.350	0.255^{*}	0.106	0.131	0.107
Openness to experience	-0.447	0.341	-0.688^{*}	0.307	-0.166	0.103	-0.232^{*}	0.094
Health shock (hlth s)	-0.034	0.057	0.045	0.069	-0.011	0.017	0.009	0.021
Neuroticism × hlth s	$-0.931^{\dagger}$	0.541	-0.047	0.599	-0.218	0.157	-0.167	0.179
Extraversion × hlth s	1.033^{*}	0.518	-0.309	0.653	0.318^{*}	0.149	-0.092	0.192
Agreeableness × hlth s	-0.536	0.583	-0.834	0.832	-0.046	0.165	-0.237	0.240
Conscientiousness × hlth s	-0.322	0.551	0.039	0.693	-0.171	0.162	0.001	0.201
Openness to experience × hlth s	-0.559	0.509	-0.074	0.600	-0.218	0.148	-0.072	0.167
AIC	11674.91		11678.94		16665.01		16669.27	
BIC	12000.25		12004.27		16997.74		17002.00	

Note: Statistical significance is denoted by: $^{\dagger}p < 0.1;^{*}p < 0.05;^{**}p < 0.01$. NT = 18388. The estimates have been run using a subsample of the dataset of about 12.000 observations, consisting of individuals who are less than 70 years of Age. This is done to test the assumption of intra-individual stability