How vulnerable is risk aversion to wealth, health and other risks? An empirical analysis for Europe

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1. Introduction

Risk aversion behaviours drive many economic decisions, whether this is related to insurance, investment, portfolio allocation, health care or housing. Better understanding the determinants of risk aversion behaviours is therefore key to many areas in economics.

Risk aversion has been shown to be influenced by various factors amongst which individual's wealth, individual's health and the presence of other risks faced by individuals. Arrow (1965) was the first to make the assumption of risk aversion decreasing in wealth, also known as decreasing absolute risk aversion (DARA). Other works, e.g. Malevergne and Rey (2009), made reference to the concept of cross-DARA, i.e. risk aversion to wealth decreasing with individual's health. While DARA and cross-DARA deal with how vulnerable risk aversion is to a loss of wealth or health, another strand of literature investigated how risk aversion towards financial risk is vulnerable to the presence of another risk, i.e. a background risk, being either financial or non-financial. This has given rise to the concept of risk vulnerability (Gollier and Pratt, 1996) and cross-risk vulnerability (Malevergne and Rey, 2009), respectively. Both strands of literature are theoretically linked to each other. For instance, under the expected utility framework, DARA along with the convexity of absolute risk aversion is a sufficient condition for risk vulnerability (Gollier and Pratt, 1996). In addition, (cross-) DARA is a necessary condition for (cross-) risk vulnerability (Gollier and Pratt, 1996; Malevergne and Rey, 2009).

The aim of this paper is to empirically assess how financial risk aversion reacts to a change in individuals' wealth and health and to the presence of both financial and health risk using the Survey of Health, Ageing, and Retirement in Europe (SHARE) database. This allows to test whether individuals' preferences exhibit DARA, cross-DARA, risk vulnerability and

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cross-risk vulnerability. In addition, this paper also tests the hypotheses of convexity of financial risk aversion in wealth and in health. While the DARA and cross-DARA hypotheses have been empirically studied rather extensively, few papers have investigated the other hypotheses directly. When they did, they often indirectly tested risk aversion through the composition of a financial portfolio in terms of risky assets, they did consider specific background risks or they considered these hypothesis separately. This paper takes advantage of a specific question in SHARE that makes it possible to measure directly risk aversion in terms of individual preferences in the spirit of the definition by Arrow (1965) and Pratt (1964). By using the SHARE database, we can also study these hypothesis altogether and then investigate the links that exist amongst themselves.

This paper uses various variables to define the level of wealth, the level of health as well as financial and health risks so as to take into account potential endogeneity concerns regarding risk aversion. In particular, we once again take advantage of the SHARE database that makes it possible to define precise measures of wealth and health status as well as of financial and health risks. Moreover, the dataset we use allows us to address different econometric issues potentially biasing our analysis and results. In particular, we address the issue of endogeneity in the variables defining wealth and financial background risk and the problem of measurement error in the variable quantifying individuals' health.

Our results show that, indeed, individuals exhibit DARA and cross-DARA, i.e. financial risk aversion decreases in wealth and health. They also show that individuals exhibit risk vulnerability and cross-risk vulnerability, i.e. financial risk aversion increases with the presence of a background financial and health risk. Furthermore, we also find risk aversion to be convex with respect to wealth while linear with respect to health. These findings complement the literature on risk aversion behaviours. They can shed light on how various economic decisions under risk should be impacted by changes in the external environment of individuals regarding their wealth and health.

The article is organised as follows. In section 2, we briefly summarise the theoretical and empirical literature related to the hypothesis of risk aversion. Section 3 is devoted to the presentation of the database and the variables used. Section 4 presents and discuss the empirical strategy and the results of various econometric specifications. Finally, the last section is devoted to some concluding remarks.

2. Literature review

The literature of risk aversion stems from the seminal works of Arrow (1965) and Pratt (1964) who defined an individual as risk-averse if he always prefers the expected outcome of a lottery with certainty rather than the lottery itself. Arrow (1965) was the first to hypothesise that risk aversion is likely to be decreasing with individual wealth, a hypothesis know as DARA. DARA has been extensively empirically studied. Most empirical works confirm this hypothesis, for instance whether this is for a sample of rice growers on small farms in Nepal (Hamal and Anderson, 1987), for Italy (Guiso and Paiella, 2008), or using experiments (Levy, 1994). DARA explains why wealthier people should buy less insurance and invest more in risky assets than people with less wealth. Yet, a few studies have found increasing absolute risk aversion based on life insurance decisions (see e.g. Eisenhauer, 1997).

Cross-DARA is a much more recent hypothesis and stems from the literature on multivariate risk aversion where preferences depend both on wealth and health. The term cross-DARA was first coined in Malevergne and Rey (2009) as risk aversion to wealth being decreasing in health even if this hypothesis was studied earlier on. Empirically, there is currently a debate on the effects of a deterioration in health on risk aversion. Cross-DARA has been studied mostly in the financial literature in the context of the determinants of individuals' asset allocation without making explicit reference to the term cross-DARA. Rosen and Wu (2004) using American data from the 1992-1998 waves of the Health and Retirement Study (HRS) show that poor health is associated with a smaller share of financial wealth held in risky assets and a larger share in safe assets, therefore supporting the cross-DARA hypothesis. This is confirmed by Cardak and Wilkins (2009) who find that risky asset holding is discouraged by poor health using Australian data. Yet, Love and Smith (2010), using the 1992-2006 waves of the HRS and controlling for unobserved household heterogeneity, find that health does not appear to significantly affect portfolio choice among single households. Fratantoni (1998), using the U.S. 1989 Survey of Consumer Finances, finds that self-perceived health is positively correlated with the share in risky assets. Atella et al. (2012), using the SHARE database, find mixed evidence of cross-DARA as they show that worse current perceived health status force households to reduce the exposure to financial risk in their portfolio allocation only in countries without a protective full-coverage national health service. A few other papers directly test cross-DARA (still without making reference to this term) by looking at the effect of health shocks on various measures of risk aversion. Hammit et al. (2009), using data from a stated-preference survey, find that financial risk tolerance, measured in terms of choices over risky gambles, is positively associated with health, supporting the cross-DARA hypothesis. Schurer (2015) finds that health shocks significantly increase individual risk aversion using data from waves 2006–2012 of the German Socio-Economic Panel and where risk aversion is measured by self-assessed risk willingness. Decker and Schmitz (2016) find that individuals, after a shock in their health measured as a sharp reduction in their grip strength, declare themselves to be less willing to take risks in general.

Risk vulnerability stems from Gollier and Pratt (1996) and means that risk aversion increases with the presence of an independent unfair background risk. Empirical studies on risk vulnerability are rather scarce. Once again, most papers use portfolio asset allocation decisions as a measure of risk aversion. Guiso et al. (1996) show that investment in risky financial assets responds negatively to income risk using the 1989 Bank of Italy Survey of Household Income and Wealth and where income risk is defined by the subjective variance of the expected future real income, supporting the risk vulnerability hypothesis. Similar results are found for U.S. data (Haliassos and Bertaut, 1995; Frantatoni, 1998), German data (Hochguertel, 2003) and Australian data (Cardak and Wilkins, 2008). Very few papers define risk aversion in terms of willingness to take risks and not in terms of portfolio allocation decision. The only one we are aware of is Guiso and Paiella (2008). Using a macroeconomic indicator of background risk and defining risk aversion by the willingness to take risks, they find that risk aversion is positively affected by background risk for Italian households, supporting also the risk vulnerability hypothesis. Their results also lead support to convexity of risk aversion in wealth while not directly testing such assumption.

Finally, regarding cross-risk vulnerability, this concept was theoretically introduced by Malevergne and Rey (2009). Very few papers have tested this hypothesis and they strongly rely on both the definition of health risks and of risk aversion. Edwards (2008) shows that individuals with higher probabilities of medical expenses lower their risky portfolio shares. This is confirmed by Goldman and Maestas (2013) showing that Medicare beneficiaries who face less medical expenditure risk are more likely to hold risky financial assets. Atella et al. (2012) using SHARE data show that health risks, as measured by an index taking into account risky behaviour and asymptomatic disease, affect portfolio choices only in countries without a protective full-coverage national health service.

3. Data and variables

We use the Survey of Health Ageing and Retirement in Europe (SHARE) database to empirically assess how financial risk aversion react to various exogenous shocks on individual's wealth and health. SHARE is a multidisciplinary, longitudinal and cross-national micro-database containing information on health-related variables, labour market variables, economic variables and other variables (including education, housing, social support and risk attitudes) of a representative sample of European individuals aged 50 or older and their spouses. A first wave of SHARE was released in 2004. Since then, five other waves of the survey were released. SHARE follows the design of the U.S. Health and Retirement study and the English Longitudinal Study of Ageing. In this study, we use the second, fourth and fifth waves of the survey which were conducted in 2006, 2011 and 2013 respectively[1]. For more details on SHARE, readers should refer to Börsch-Supan and Jürges (2005).

3.1. Financial risk aversion

In SHARE, individuals evaluate their financial risk aversion by answering the following question:

When people invest their savings they can choose between assets that give low return with little risk to lose money, for instance a bank account or a safe bond, or assets with a high return but also a higher risk of losing, for instance stocks and shares. Which of the statements on the card comes closest to the amount of financial risk that you are willing to take when you save or make investments?

1. *Take substantial financial risks expecting to earn substantial returns*
2. *Take above average financial risks expecting to earn above average returns*
3. *Take average financial risks expecting to earn average returns*
4. *Not willing to take any financial risks*

Given the categorical nature of this variable, we recoded it as a binary variable, with 0 corresponding to individuals reporting to be willing to take financial risks (i.e., individuals answering to be willing to take substantial, above average or average financial risks) and 1 corresponding to individuals not willing to take any financial risks.

As it often happens with self-assessed variables, one could question the reliability of self-reported risk aversion in predicting future real-life behaviour. For instance, are incentives correctly aligned in order to ensure that interviewed people are going to reveal their true preferences? Dohmen et al. (2011) address this particular issue for risk aversion and conclude that the answers to that kind of question reflect in a reliable way the behaviour of people in a laboratory experiment.

3.2. Financial wealth

We consider financial wealth, i.e. the amount the respondent has in bank accounts, bonds, stocks, mutual funds and retirement accounts, measured in euros, as the variable to test the DARA hypothesis. We decided to focus on wealth and not on income as we expect, for our sample of relatively aged individuals, changes in wealth to be more relevant in determining

[1] Waves 1 and 3 are not used because some of the variables of interest were missing. Wave 6 is not used due to the very low response rate for the variable defining financial risk aversion.

risk aversion than changes in income. Similarly, we decided to focus only on financial wealth, excluding real assets, as we expect liquid wealth to have a higher impact on risk aversion than less liquid forms of wealth such as the value of owned property.

Potential endogeneity in the marginal effect of financial wealth on risk aversion, coming from simultaneity bias, is likely to be present in our study. Indeed, an increase in financial assets might cause a decrease in risk aversion (DARA property), but the relationship can go the other way round as well if a decrease in risk aversion increases financial wealth. This happens, for example, via stock returns if they are larger than for safer investments' returns. In this case, a negative estimated marginal effect of wealth on risk aversion might not reflect DARA behaviour in our sample, but rather a negative correlation between risk aversion and financial wealth coming from conservative investment.

3.3. Health

In SHARE, two categories of questions can be used to measure the respondents' health status. The first category relates to the standard self-reported measure of health for which individuals are asked how they would define their health status between excellent, very good, good fair and poor. However, drawbacks of self-reported measures of health have largely been documented in the literature. In particular, Bound et al. (1999) acknowledge measurement bias, i.e. given that respondents are asked for subjective judgments, those judgments might not be entirely comparable across respondents, leading to the so-called error of measurement bias which tends to underestimate the impact of health on the variable of interest.

The second category of questions relates to objective and detailed measures of health for which individuals are asked whether they have ever been diagnosed to have had a series of diseases[2]. The inclusion as an explanatory variable of each detailed measure of health defined through diagnosis of a specific disease can be problematic because of the difficulties of interpreting the marginal effect of a change in a given health condition on the outcome of interest and because of multicollinearity (Bound et al., 1999). By aggregating the individual health conditions in an index, for example by using the weighted number of chronic diseases, measurement error can also be present if this aggregate objective measure does not reflect correctly the severity of the respondents' diseases or the worsening in their quality of life. For instance, measurement error bias might be the reason why Attella et al. (2012) find that self-reported health affects stockholding contrary to an objective measure of health status. Other studies in health economics such as Van Houtven et al. (2015) come to the same conclusion, finding significant effects of self-reported health but not of objective measures of health on their variable of interest.

In order to circumvent the problems of measurement error and multicollinearity, we create a health index such as the one suggested by Bound et al. (1999). This index is constructed by using an ordered probit model with the categorical self-reported measure of health as the dependent variable and a set of significant dummy variables indicating the diagnosis of a chronic disease as independent variables. As a way to investigate the convexity of risk aversion with respect to health, we additionally estimate with the same methodology a second health index using the square of the categorical self-reported measure of health as the dependent variable.

Finally, in order to facilitate the interpretation of the results, we re-scaled the original self-reported health question in SHARE so as to have zero as the modal answer and we inversed

[2] Individuals are asked if they have ever had a heart attack, high blood pressure or hypertension, high blood cholesterol, a stroke, diabetes or high blood sugar, chronic lung disease, cancer, stomach or duodenal ulcer, Parkinson, cataracts, hip or femoral fracture, other fractures, arthritis, Alzheimer or any other non-mentioned condition.

the order of the answers i.e., answer 2 corresponds to an excellent level of health and answer -2 to a poor level of health. The estimates of the two ordered probit models are displayed in appendix A.1. From the results of the two ordered probits, we compute the predicted expected latent variable and use its value as our measure of health.

3.4. Financial background risk

Different measures of financial background risk have been used in the literature, with labour income uncertainty being the dominant one. For instance, Guiso et al. (2002) and Hochguertel (2003) model financial background risk by using self-perceived measures of income uncertainty. Cardak and Wilkins (2009) measure financial background risk as the realized variation of the household past labour income controlled with other variables such as the fact of being multiple earners in the household, the occupation and the mortgage over income ratio. Haliassos and Bertaut (1995) consider observed individual characteristics such as the fact of working in a profession with high risk of unemployment. Finally, Guiso and Paiella (2008) use a macroeconomic indicator of financial background risk, i.e. the variance of the residuals obtained by regressing the GDP in the province of the surveyed individual on a time trend.

We follow this literature and define financial background risk in the form of income risk through a binary variable equal to 1 if the individual feels his/her job security is poor and equal to zero if he/she does not have this feeling. As for financial wealth, we suspect this definition of background risk to be endogenous and to suffer from simultaneity bias. Indeed, risk aversion is likely to determine the individuals' exposition to financial background risk, if more risk averse individuals are less prone to choose risky professions in terms of job security than less risk averse individuals.

3.5. Health background risk

Defining a health risk is not so obvious. Attella et al. (2012), studying the effect of future health risk on the probability of stock holding, define health risk through an index including an average number of risky behaviours (smoking, drinking and sedentary lifestyle), an average number of asymptomatic diseases (high blood pressure, high blood cholesterol and osteoporosis) and grip strength. However, such a measure could be potentially biased. Indeed, risky behaviours might be endogenous as financial risk aversion could be correlated with unobserved determinants of risky healthy behaviour. Endogeneity could also affect the number of asymptomatic diseases as this variable is dependent on risky behaviours according to different WHO reports (WHO; 2009, 2013) studying the risk factors leading to different diseases such as hypertension or diabetes.

In order to avoid these potential endogeneity concerns, we define health risk through a binary variable equal to 1 if the interviewed qualifies his/her current job as physically demanding and zero if he/she does not. Indeed, amongst individuals having the same current health status, the fact of working in a physically demanding job can be seen as a health risk factor because of the increased and continuous exposition to different physical hazards, physical load or fatigue. Empirical evidence corroborates this hypothesis. For instance, Leino-Arjas et al. (2004) find high physical work strenuousness to predict poor physical functioning 28 years later in a cohort of metal industry employees. In the same line, Russo et al. (2006) find that individuals having had a history of manual work are more likely to have worse physical function than those with a history of non-manual work.

3.6. Other variables

In the econometric analysis, we control the effect of wealth, health and background risks on financial risk aversion with a series of additional variables. We first include four personal characteristics studied by Dohmen et al. (2011) as plausibly exogenous determinants of risk aversion which are gender (equal to 1 if the respondent is a woman, 0 otherwise), age, height and education in years. Additionally, we include a measure of cognitive ability created from three different tests, i.e. numeracy questions, verbal fluidity and memory following Bonsang and Dohmen (2015) who show that this variable is an important determinant of risk attitudes for old people. We include a dummy variable equal to 1 if the individual is self-employed as this might be simultaneously correlated with risk aversion, wealth and background financial risk. We also include two measures of household composition, a dummy variable which equals one if the surveyed is married or has a registered partnership and another variable specifying the number of people living in the same household as the interviewed individual, including co-residential children and parents but excluding lodgers (i.e. persons subletting the respondent's apartment). Indeed, being married or having a large family might act as a hedge for background financial and health risks if home production and market production are substitutes (Edwards, 2008). Besides, we include in the econometric specification a series of behaviours potentially induced by risk aversion and likely to simultaneously influence the effects of the variables of interest. Those behaviours are smoking, drinking, defined as having drunk six or more drinks in one occasion at least once a month in the last three months, and physical activity defined as performing a vigorous physical activity at least once a month. We also control for the fact of being overweight, defined as having a BMI greater than 30.

4. Empirical analysis and results

4.1. Sample selection criteria and descriptive statistics

Given that our definitions of financial background risk and health background risk are closely related to labour market participation, we selected for our analysis only those respondents declaring themselves to be employed or self-employed, excluding those declaring to be housemakers, retired, unemployed or permanently sick or disabled. We additionally discarded some observations with unreliable values for the variable quantifying financial wealth. These restrictions together with missing values for some variables left us with an unbalanced panel containing 18'030 observations corresponding to 14'141 different individuals. The following table reports some descriptive statistics for the variables used in the empirical analysis.

Table 1
Descriptive statistics

Variable	Mean (all)	Mean (unwilling to take risks)	Mean (risk takers)	Difference
Financial risk Aversion (%)	61.3	100.0	0.0	100.0***
Financial wealth (in €)	64'146	39'051	103'856	–64'804***
Health index	0.356	0.333	0.393	–0.060***
Job insecurity (%)	21.5	23.5	18.5	5.0***

Physical job (%)	42.7	47.7	34.8	12.9***
Female (%)	50.6	56.2	41.7	14.5***
Age	56.047	56.125	55.923	0.202**
Height (in cm)	170.752	169.468	172.783	–3.315***
Education (in years)	12.479	11.940	13.330	–1.390***
Cognitive ability	6.689	6.532	6.937	–0.405***
Self-employed (%)	15.3	13.0	18.9	–6.0***
Married (%)	73.3	72.2	75.1	–2.9***
Household members	2.482	2.464	2.509	–0.045***
Smoking (%)	23.6	24.9	21.5	3.4***
Drinking (%)	13.3	12.9	14.0	–1.1**
Physical activity (%)	67.8	66.7	69.5	–2.8***
Overweight (%)	17.8	19.1	15.7	3.4***

Number of observations: 18’030. The significance levels of the two-tailed hypothesis test are coded as follows: * Significant at 10%, ** Significant at 5%, *** Significant at 1%.

The majority of our sample (61.3% of the respondents) reports to be unwilling to take any financial risk, i.e. are financial risk averse. The sample average financial wealth is 64’146 €. Looking at the health index, its sample mean is equal to 0.356. Regarding the exposure to financial and health background risks, 21.5% of individuals in our sample declare to be in a job with poor security and 42.7% consider their current profession to be a physical job.

We additionally computed the explanatory variables means conditioned on risk aversion by taking advantage of using a dichotomous risk aversion measure. The more risk averse group, i.e. declaring to be unwilling to take any financial risk has, on average, 2.7 times less financial wealth than the less risk averse group, i.e. reporting to be willing to take financial risks. Moreover, individuals in the first group have, as well, a lower level of health on average and have higher probabilities of working in a precarious or physical job.

4.2. Econometric specifications

In order to test, in our sample, the hypotheses of DARA, cross-DARA, risk vulnerability and cross risk vulnerability, we assume our binary measure of financial risk aversion (RA_{it}) to be a function of the natural logarithm of financial wealth (w_{it}), health (h_{it}) and health squared, financial background risk (fr_{it}), health background risk (hr_{it}), a vector of controls (X_{it}), a vector of country dummies (C_i) and a vector of wave dummies (W_{it}). These assumptions correspond to the following model:

$$P(RA_{it}=1|\Omega)= F(\alpha+ \beta_1 \ln w_{it}+\beta_2 h_{it}+\beta_3 h_{it}^2+\beta_4 fr_{it}+ \beta_5 hr_{it}+X_{it}\beta_x+C_i\beta_c+ W_{it}\beta_W)$$

Assuming *F*. to be the cumulative distribution function of a standard normal distribution, the model described by Eq. (1) can be estimated using a probit model. However, in the framework of a probit model, it is very difficult to study the convexity of financial risk aversion with respect to wealth and to health. Moreover, given that financial wealth (w_{it}) and financial background risk (fr_{it}) are potentially endogenous and the fact that the instrumental variables approach applied to non-linear models leads to inconsistent estimates (Terza et al., 2008), we additionally study the case where *F(.)* is a linear function. This corresponds to a linear probability model which can be estimated with the ordinary least squares (OLS) and two steps least squares (2SLS) methods.

4.3. Probit and OLS results

The following table presents the results of different estimations assuming exogeneity of financial wealth and financial background risk. In the first two columns, we present the results of two probit models. The specification of the first column does not include the health squared index and the second model includes this variable. In the third and fourth columns, we present the results of two linear probability specifications estimated by OLS. As in the previous two columns, the third column does not include the health squared index while the fourth column includes it.

Table 2
Results of the probit and the OLS models

Dependent variable: Financial Risk Aversion	Probit (i)	Probit (ii)	OLS (iii)	OLS (iv)
Intercept	2.668***	2.717***	1.386***	1.399***
	(0.321)	(0.339)	(0.106)	(0.112)
Financial wealth (log)	–0.148***	–0.148***	–0.047***	–0.047***
	(0.007)	(0.007)	(0.002)	(0.002)
Health index	–0.094***	–0.088***	–0.027***	–0.025**
	(0.027)	(0.030)	(0.009)	(0.010)
Health squared index	–	–0.043	–	–0.012
		(0.096)		(0.032)
Financial Background Risk	0.078***	0.078***	0.024***	0.024***
	(0.026)	(0.026)	(0.008)	(0.007)
Health Background Risk	0.197***	0.197***	0.067***	0.067***
	(0.022)	(0.022)	(0.007)	(0.007)
Female	0.283***	0.283***	0.097***	0.097***
	(0.028)	(0.028)	(0.009)	(0.009)
Age	0.015***	0.015***	0.005***	0.004***
	(0.002)	(0.002)	(0.001)	(0.001)
Height (in cm)	–0.006***	–0.006***	–0.002***	–0.002***
	(0.002)	(0.002)	(0.001)	(0.001)
Education (in years)	–0.024***	–0.024***	–0.008***	–0.008***
	(0.003)	(0.003)	(0.001)	(0.001)
Cognitive Ability	–0.041***	–0.041***	–0.013***	–0.013***
	(0.007)	(0.007)	(0.002)	(0.002)
Self Employed	–0.278***	–0.278***	–0.096***	–0.096***
	(0.029)	(0.029)	(0.010)	(0.010)
Married	0.041	0.041	0.015*	0.015*
	(0.026)	(0.026)	(0.009)	0.009
Household Members	–0.011	–0.011	–0.004	–0.004
	(0.011)	(0.011)	(0.004)	(0.004)
Smoking	0.024	0.024	0.011	0.011
	(0.024)	(0.024)	(0.008)	(0.008)

Drinking	0.029	0.029	0.010	0.010
	(0.030)	(0.030)	(0.010)	(0.953)
Physical activity	–0.077***	–0.077***	–0.026***	–0.026***
	(0.022)	(0.022)	(0.007)	(0.007)
Overweight	0.005	0.004	0.004	0.003
	(0.028)	(0.028)	(0.009)	(0.09)
Country Dummies	YES	YES	YES	YES
Wave Dummies	YES	YES	YES	YES
Observations	18’030	18’030	18’030	18’030
Adjusted R^2 (%) †	15.1	15.1	14.8	14.8

Country dummies (Italy as reference country) and wave dummies (wave 5 as reference wave) are included but not reported.

Robust standard errors are recorded in parentheses. The significance levels of the two-tailed hypothesis test are coded as follows: * significance at 10% level, ** significance at 5% level, *** significance at 1% level.

† Cox and Snell pseudo-R^2

The effect of the logarithm of financial wealth on risk aversion is negative and highly significant, being by far the coefficient with the largest t-statistic in all regressions. Moreover, as wealth enters in the model as the natural logarithm of financial wealth, a convex instead of a linear relationship between wealth and financial risk aversion is found in the OLS models of columns 3 and 4. Like DARA, convexity of risk aversion is a common assumption in the theoretical literature (e.g. Gollier and Pratt, 1996).

Looking at the relationship between health and risk aversion, the health index coefficient is negative and statistically significant at the 1% level in the first three cases and significant at the 5% level in the last case. The coefficient corresponding to health squared is negative but not significant in any case and no relevant changes in the rest of the coefficients are observed in the models including the quadratic term. Therefore, even if a slight reduction in the coefficient corresponding to health is observed in these models, the models not including the health squared index are preferred. The non-significance of the reduction in the coefficients corresponding to the health index is confirmed by a one parameter Hausman test[3] on these estimates in the probit and OLS specifications. Indeed, the results of these tests equal 0.446 and 0.367 (p-values equal to 50.41% and 54.48%) for the probit and the OLS models respectively. This shows that the inclusion of the quadratic term does not significantly alter the effect of the health index on risk aversion.

The fact of feeling to be in a job with poor security, i.e. facing a background financial risk, is positively and significantly related to more risk aversion. Working in a physical job, which is a proxy of facing a health background risk, is also positively and significantly linked to a higher level of risk aversion.

Thus, our first empirical results support the DARA, cross-DARA, risk vulnerability and cross-risk vulnerability hypotheses. The effect of the health background risk is found to be the one having the largest magnitude in the three models, as this is, in absolute value, the largest among the four coefficients of interest in the three specifications. Our results also support the hypothesis of convexity of risk aversion with respect to wealth but not with respect to health as the health squared index coefficient in the model of column 4 is not statistically significant at the usual levels.

Concerning the set of controls, the exogenous determinants of risk aversion suggested by Dohmen et al. (2011) have the expected signs and are also highly significant. Women and older people are expected to be more risk-averse while tall individuals, highly educated individuals and people with good results in the test of cognitive ability are less risk-averse on

[3] The Hausman test for one parameter is in the form
[illegible]

average. Looking at the effects of risky behaviours used by Atella et al. (2012) to define health risks, results are non-significant, as neither drinking nor smoking are significantly associated with risk aversion. Finally, physical activity, which can be seen as an activity reducing health risk, is related to lower risk aversion. However, causal interpretations of the control variables, especially those defining a behaviour, should be done with caution as their OLS estimates, without appropriate robustness checks, might not capture causality anyhow.

4.4. Instrumental variables approach and results

In this section, we follow an instrumental variables strategy and estimate the OLS model of the column 3 of section 4.3 by the two Steps Least Squares (2SLS) method[4]. This is done as we suspect the variables quantifying wealth and financial background risk to be endogenous. Concretely, we estimate two different models: the first one (column 1) assuming wealth is the endogenous variable and the second one (column 2) assuming financial background risk to be the inconsistent variable. In both models we discard the inclusion of the health squared index, as it was found to be non-significant in the previous section.

For the design of the instrumental variables (IV) strategy, we follow Mullahy (1999) by assuming there are some control variables highly correlated with the endogenous variables, included in our definition of X, that might be properly excluded from X but included in Z, the set of instrumental variables. Concretely, given that the variables smoking, drinking and overweight as well as some country dummies and the time dummies are not significant in any of the models of section 4.3, they can potentially be excluded from these specifications.

In the first model, we use two country dummies, Switzerland and Estonia, equal to one if the interviewed lives in Switzerland and Estonia respectively and zero otherwise, as instruments for the logarithm of financial wealth. Indeed, given the international dimension of our sample, the assumption of relevance for these two instruments is a plausible one, as in 2015, the Swiss GDP per capita was 66% higher than the EU-28 average, while the Estonian was 25% lower (Eurostat, 2017). The weak instruments F-statistic (see Table 3) and R^2 of the first-stage regression (see appendix A.2.1) show the high relevance of these instruments.

In the second model, we instrument the variable financial background risk with the three binary control variables smoking, drinking and overweight, with four country dummies Switzerland, Estonia, Portugal and Belgium and with the time dummy wave 4, equal to one if the individual was interviewed in the wave 4 of the survey and zero otherwise. Given that the available instruments for financial background risk are much less powerful than the instruments for financial wealth, in order to maximize the predictive power of the first stage regression, we have to include in Z all the available non-significant control variables in the OLS model significantly associated with financial background risk. Intuitively, the three variables smoking, drinking and overweight are likely to be correlated with poor job security as cigarette, alcohol use and high biometric personal values are found to be positively associated with presenteeism (i.e. working while sick) and absenteeism (i.e. absence from work) (Goetzel et al., 2009). The four country dummies might be exogenous determinants of poor job security because these countries have very different job market institutions. Lastly, wave 4 might be a good predictor for job insecurity as this wave field work was done in 2011, a period of relative low economic growth in Europe (Eurostat, 2017). The weak instruments statistic p-value (see Table 3), the F-statistic and the R^2 of the first-stage regression (see appendix A.2.2) show that the set of instruments used in the second 2SLS model is still relevant but to a much lower extent than the instruments for financial wealth.

[4] The following models are estimated with the ivreg function included the library AER of the R statistical software.

The following table presents the results of the IV regressions:

Table 3
Results of the instrumental variables models

Dependent variable: Financial Risk Aversion	2SLS (i)	2SLS (ii)
Intercept	1.394***	1.321***
	(0.108)	(0.124)
Financial wealth (log)	–0.051***	–0.046***
	(0.004)	(0.003)
Health index	–0.026***	–0.023**
	(0.008)	(0.009)
Health squared index	-	-
Financial Background Risk	0.022***	0.157
	(0.008)	(0.102)
Health Background Risk	0.066***	0.060***
	(0.010)	(0.009)
Female	0.096***	0.095***
	(0.001)	(0.009)
Age	0.005***	0.005***
	(0.001)	(0.001)
Height (in cm)	–0.002***	–0.002***
	(0.001)	(0.001)
Education (in years)	–0.008***	–0.008***
	(0.001)	(0.001)
Cognitive Ability	-0.013***	–0.013***
	(0.002)	(0.002)
Self Employed	–0.095***	–0.098***
	(0.010)	(0.010)
Married	0.017**	0.014*
	(0.009)	(0.009)
Household Members	–0.004	–0.003
	(0.004)	(0.004)
Smoking	0.010	-
	(0.008)	
Drinking	0.009	-
	(0.010)	
Physical activity	–0.026***	–0.025***
	(0.007)	(0.008)
Overweight	0.002	-
	(0.009)	
Country Dummies	YES	YES
Wave Dummies	YES	YES
Observations	18’030	18’030
Adjusted R^2 (%)	14.8	13.6
Weak instruments test (p-value)	0.000	0.000
Wu-Hausmann test (p-value)	0.308	0.189
Sargan test (p-value)	0.222	0.290

Country dummies (Italy as reference country) and wave dummies (wave 5 as reference wave) are included but not reported.

*Robust standard errors are recorded in parentheses. The significance levels of the two-tailed hypothesis test are coded as follows: * significance at 10% level, ** significance at 5% level, *** significance at 1% level.*

When financial wealth is instrumented by Switzerland and Estonia (column 1), the marginal effect of wealth on financial risk aversion increases in absolute value, from -0.047 (see column 3 of Table 2) to -0.051, and still being significant at the 1% level. However, the Wu-Hausman test does not reject the consistency of the OLS coefficient and therefore, we prefer the OLS estimate as it is more efficient. Excluding the two country dummies and using them as instruments has no effect on the remaining coefficients, as no additional significant changes are observed between the results of the OLS model of the third column of section 4.3 and the results of the first IV model of this section. Consequently, the Sargan test does not reject the null of validity of the overidentifying restrictions.

In the second model of Table 3, the estimated marginal effect of a financial background risk on risk aversion still has a positive sign and increases sharply, from 0.024 (see column 3 of Table 2) to 0.157. However, the coefficient's precision is dramatically reduced as the estimate's standard error increases much more, from 0.008 to 0.102. As a consequence, even if the IV coefficient is around 6.5 times larger than the OLS coefficient, it becomes non-significant at the usual confidence levels. Concretely, the two-tailed hypothesis test with the null hypothesis $H0 : \beta3=0$ displays a t-statistic equal to 1.541, corresponding to a p-value of 12.34%. However, the Wu-Hausman test does not reject the validity of the OLS estimate for financial background risk. Finally, the remaining coefficients remain stable and the only additional remarkable difference observed with respect to the OLS model of the previous section is a moderate reduction of the health index coefficient, which is still anyway significant at the 5% level. As a consequence, the Sargan test does not reject the validity of this model overidentifying restrictions.

Hence, the IV approach validates the DARA hypothesis and the hypothesis of convexity of risk aversion with respect to wealth. The coefficient corresponding to financial wealth instrumented by Switzerland and Estonia (column 1) still has the expected negative sign and is highly significant. Moreover, the Wu-Hausmann test does not reject the consistency of the OLS coefficient. As for the risk vulnerability hypothesis, the IV results are less conclusive as the unbiased estimate is close, but not significant at the usual levels (p-value of 12.34%). Nevertheless, the IV parameter of column 2 still has the expected positive sign, its magnitude is greater than the OLS parameter and the Wu-Hausman test does not reject the validity of the OLS estimate.

5. Conclusion

This paper empirically assesses how financial risk aversion reacts to a change in individuals' wealth and health and to the presence of both financial and health risks using the SHARE database. We take advantage of a specific question in SHARE that makes it possible to measure directly risk aversion in terms of individual preferences in the spirit of the definition by Arrow (1965) and Pratt (1964). The measure of financial risk aversion is based on a question on the unwillingness by individuals to take any financial risk when hypothetically saving or making an investment. By using the SHARE database, we can also study many hypothesis about risk aversion altogether and then investigate the links that exist amongst themselves.

Our findings support the hypothesis of DARA, cross-DARA, risk vulnerability and cross-risk vulnerability. Moreover, financial risk aversion is found to be convex with respect to wealth while linear with respect to health.

We also consider the potential endogeneity of wealth and financial background and develop an instrumental variable strategy. In that latter case, the DARA hypothesis still holds while the results for the risk vulnerability hypothesis are only partially validated.

These results can offer some valuable recommendations regarding various economic decisions in the face of shocks on health and wealth as they are often driven by risk aversion behaviours with respect to wealth. We provide a few illustrations. For instance, people facing risky wealth or risky health should increase their purchase of insurance. Those facing health risks should invest less in risky financial assets than those not facing health risks. Marriage and childhood have also been shown to be influenced by risk aversion (Schmidt, 2008); more risk-averse women being less likely to delay marriage and more likely to delay birth or give birth at later ages. So women facing financial risks or health risks should marry young and/or give birth at later ages than women facing no financial or health risk.

Finally, our results are also in accordance with various links that have been theoretically shown in relation to risk vulnerability and cross-risk vulnerability. (Cross-) DARA is known to be a necessary condition for (cross-) risk vulnerability (Gollier and Pratt, 1996; Malevergne and Rey, 2009). Our results do not contradict these relationships as the hypothesis of DARA, cross-DARA, risk vulnerability and cross-risk vulnerability are found within our sample. In addition, convexity of risk aversion along with DARA are sufficient conditions for risk vulnerability (Gollier and Pratt, 1996). Hence, as convexity of risk aversion with respect to wealth is also found in our sample, our results empirically validate these theoretical links. Lastly, we find that risk aversion is linear in health which is not incompatible with cross-risk vulnerability. Indeed, Malvergne and Rey (2009) show that cross-DARA together with the convexity or linearity of risk aversion in health and a negative cross derivative of the utility function are sufficient conditions for cross-risk vulnerability. Unfortunately, our analysis could not identify empirically the sign of the cross derivative of the utility function[5] as well as whether the condition to obtain (cross-) risk vulnerability are sufficient or necessary conditions. Such analysis which requires additional data beyond the ones we use in this paper are left to further empirical research.

[5] Evans and Viscusi (1991) and Finkelstein et al. (2009) present empirical evidence suggesting that the marginal utility of wealth is higher when healthy than when sick, supporting the negative sign of the cross derivative of the utility function.

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Appendix

A.1. Multinomial probit model

Table A.1.1.
Multinomial ordered probit: health index[5]

Dependent variable: Self-Reported Health	Model: Ordered probit
Heart Disease	–0.717***
	(0.039)
Hypertension	–0.486***
	(0.019)
Cholesterol	–0.154***
	(0.022)
Stroke	–0.425***
	(0.079)
Diabetes	–0.556***
	(0.035)
Lung Disease	–0.650***
	(0.048)
Arthritis	–0.694***
	(0.027)
Cancer	–0.614***
	(0.050)
Ulcer	–0.577***
	(0.044)
Parkinson	–1.293***
	(0.265)
Cataracts	–0.133**
	(0.057)
Hip Fracture	–0.247**
	(0.102)
Other Fracture	–0.170***
	(0.035)
Alzheimer	–0.668**
	(0.265)
–2 | –1	–2.616***
	(0.026)
–1 | 0	–1.321***
	(0.014)
0 | 1	–0.137***
	(0.011)
1 | 2	0.817***
	(0.013)
Observations	18’030
Pseudo R^2 (%) †	17.33

Table A.1.2.
Multinomial ordered probit: health squared index[6]

Dependent variable: Self-Reported Health squared	Model: Ordered probit
Heart Disease	0.086**
	(0.040)
Hypertension	–0.197***
	(0.020)
Cholesterol	–0.148***
	(0.023)
Stroke	0.284***
	(0.081)
Arthritis	–0.005**
	(0.028)
0 | 1	–0.375***
	(0.011)
1 | 4	0.900***
	(0.013)
Observations	18’030
Pseudo R^2 (%) †	0.96

[6] In multinomial probit models, the t-statistics’ critical values are not the usual ones.

Robust standard errors are recorded in parentheses. The significance levels of the two-tailed hypothesis test are coded as follows: * significance at 10% level, ** significance at 5% level, *** significance at 1% level. † Cox and Snell pseudo-R^2

A.2. First stage regressions of the IV models

Table A.2.1
First stage IV model (Wealth)

Dependent variable: Wealth (log)	IV model (First stage)
Intercept	9.309***
	(0.017)
Switzerland	1.647***
	(0.046)
Estonia	–1.701***
	(0.043)
Observations	18’030
Adjusted R^2 (%)	15.5
F-statistic	1’653.625

Table A.2.2
First stage IV model (Financial background risk)

Dependent variable: Financial background risk	IV model (First stage)
Intercept	0.181***
	(0.005)
Smoker	0.027***
	(0.007)
Drinking	0.019**
	(0.009)
Overweight	0.024***
	(0.008)
Switzerland	–0.021**
	(0.010)
Estonia	0.083***
	(0.009)
Portugal	0.070***
	(0.025)
Belgium	–0.084***
	(0.010)
Wave 4	0.046***
	(0.006)
Observations	18’030
Adjusted R^2 (%)	1.68
F-statistic	39.499

Robust standard errors are recorded in parentheses. The significance levels of the two-tailed hypothesis test are coded as follows: * significance at 10% level, ** significance at 5% level, *** significance at 1% level.