DISCUSSION PAPER SERIES

IZA DP No. 8821

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January 2015

Forschungsinstitut
zur Zukunft der Arbeit
Institute for the Study
of Labor

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Discussion Paper No. 8821
January 2015

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IZA Discussion Paper No. 8821
January 2015

ABSTRACT

Lifecycle Patterns in the Socioeconomic Gradient of Risk Preferences*

Who is most likely to change their risk preferences over the lifecourse? Using German nationally representative survey data and methods to separate age from cohort effects, we estimate the lifecycle patterns in the socioeconomic gradient of self-reported risk preferences. Tolerance to risk drops by 0.5 SD across all groups from late adolescence to age 40. From mid to old age, risk tolerance continues to drop for the most disadvantaged, while it stabilizes for all other groups. By age 65, the socioeconomic gradient reaches a maximum of 0.5 SD. Extreme risk aversion among the elderly poor has important policy implications.

JEL Classification: D81, D01, D63

Keywords: risk preferences, socioeconomic inequalities, life-course analysis, cohort effects, SOEP

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* The author would like to acknowledge funding from the Australian Research Council from a Discovery Early Career grant and from the ARC Centre of Excellence for Children and Families over the Lifecourse. Special thanks go to Agnieszka Tymula and Bart Golsteyn for valuable comments and Wei Tian for excellent research assistance.

I. Introduction

Economic theory on risky choices has built over many decades on the assumption that risk preferences are stable both across domains and across time (Stigler and Becker, 1977). Such assumption simplifies the mathematical derivations from economic models, but in practice it is not likely to hold. The circumstances and incentives that individuals face are certainly changing over the life-course. Some studies demonstrate that individual risk preferences systematically vary across birth cohorts due to heterogeneity in the macroeconomic (Malmendier and Nagel, 2011) or institutional (Cameron et al., 2013) climates in which the cohort members grew up. Although many attempts have been made in recent years to understand the age-related differences in risk preferences (e.g. Tymula et al., 2013; Mata et al., 2011), almost nothing is known about the individual time-varying properties of risk preferences (see Zeisberger, Vrecko and Langer, 2012).

In this study we quantify the degree of change in risk preferences as individuals age and explore the heterogeneity in this aging process across the social spectrum. The experimental economics literature, so far, could not fill this gap because it predominantly relies on incentive-compatible measures of risk preferences assembled for college students at one point in time. One exception is Tymula et al. (2013) who collected data on 135 individuals across all age groups (12-90), but because of the small sample and cross-sectional nature of the data no conclusions can be drawn about representativeness and true ageing effects. Another exception is Dohmen et al. (2014) who circumvent the problem by using a survey-based, but validated, measure of risk preferences to identify the true ageing-effects of risk preferences over a six-year window. Their study finds that risk tolerance drops monotonically

as people age, and the decline is particularly strong for women.

We build on Dohmen et al. (2014), but focus on the heterogeneity in the dynamics of risk preferences over time. Using seven years of the German Socio-Economic Panel (SOEP), we estimate lifecycle patterns of risk tolerance by various definitions of socioeconomic status - education, income, and occupation - to capture all possible channels through which disadvantage can affect risk attitudes. To identify the lifecycle patterns in the socioeconomic gradient in risk tolerance we adapt a methodology used in Schurer, Shields and Jones (2014), van Kippersluis et al. (2009), and Case, Lubotsky and Paxson (2002) in the context of health.[1] This methodology allows us to carefully control for the cohort differences by first continuously overlaying the risk path of various birth cohorts, and then averaging the risk preferences over several cohorts at each age group. The sequence of cohort-averaged risk preferences over the full age interval, in our case 17-80, approximates the lifecycle pattern of risk tolerance.

Our measure of risk preference is the response to a general question on whether the individual considers him or herself to be fully prepared to take or avoid risks. This measure is not incentive compatible, and it suffers from the same type of scaling-bias as all measures of self-assessed health, personality, and attitudes. We rely on the work of Dohmen et al. (2011) who validated this measure by comparing its correlation with, and predictive validity of, a standard measure of risk preferences elicited through paid experiments.

[1] All three studies use longitudinal data with eleven (HILDA), eight (ECHP), and nine years (PSID) of length respectively to construct age-profiles by cohort members. For instance, Case and Paxson (1998) construct for each birth cohort a dummy variable, and then graph for this birth cohort the health path and the variation in health over the nine years. The individual health paths of all cohorts combined give then a lifecycle pattern of health. The same approach is used in Schurer, Shields and Jones (2014) and van Kippersluis et al. (2009), with the only exception that cohorts are formed within five-year intervals.

This measure is used in Dohmen et al. (2012) to explore the intergenerational transmission of risk and trust preferences and in Dohmen et al. (2010) to study the link between cognitive ability and risk preferences.

We find that risk tolerance declines strongly for all socioeconomic groups alike from late adolescence into middle age. From middle age onward, a dramatic gradient in risk tolerance emerges between people at the bottom and the top of the socioeconomic ladder. People living life at the top stabilize, and even increase, their risk tolerance, while people at the bottom continue to drop at the same rate as observed before middle age. These heterogeneous dynamics lead to a gap in risk tolerance between the two groups of 0.5 standard deviation, which is associated with a 2 standard-deviation difference in cognitive skills. These differences hold across three definitions of socioeconomic disadvantage, they are not driven by a possible misclassification into socioeconomic class, and they are not explained by systematic panel attrition.

II. Literature Review

Life is full of risks for everyone, yet, preferences over risk is a very subjective matter. Standard economic theory assumes risk preferences to be exogenous and stable (Stigler and Becker, 1977), where stability can refer to both individual variation across situations and across time (See Zeisberger, Vrecko and Langer, 2012, for an overview of the concepts). Surprisingly, very little is known about the individual-specific nature of change in risk tolerance and aversion over time.

However, much is already known about the differences in risk preferences across age groups (See Table A1 in the Online Appendix for a summary).

Studies based on large samples generally find a negative relationship between risk attitudes and age. For example, Donkers, Melenberg and van Soest (2001), using data on a set of hypothetical lottery questions administered to individuals aged 16 and above from the Dutch Household Survey (CSS), show that older subjects are significantly more risk averse than younger ones. Dohmen et al. (2011), using both survey-based and experimentally-elicited measures, find a negative relationship between age and willingness to take risks. Bonsang and Dohmen (2012) demonstrate a negative relationship between self-assessed willingness to take financial risks and age in a sample of older individuals aged 50 to 90 across 11 countries using data from the Survey of Health, Ageing, and Retirement in Europe (SHARE).

The behavioral sciences send more mixed signals about the likely age pattern in risk preferences (See Mata et al., 2011, for an overview). Statistics on risk-taking behavior suggest that adolescents/young adults are more likely to take risks than both children and adults, especially so when acting among their peers. One explanation for this heightened level of risk taking in adolescence is not a lack of logical-reasoning ability but a lack of psychosocial maturity (See Steinberg, 2004, 2007).

A meta-analysis of 29 studies assembling data on more than 4,000 observations finds that the pattern of age differences varies as a function of the task and whether the involved tasks involve a learning component (by experience versus by description) (Mata et al., 2011). On average, aggregating all studies that involve a learning component (by experience), older adults are more risk-seeking if no explicit information is given in the experiment about the risk probabilities in the gamble. Significant heterogeneity though is found across the task characteristics, which Mata et al. (2011) attribute to differ-

ences in the pay-off structures of these tasks. Older adults tend to be more risk seeking in games involving card gambling or financial investment strategies (Iowa Gambling Task, Behavioral Investment Allocation Strategy), and are more risk averse in a task that involves risk taking through a physical exercise (Balloon Analogue Risk Task). On the other hand, aggregating across all studies with tasks that provided full information about the probabilities and outcomes (by description) no distinct age-gradient emerges.

Tymula et al. (2013) extend the previous literature by evaluating the age-gradient in risk preferences in both gains and loss domains. This study uses data on 135 healthy urban subjects and behavioral measures of risk derived from decisions concerning monetary rewards in a lottery experiment. The sample includes individuals aged between 12 and 90, which are combined into four different age groups (ages 12-17, 21-25, 30-50, and 65-90). Importantly, the authors find that older adults are always further away from risk neutrality in both gain and loss domains than any other group: They tend to be more risk seeking in the loss domain, and more risk averse in the gain domain. The oldest age-group members also tend to be most inconsistent in their strategies, which makes them loose the largest amount of income in the experiments relative to all other group members. Further, the authors explain the heightened risk behavior among adolescents that is also reported in Steinberg (e.g. 2004, 2007) with a greater tolerance to ambiguity rather than to risk.

None of the above summarized studies is able to separate out true ageing from cohort effects, even though cohort effects could be the driving force in explaining the age gradient. Malmendier and Nagel (2011) show that macroeconomic conditions, a summary measure for lifetime experiences,

have dramatic effects on both the perceptions of risk and investment strategies. Using data from the Survey of Consumer Finances, they demonstrate that individuals who experienced low stock market returns throughout their lives report lower willingness to take financial risks, are less likely to participate in the stock market, and are more pessimistic about future returns. Cameron et al. (2013) elicit experimentally risk preferences, among others, from 421 urban subjects from Beijing that were born just before and after China had introduced its One Child Policy. Among many emerging behavioral differences, children raised without siblings became more risk averse than children who had to share their parents' attention across siblings.

To best of our knowledge, there are currently only two studies which assess the individual-specific variation of risk preferences over time (Dohmen et al., 2014; Sahm, 2013). Using data on self-assessed risk preferences from two household longitudinal studies on individuals aged between 16 and 80, Dohmen et al. (2014) find strong and robust evidence on a negative effect of age on risk attitudes up until age 65. The effects remain when controlling for individual-specific fixed and calendar time effects. Men are more risk-loving than women - a result that is generally found in the literature (Dohmen et al., 2011; Frederick, 2005; Donkers, Melenberg and van Soest, 2001) - but the difference across the sexes rise sharply from adolescence until age 25 until they stabilize in old age. The strong difference in risk tolerance between men and women is consistent with the hypothesis that reproductive competition drives risk preferences, and that this competition is more intense for young men (Low, 2000).

In contrast, Sahm (2013), using data on 18,625 hypothetical-gamble responses from 12,003 individuals between ages 45 and 70 from the Health

and Retirement Survey (HRS), finds only a very modest decline in risk tolerance over a window of ten years. Major life events have little impact on the gamble responses, and time varying shocks explain only a quarter of the variation in risk tolerance. She concludes that risk preferences vary mainly across but not within individuals. One reason why Sahm (2013) cannot find significant age effects may be that her sample is restricted to an older age working population followed up until early retirement, while individual change may still be possible before the age of 45.

Some studies interpret the negative age effect as a true "ageing" effect in terms of cognitive decline. As the ability for attention, memory, learning, and cognitive control declines from about age 20 to 25 onward (Baltes and Lindenberger, 1997; McArdle et al., 2002), individuals adopt different strategies to respond to risk. High levels of cognitive functioning have been strongly linked with high levels of risk tolerance (Frederick, 2005; Burks et al., 2009; Dohmen et al., 2010; Benjamin, Brown and Shapiro, 2013). Using data from SHARE, Bonsang and Dohmen (2012) find that at least 70% of the correlation between risk preferences and age can be attributed to cognitive skills, and this insight holds for a representative sample of older individuals from 11 European countries. Other explanations for an age-gradient in risk aversion are that as people age their motivation declines and emotional regulation abilities improve leading to a reduced willingness to take risks (Mata et al., 2011).

If it is true that an increase in risk aversion over the life course is caused by cognitive decline, then not everyone in the population should alter their risk preferences alike. Some individuals are more at risk of losing their cognitive abilities, while others age healthily (for similar arguments see Tymula et al.,

2013). In fact, heterogeneity in the aging process has been reported widely (See Schurer, Shields and Jones, 2014, for an overview). Most dramatic declines in cognitive functioning are likely to occur within occupations which require little skills or learning over time such as manual, highly-routinized work. Hence, a socioeconomic gradient in risk aversion is likely to emerge as people age physically.

An alternative pathway via which a socioeconomic gradient emerges over the lifecycle is through the increased frequency of negative life events. Generally, risk aversion is more common among individuals with lower levels of education or economic means (Donkers, Melenberg and van Soest, 2001; Dohmen et al., 2011).[2] Disadvantaged families may experience such negative events more often. For instance, manual and low-skilled occupations, a defining characteristics of the working class, tend to experience a larger number of accidents at the workplace and are more exposed to job loss during economic downturn. As life goes on, the frequency of these negative events increases, but it may be disproportionately so among groups at the lower end of the social ladder. As a consequence, through experience individuals from disadvantaged backgrounds should be more likely to develop risk aversion than individuals from privileged backgrounds.

In this study, we are not testing one hypothesis against the other - in fact they may work in conjunction - but we will explore whether we find any heterogeneity in the dynamics of risk preferences that is consistent with these two hypotheses.

[2]Tymula et al. (2013) cannot find any socioeconomic gradient in experimentally elicited risk preferences.

III. Data and variable definition

A. Data

To carry out the analysis we use seven waves of data from the German Socio-Economic Panel covering the years 2004, 2006, and 2008-2012. The SOEP is a longitudinal survey of private households established in West Germany in 1984, which extended its sample after Germany's reunification to include the new Bundeslaender.[3] In its first year the study included 5,921 households from which 12,245 individuals were successfully interviewed ("German West" and "Foreigner" sample). Further samples were added in consecutive years including the "German East" (1990), "Immigrant" (1994/1995) and the "Refreshment" (1998) samples. The SOEP achieved a reasonably high first wave cross-sectional response rate of 64.5% and has an average longitudinal response rate of 92.2% (Wagner, Frick and Schupp, 2007). The study is set up as life panel, where the household is sampled as a unit, and the members of the households are traced and interviewed by professional interviewers every year from age 17 onward.

Our estimation sample comprises 135,807 person-year observations, or 36,105 individuals observed over nine time periods (2004-2012). Around 26% of the sample members remained in the sample over the full interval. Another 10% stayed in the sample over the full time period, but missed one year of the interview. The median length of stay in the sample is 5 waves.

[3]The data used in this paper was extracted from the SOEP Database provided by the DIW Berlin (http://www.diw.de/soep) using the Add-On package SOEP Info for Stata(R). It uses the 95% Scientific sample obtained from Cornell University.

B. Variable definitions

Risk preferences

In the years 2004, 2006, and 2008-2012 the SOEP included several questions on risk preferences as part of the standard person questionnaire. We focus on the general risk question which asks the respondent "How do you see yourself: are you generally a person who is fully prepared to take risks or do you try to avoid taking risks? Please tick a box on the scale, where the value 0 means: 'not at all willing to take risks' and the value 10 means: 'very willing to take risks'". The same measure is used in Dohmen et al. (2014), Dohmen et al. (2012) and Dohmen et al. (2010).[4] Larger values on this self-assessed measure indicate greater tolerance of risk. We refer from here on to this measure as risk tolerance.

In our analysis, we assume this measure to be approximately continuous. We also construct binary measures of high levels of risk tolerance (risk tolerance score of 7 or higher) and extreme levels of risk aversion (risk tolerance score of 0). Roughly 20% and 6% of the sample members are located within the right and left tail of the distribution, respectively (See Table 2).

Although this risk-assessment measure is not incentive compatible, Dohmen et al. (2011) have shown in a validation study that it is a meaningful proxy for a standard risk-preference measure elicited from an incentivized lottery experiment. Dohmen et al. (2011) sampled 450 German individuals from all age groups using the same sampling framework as the SOEP survey. The team administered both a survey and conduced a paid lottery experiment

[4]Non-response is very low. Less than 0.5% of sample members refused to answer the risk preference question.

on this nationally-representative sample.[5] The value of the safe option at the switching point, i.e. the value at which individuals become indifferent between the safe option and the lottery, was regressed on self-rated risk preference controlling for a battery of potentially confounding variables. The estimated coefficient on the self-assessed risk measure ranges between 0.4 and 0.6 and is highly statistically significant despite a small sample of 383-450 individuals. Dohmen et al. (2011) also found that the general risk question is the best all-round indicator for risk attitudes, while each specific risk measure has the most explaining power in a specific context such as car driving, financial matters, sports and leisure, health, and career.

Socioeconomic status

To measure socioeconomic status (SES), we derive three standard measures from: (1) Disposable household income; (2) Educational attainment; and (3) Occupation status (See Schurer, Shields and Jones (2014) for the same definitions). All three dimensions are considered because of the various pathways how socioeconomic disadvantage can affect risk preferences (Donkers, Melenberg and van Soest, 2001; Dohmen et al., 2011).

We define four income groups by constructing income quartiles from equivalized household disposable income which adjusts for the needs and the number of members of the household. The needs adjustment is based on the modified OECD scale which gives a weight of 1 for the first adult, 0.5 for

[5]The experiment asked participants to choose from a lottery with equal probability to earn 300 Euro or 0, and 20 rows of safe options starting from 0, 10 to 190. Starting from 0, a participant will switch from the lottery to the safe option at some row. The value of this safe option represents the risk attitude of the participant, and only the extremely risk seeking person will choose to switch at 190. The experiment was incentive compatible and could reveal real risk attitudes as the participants had a 1 in 7 chance to win and the payment will depend on the choice the participant made on the rows.

subsequent adults (aged over 14) and 0.3 for each child (Hagenaars et al., 1994). Income is a good indicator for the immediate access a household has to goods and services, however it does not capture accumulated wealth.

Educational attainment is defined by the highest educational qualification an individual has ever achieved. We generate four categories: minimum schooling or less, apprenticeship certificate, higher vocational degree, and university degree. The educational-attainment measure has the advantage that it is fairly stable in adulthood. Among all three SES measures, education is most likely to tell a story of risk-relevant lifestyles and behaviors, and, due to its fixed attribute, it is reflective of childhood socioeconomic position.

Occupational class is defined as belonging to an occupational group based on the two-digit code of the International Standard Classification of Occupations (ISCO-88). We distinguish eight categories ranked in order of skill intensity: Professional, legislator/manager, technician, service employee, skilled agricultural worker, craft worker, machine operator, and elementary worker. The same classification is used by the International Labour Organization (ILO) to define groups according to the tasks and duties undertaken (United Nations, 2010). As some persons changed their occupation over time, we assign the highest occupation ever attained. In some cases the individual did not have an occupation (e.g. when unemployed in one particular year). For these cases, we assigned the occupation from the last employment observed. Details about occupation reassignment can be found in Tables A2 and A3 in the Online Appendix.[6] Occupation is the structural

[6]For 43,965 person-year observations we initially had no occupation code. We are able to reassign an occupation code for 13,815 individuals by backtracking employment histories. For the remaining 22.2% of the estimation sample we find no occupational code. These are mainly older women who never entered the labour market. By re-assigning

link between education and income: it provides a measure of environmental and working conditions, and cognitive and psychological demands of the job.

Summary statistics of all variables used in the analysis are provided in Table 1.

IV. Estimation strategy

We start our analysis by estimating the determinants of the probabilities of reporting high levels of risk tolerance and extreme levels of risk aversion. To estimate the differences in the odds of these outcomes between age, socioeconomic groups, and health conditions, we apply a random effects logistic regression analysis which is commonly used when the dependent variable is a binary indicator (Long and Freese, 2014). The latent, but true level of risk tolerance (RA^*_{it}) is a function of observable characteristics (X_{it}), an individual-specific random effect (ν_i), and random shocks ε_{it}:

$$RA^*_{it} = \alpha + X_{it}\beta + \nu_i + \varepsilon_{it} \tag{1}$$

We do not observe the true level of risk tolerance (aversion), but a binary indicator RA_{it} that takes the value 1 if the latent risk attitude is beyond a threshold (which we standardize to 0), and 0 otherwise. The error terms ε_{it} and ν_i have a distribution of mean zero and constant variance and are assumed to be independent of the regressors. Due to the longitudinal na-

occupational codes, we face the problem of classification error. This is particularly likely for individuals who changed occupations more than three times. In fact, 38% of the sample have more than one occupational classification, and 4% have more than three occupations through their lives. In a robustness check to the main results, we are able to show that removing individuals with more than 3 occupational codes does not alter our conclusions.

ture of the data, we are able to exploit both the within- and across-group variation, which ensures efficient estimates. Allowing for individual-specific, random variations in self-reported risk attitudes, we are able to control to some degree for heterogeneity in self-reports (For simular arguments, see Schurer, Shields and Jones, 2014, in the context of self-assessed pain).

Equation (1) is estimated separately for a) high levels of risk tolerance (risk tolerance of 7 or higher), and b) extreme levels of risk aversion (risk tolerance score of 0). We control for education, household income, occupation and labour force status, age-groups, gender, marital and foreigner status, children, and health status (high blood pressure, stroke, cardiovascular disease, depression, cancer, and dementia). To control for unexpected time variations, we follow Dohmen et al. (2014) in adding a measure for the annual GDP growth rate, to especially proxy for the unexpected changes in perceptions during the global financial crisis in 2008. Using the estimated coefficients obtained from equation (1), we calculate the odds ratios and their standard errors.

To document the socioeconomic gradient in risk tolerance by age, we first estimate a linear random effects model and predict the unexplained, permanent part of risk tolerance purged of the influence of marital status, children, ethnicity, health status, calendar time-effects, and SES (omitting one category of SES, e.g. occupation when constructing the risk-attitude age gradient by occupational groups). In a second step, we apply bivariate kernel regression methods to estimate the relationship between the permanent component in risk tolerance and age for the socioeconomic group that was omitted from the list of SES control variables in the first-step regression model. Kernel regression methods are flexible as they do not impose a func-

tional form for the relationship between risk attitude levels and age (Wand and Jones, 1995). The estimated relationships between risk tolerance and age are plotted graphically between the ages of 17 and 80. A similar procedure was used in Kruger and Stone (2008) and Schurer, Shields and Jones (2014) to plot pain-age profiles. Risk tolerance levels are standardized to mean 0 and standard deviation of 1 in all samples to express differences in risk tolerance across the socioeconomic groups in terms of sample standard deviations.

Finally, to separately identify age from cohort effects, we overlay the age-path of a series of birth cohorts within each socioeconomic group. The lifecycle patterns of risk tolerance is approximated by averaging risk tolerance levels across overlapping birth cohorts in each available age-group (See Schurer, Shields and Jones, 2014; van Kippersluis et al., 2009; Case, Lubotsky and Paxson, 2002, for applications in health). This method involves four steps: in a first step we generate ten birth cohorts; in a second step we estimate the permanent component in risk tolerance as outlined above for each of the ten birth cohorts in each socioeconomic group; in a third step we estimate non-parametrically for each of the ten cohorts the relationship between the permanent component in risk tolerance and age; in a fourth step, we average at each age-data point the permanent component in risk tolerance across the overlapping cohorts.

Similar to Schurer, Shields and Jones (2014) and van Kippersluis et al. (2009), we define a birth cohort for a five-year interval except for slightly longer intervals of nine and eights years for the oldest and youngest birth cohorts. The oldest birth cohort includes individuals born between 1930 and 1939 (average age of 68 in 2004 and 75 in 2012) and the youngest birth cohort

includes individuals born between 1980 and 1987 (average age of 21 in 2004 and 28 in 2012). Each of the ten cohorts can be followed over seven years.[7] The overlapping risk tolerance paths of these ten cohorts are then plotted by socioeconomic groups: (1) minimum education versus university education, (2) low versus high household income, and (3) manual/elementary versus professional/managerial occupations.

Table 3 illustrates the idea with four birth cohorts. The 1940-44 cohort ages from 60 to 72 during the seven waves of the panel; the 1945-49 cohort ages from 55 to 67; the 1959-54 cohort ages from 50 to 62; and the 1955-1959 cohort ages from 45 to 57. For instance, at ages 60, 61, and 62, we have three overlapping cohorts, and at age 59, we have two overlapping cohorts, and so on. In the full data, age effects are identified by three cohorts for age-groups 30 to 65, by two cohorts between 25 and 30 and 65 and 70, and by one cohort for individuals younger than 25 and older than 72. The advantage of our data is that for every birth cohort at every considered age-data point we have 1000-2500 observations (See Table A4 in the Online Appendix) in the aggregate, and between 42-150 observations for the smallest socioeconomic groups (See Tables A5 - A8 in the Online Appendix).

V. Estimation results

A. The age and socioeconomic gradient in risk preferences

We report the determinants of the probability to score high on risk tolerance (Model 1), of the probability to score extremely low on risk tolerance

[7]Strictly speaking, we follow each birth cohort over a time interval of nine years, i.e. from 2004 to 2012. However, we have only in seven of the nine years data available on risk preferences. This leaves us with two gaps in the data sequence, for which the change in age is two years instead of one, a trade-off we have to make to maximize the total number of time observations available for each individual.

(Model 2), and of the mean level in risk tolerance (Model 3) in Table 4. The reported magnitudes refer to odds ratios in the case of Models (1) and (2), and to marginal effects in the case of Model (3). We report both results from pooled logit/OLS and their random effects equivalents (FGLS-RE), but interpret only selected results from the random effects models (age-, socioeconomic-, and health-gradients). Statistical significance levels of 10%, 5%, and 1% are flagged with one, two and three stars, respectively. The odds ratios are interpreted relative to the omitted category of the dummy variables, which takes the value of 1.

The odds of high levels of risk tolerance (Model (1)) are strongly negatively correlated with age. While individuals younger than age 20 are 2.75 times more likely to report extreme levels of risk tolerance relative to individuals in mid age (age 36-40), older individuals are between 54% to 64% less likely to report such preferences. The socioeconomic gradient is strongest across educational qualifications and weakest across occupational groups. For instance, individuals with minimum schooling or no schooling qualification are 25% less likely to express high levels of risk tolerance than individuals with a university degree. A similar result is obtained for comparing individuals from the bottom to individuals in the top income quartiles. Almost none of the estimated odds ratios on the occupational groups are statistically different from the odds ratio of the base group (Professionals). Individuals suffering from depression, the most common mood disorder, are 30% less likely to be in this category.[8]

The odds of extremely low levels of risk tolerance (Model (2)) are strongly influenced by the same variables in opposite directions, but some new pat-

[8]These results are robust to small changes in the cut-off value (> 7) to classify individuals to score high levels of risk tolerance. Results are provided upon request.

terns emerge. On the one hand, the age and socioeconomic gradients tend to be stronger. For instance, while the youngest individuals in the sample are almost 70% less likely, the oldest individuals are more than 4 times more likely than middle-aged individuals to report extreme risk aversion. Individuals with minimum or no schooling are 3.7 times more likely than individuals with university degrees and individuals in the highest quartile of income are almost 50% less likely than individuals in the lowest quartile to report extreme levels of risk aversion. Even more so, an occupational gradient emerges at the left tail of the risk distribution: individuals who work as operators, manual workers or skilled agricultural workers are roughly 2 times more likely to report extreme levels of risk aversion than individuals working as professionals. The same odds ratios are obtained for people out of the labour force or being currently unemployed (relative to professionals). Individuals suffering from dementia, depression, and stroke are 2.5, 1.3, and 1.3 times, respectively more likely to be extremely risk averse than individuals not suffering from the limiting illnesses.

Last, it should be noted that we are able to draw the same conclusions about the age and socioeconomic gradients of risk tolerance when estimating a linear model on the levels of risk tolerance (See Model (3)).

B. Lifecycle patterns in the socioeconomic gradient of risk preferences

In this section we present the lifecycle patterns in risk tolerance by gender (Figure 1) and socioeconomic groups (Figures 2). We first discuss these lifecycle profiles without controlling for cohort effects to provide a big-picture overview of the gradients for all subcategories within each socioeconomic group and all age-data points available. All presented figures display the

non-parametrically estimated bivariate relationship between the permanent component in risk tolerance - derived from an estimation model of risk tolerance that controls for the same control variables as in Model (3) in Table 4 - and age. Changes in risk tolerance over time are interpreted in terms of standard deviations.

Figure 1 reports the differences in risk tolerance separately for men and women over the lifecycle. At any point in time women are between 0.3 and 0.6 standard deviations less risk tolerant than men. For both men and women risk tolerance drops dramatically between age 17 and 35 (0.6 SD for women, 0.3 SD for men). Risk tolerance remains relatively constant for women up until retirement age, but then plummets another 0.2 SD into old age. For men, risk tolerance levels drop monotonically across the age groups (17-80) by a total of 0.6 SD; for women they drop by a total of 0.8 SD.

Figure 2(a) demonstrates the lifecycle patterns across four income-quartile groups. There are no discernable differences in the dramatic drop of 0.5 SD in risk tolerance across income quartiles from age 17 to age 35. However, a socioeconomic gradient emerges from age 40 onward. While individuals in the richest income-quartile group increase their risk tolerance slightly up until retirement age by 0.2 SD, and the medium income-quartile groups stabilize their risk tolerance around the mean (score 0), individuals in the poorest income-quartile group continue to plummet almost linearly up until old age. Around retirement age, the gap in risk tolerance between the poorest and the richest is over 0.5 SD, which translates into a difference of over 1.15 units on the original score (0-10).

Almost identical lifecycle differences across socioeconomic groups emerge when using education or occupation measures to proxy socioeconomic status.

No socioeconomic gradient exists before the age of 40, but around that age individuals with minimum schooling (Figure 2(b)) or working in non-skilled occupation/service jobs (Figure 2(c)) continue to drop in their risk-tolerance levels. The education gradient peaks in old age with a difference of almost 0.8 SD, which translates into a difference of almost 2 units on the original risk tolerance score. Less extreme is the occupational gradient in risk tolerance; while also peaking in old age, its maximum difference is 0.5 SD.

We also compare the lifecycle patterns in risk tolerance of individuals who were at least once in their life diagnosed with depression with healthy individuals (Figure 2(d)). Although individuals diagnosed with depression tend to report lower levels of risk tolerance at any age, the difference between healthy and not-so-healthy groups remains fairly stable over the lifecourse. We judge from Figure 2(d) that the growing socioeconomic gradient in risk tolerance over the life course is not the result of systematic differences in mental health across socioeconomic groups.[9]

C. Controlling for cohort effects

In this section we test whether the same lifecycle patterns in the socioeconomic gradient of risk tolerance are obtained when controlling for cohort effects. This is important for two reasons: (1) The very strong age gradient in risk tolerance reported in Figures 1 to 2 may be the result of differences in exposure to risk across cohorts. Older cohorts may have been exposed systematically more to risk than younger cohorts when born and/or throughout their puberty, and exposure to real risk may make individuals more risk

[9]We further compared the lifecycle patterns of risk tolerance for individuals diagnosed with high blood pressure and healthy individuals. At no point in time are individuals with high blood pressure more risk averse than healthy individuals, except for a very large gap at age 35-45. Provided upon request.

averse (e.g. Malmendier and Nagel, 2011). Alternatively, older cohorts may have been exposed to more risk-averse parenting styles than younger cohorts and thus became more risk averse themselves (e.g. Cameron et al., 2013). (2) It is likely that the emerging socioeconomic gradient in risk tolerance from age 40 onward is the result of a greater exposure to risk for disadvantaged families relative to better-to-do families in the older cohorts. For instance, people born into low socioeconomic background around World War II (Cohorts 1930-39, 1940-44, 1945-49) may have been more heavily exposed to food shortages and economic deprivation than people born into well-to-do families. In contrast, the younger cohorts (Cohorts 1965-69, 1970-74) were much less affected by socioeconomic disparities because of strong social equity and redistribution policies conducted by the social democrat government in the 1970s.

The subsequent figures report the risk tolerance-age profiles (referred to as RT-age from here onward) for each of the ten cohorts by the top and bottom of the socioeconomic ladder: minimum schooling versus university education; first versus fourth income quartiles; and manual/elementary versus professional/managerial occupations. All figures in the left panel graph the sum of RT-age profiles for each cohort followed over seven years (non-parametric estimates). The RT-age profiles depicted in a long-dashed line refer to the low SES groups, while the ones depicted in a short-dashed line refer to the high SES groups. Except for the extreme ends of the age distribution, the RT profiles at each year of age overlap for three cohorts. It is these overlapping data that help us to approximate the true lifecycle profiles in RT.

All figures in the right panels graph the difference in RT at each age

between the low and high socioeconomic groups (solid, light-grey line). For each age, the RT data used to construct this difference stems from an average that is taken across the number of cohorts for whom data are available at this age. In addition, we include in this graph the average difference in RT between low and high SES groups for each birth cohort, i.e. averaged over all ages which the birth cohort covers. This second graph is a summary indicator of the trend in the socioeconomic gradient in RT across cohorts, irrespective of age (solid black line with bullet points).

Figure 4(a) compares the RT-age profiles between the richest and the poorest groups measured by household income. The profiles between the two groups are strictly overlapping up until age 40, but from then onward RT levels of each cohort in the poorer group fall dramatically, while RT levels remain constant, or increase, for the richest. The shape of the RT-age profiles across the two income groups change substantially in old age. For the three oldest cohorts in the low-income group the RT-age profiles are strictly increasing, while for the equivalent three richest cohorts they are U-shaped or strictly declining. Despite the shape differences for the older cohorts, the socioeconomic gradient in the RT-age profiles reaches a maximum of 0.4 SD at retirement age. Figure 4(b) displays the unambiguous, linear increase in the socioeconomic gradient.

An almost identical pattern emerges when differentiating the lifecycle patterns in RT between high and low levels of education (see Figures 5(a) and 5(b)). No discernable socioeconomic gradient in RT occurs until age 40, but a quick and steep decline in RT emerges for individuals with minimum schooling, while individuals with university education remain constant. By age 80, the socioeconomic gradient in RT as measured by education reaches

a maximum of 0.5 SD. The same lifecycle pattern is obtained when using occupational status as measure for socioeconomic disadvantage (see Figures 6(a) and 6(b)).

Finally, we conduct two robustness checks to ensure that our results are (1) not driven by a misclassification of individuals into occupational classes, and (2) by systematic dropout of highly risk-averse individuals from the high socioeconomic groups, or of the highly risk-loving individuals from low socioeconomic groups over time. Regarding (1), we obtain an almost identical lifecycle pattern in the occupational risk gradient when dropping all individuals that initially did not have an occupational classification or who had more than three occupations.[10]

Regarding (2), when dropping all individuals who are less than six out of the seven available time periods in the sample (65%) we also obtain almost identical lifecycle patterns in the socioeconomic gradient in risk tolerance. The only exception is that the maximum peak in risk tolerance between the bottom and the top socioeconomic groups is reduced by 0.1 SD.[11] We therefore conclude that our results are not driven by misclassification or selective sample drop-put.

VI. Discussion and Conclusions

The major decisions of an individual's life regarding finances, health behaviors, and career choices are driven by perceptions of risk. Thus, understanding the dynamics of risk preferences and their heterogeneity over the lifecourse is of vital importance for policy-makers who seek to incentivize socially-desirable behaviors. We contribute to the current literature by ex-

[10]In total, 18801 person-year observations; see Figure A1 in the Online Appendix.
[11]See Figures A2, A3 and A4 in the Online Appendix

ploring the heterogeneity in the lifecycle patterns of risk tolerance using data from a large nationally representative survey from Germany. We find a dramatic increase in the gap of risk tolerance between the bottom and the top of the socioeconomic ladder from mid-age onward, independent of which measure of socioeconomic status we employ and whether we control for cohort effects.

The magnitudes of the differences in risk tolerance across the socioeconomic groups by retirement age are enormous. A 0.5 SD difference in risk tolerance between the bottom and the top translates into a 1.15 score difference on the original risk tolerance index (0-10). For instance, Dohmen et al. (2010) using the same risk-tolerance measure and data as we do, find that a 1 SD deviation increase in cognitive ability increases the response in risk tolerance by between 0.23 and 0.56 points on a 0 to 10 scale, depending on the control variables included (See Table 4 in Dohmen et al. (2010)). Translated into our context, a socioeconomic gradient in risk tolerance of 1.15 points before retirement age implies a difference in cognitive ability of at least two standard deviations. Dohmen et al. (2011), also using the same measure and data, show that a 1 SD increase in the willingness to take risks translates into a 6.1 p.p. higher probability to engage actively in sport, a 2.4 p.p. increase in the probability to be self-employed and a 2.9 p.p. increase in the probability to invest in stocks. Translated into our context in terms of percent increases, these numbers imply that the socioeconomic gap in risk tolerance before retirement is equivalent to a 5% difference in actively engaging in sport, a 14.3% difference in being self-employed, and a 4.3% difference in investing in stocks.

Our study has various strengths and limitations. The main strength is the

use of a large, nationally-representative longitudinal survey that allows us to draw conclusions for a whole population. In addition, owing to the longitudinal nature of the data source, we have been able to model individual-specific random variations in the self reported risk attitudes explicitly. This is especially important as risk preferences could theoretically be influenced by random events that occur just before or during the interview (See Carney, Cuddy and Yap, 2010, for experimental evidence). Another advantage is that we have been able to control for cohort effects when comparing the age-risk attitudes profiles between the considered groups. Sample sizes are large enough within each birth cohort and age-group to obtain statistically meaningful results.

The main limitation of our study is that our measure of risk tolerance is not incentive compatible and cannot distinguish been the gains and losses domains. However, we have some certainty about our measure's validity to act as a good proxy for experimentally-derived, incentive-compatible risk measures (Dohmen et al., 2011). Vieider et al. (2015) shows for almost all of 30 countries considered that survey-based questions on general and financial risk attitudes capture well risk attitudes that are elicited from incentivized experiments.

The same survey-based measure of risk attitudes has been used successfully in Dohmen et al. (2010) to identify the link between risk attitudes and cognitive ability, in Dohmen et al. (2012) to demonstrate the strength of the intergenerational transmission of risk preferences, and in Dohmen et al. (2014) to explore true ageing effects in risk preferences over the lifecourse. A similar self-reported measure has also been used to link macroeconomic conditions with financial risk preferences and behavior (Malmendier and Nagel,

2011; Sahm, 2013). Trading off incentive compatibility against larger sample sizes and longitudinal follow up seems to be a justifiable strategy to gain new insights about the lifecycle dynamics of economic preferences.

Our result cannot be interpreted as a causal effect of socioeconomic status on the lifecycle dynamics in risk preferences. We are not able to say that increasing an individual's income or education level causes higher levels of change in risk tolerance. All we can say is that we observe heterogeneity in the change of risk tolerance over time, and that socioeconomic status is a powerful distinction to capture this heterogeneity. We cannot find a similar gradient emerging over time by health conditions (e.g. depression or high blood pressure). Future research is needed to assess whether the socioeconomic gradient emerges due to a higher propensity to experience shocks or due to the experience of a faster decline in cognitive ability by individuals at the bottom of the socioeconomic ladder.

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Table 1—: Summary statistics

	N	Mean	SD	Min	Max
Variable	Obs	Mean	Std. Dev.	Min	Max
Risk attitude	135807	4.423	2.309	0	10
Risk attitude > 7	135807	0.095	0.293	0	1
Risk attitude = 0	135807	0.059	0.236	0	1
Female	135807	0.524	0.499	0	1
Foreigner	135807	0.057	0.232	0	1
Married	135807	0.602	0.490	0	1
Age	135807	49.949	17.581	18	102
Age below 20 (Base: 36-40)	135807	0.026	0.159	0	1
Age 20 to 25	135807	0.079	0.270	0	1
Age 26 to 30	135807	0.062	0.242	0	1
Age 31 to 35	135807	0.067	0.250	0	1
Age 36 to 40	135807	0.083	0.276	0	1
Age 41 to 45	135807	0.099	0.299	0	1
Age 46 to 50	135807	0.100	0.301	0	1
Age 51 to 55	135807	0.094	0.292	0	1
Age 56 to 60	135807	0.085	0.279	0	1
Age 61 to 65	135807	0.079	0.269	0	1
Age 66 to 70	135807	0.083	0.275	0	1
Age 71 to 75	135807	0.067	0.249	0	1
Age 76 and above	135807	0.075	0.264	0	1
University degree	135807	0.214	0.410	0	1
Higher vocational degree	135807	0.189	0.392	0	1
Apprenticeship	135807	0.437	0.496	0	1
No qualification	135807	0.161	0.367	0	1
Household income	135807	24776.770	25115.790	0	3027805
Legislators	135807	0.102	0.303	0	1
Professional	135807	0.168	0.374	0	1
Technicians	135807	0.193	0.395	0	1
Clerks	135807	0.072	0.259	0	1
Service	135807	0.065	0.247	0	1
Skilled agricultural worker	135807	0.008	0.088	0	1
Craft	135807	0.109	0.312	0	1
Operator	135807	0.032	0.175	0	1
Elementary worker	135807	0.028	0.166	0	1
Work not listed	135807	0.019	0.135	0	1
Not working	135807	0.192	0.394	0	1
Unemployed	135807	0.011	0.105	0	1
Cancer	135807	0.046	0.210	0	1
Depression	135807	0.066	0.249	0	1
Stroke	135807	0.021	0.144	0	1
High blood pressure	135807	0.258	0.437	0	1
Dementia	135807	0.004	0.064	0	1
GDP growth rate(%)	135807	1.265	2.886	-5.1	4

Table 2—: Risk Distribution of the estimation sample

	2004		2006		2008		2009		2010		2011		2012	
Risk	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
0	1,642	8.15	1,022	4.94	836	4.53	1,808	9.3	1,042	5.88	965	4.87	753	3.85
1	969	4.81	811	3.92	1,016	5.5	1,474	7.58	1,012	5.71	1,008	5.09	761	3.89
2	2,016	10	1,833	8.87	2,258	12.23	2,840	14.61	2,220	12.53	2,127	10.74	1,895	9.69
3	2,585	12.82	2,503	12.11	2,763	14.97	3,154	16.23	2,797	15.79	2,669	13.47	2,504	12.81
4	2,139	10.61	2,136	10.33	2,099	11.37	2,216	11.4	1,746	9.85	2,079	10.49	2,130	10.89
5	4,396	21.81	4,828	23.35	3,654	19.8	3,926	20.2	3,581	20.21	4,485	22.64	4,480	22.91
6	2,206	10.94	2,458	11.89	1,941	10.52	1,755	9.03	1,886	10.64	2,268	11.45	2,345	11.99
7	2,260	11.21	2,599	12.57	1,955	10.59	1,433	7.37	1,846	10.42	2,269	11.45	2,487	12.72
8	1,409	6.99	1,780	8.61	1,353	7.33	648	3.33	1,182	6.67	1,421	7.17	1,559	7.97
9	347	1.72	440	2.13	363	1.97	107	0.55	246	1.39	313	1.58	382	1.95
10	188	0.93	266	1.29	218	1.18	74	0.38	161	0.91	208	1.05	256	1.31
Total	20,157	100	20,676	100	18,456	100	19,435	100	17,719	100	19,812	100	19,552	100

Table 3—: Illustration of cohort averaged difference by age using four selected cohorts

	Age Spans																											
1940-4																	60	61	62	63	64	65	66	67	68	69	70	71	72
1945-9											55	56	57	58	59	60	61	62	63	64	65	66	67						
1950-4						50	51	52	53	54	55	56	57	58	59	60	61	62											
1955-9	45	46	47	48	49	50	51	52	53	54	55	56	57																

Table 4—: Size effects of age, socioeconomic status and health on the probability of high risk tolerance, zero risk tolerance, and levels of risk[a]

	Model (1) High Risk		**Model (2) Zero Risk**		**Model (3) Levels of risk**	
	Logit	RE	Logit	RE	OLS	FGLS-RE
Age groups - Base: Age 36-40						
Age below 20	2.17***	2.75***	0.41***	0.31***	1.11***	0.96***
Age 20 to 25	1.76***	2.21***	0.50***	0.42***	0.74***	0.67***
Age 26 to 30	1.32***	1.53***	0.69***	0.61***	0.36***	0.35***
Age 31 to 35	1.10**	1.19***	0.88	0.82*	0.14***	0.13***
Age 41 to 45	0.99	0.91*	1.08	1.08	-0.01	-0.05*
Age 46 to 50	0.91*	0.82***	1.45***	1.46***	-0.13***	-0.19***
Age 51 to 55	0.87**	0.78***	1.77***	1.91***	-0.22***	-0.26***
Age 56 to 60	0.79***	0.66***	1.81***	2.06***	-0.31***	-0.39***
Age 61 to 65	0.79***	0.61***	1.94***	2.43***	-0.32***	-0.47***
Age 66 to 70	0.72***	0.55***	2.12***	2.68***	-0.40***	-0.55***
Age 71 to 75	0.65***	0.46***	2.31***	2.98***	-0.52***	-0.65***
Age 76 and above	0.54***	0.36***	3.08***	4.18***	-0.88***	-0.92***
Education - Base: University						
Higher vocational degree	0.88***	0.84***	1.51***	1.77***	-0.14***	-0.13***
Apprenticeship	0.85***	0.80***	1.73***	2.17***	-0.22***	-0.20***
No qualification	0.79***	0.75***	2.40***	3.67***	-0.45***	-0.39***
Household income quartiles - Base: lowest						
Second	1.03	1.04	0.80***	0.83***	0.14***	0.08***
Third	1.07*	1.09*	0.66***	0.64***	0.18***	0.13***
Highest	1.31***	1.33***	0.54***	0.53***	0.37***	0.22***
Occupation - Base: Professional						
Legislators	1.57***	1.98***	0.83	0.77*	0.49***	0.46***
Technicians	1.01	1.01	1.12	1.16	0.03	0.01
Clerks	0.94	0.92	1.33**	1.41**	-0.02	-0.05
Service	1.07	1.15	1.37**	1.51***	0.05	0.04
Skilled agricultural worker	0.93	0.96	1.70**	2.14***	-0.11	-0.09
Craft	0.99	0.96	1.30**	1.53***	0.01	-0.06
Operator	1.02	1	1.57***	1.81***	-0.03	-0.09
Elementary worker	1.11	1.13	1.74***	2.25***	-0.06	-0.14*
Work not listed	1.15*	1.23*	1.15	1.39*	0.13*	0.02
Not working	0.84***	0.81***	1.81***	2.36***	-0.27***	-0.29***
Unemployed	1.30**	1.23	1.89***	2.26***	0.20*	0.05
Health conditions - Base None						
Cancer	1.06	1.08	0.96	0.93	0.06	0.08
Depression	0.80***	0.70***	1.21**	1.26**	-0.28***	-0.29***
Stroke	1.13	1.18	1.18	1.29*	-0.01	-0.06
High blood pressure	0.85***	0.80***	0.84***	0.80***	-0.06*	-0.05*
Dementia	0.87	1.02	1.82***	2.54***	-0.65***	-0.62***
Mean Risk[b]	0.204	0.204	0.059	0.059	4.423	4.423

Total number of person-year observations is 135,807. All models control for age, gender, marital status, children, being a foreigner, and the annual GDP growth rate (in %). [a] Columns 1-4 report odds ratios. Odds ratio are statistically significant if different from 1. Columns 5-6 report marginal effects (linear regression model). [b] Mean risk refer to sample proportions in columns 1-4 and levels of risk attitude in columns 5-6. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

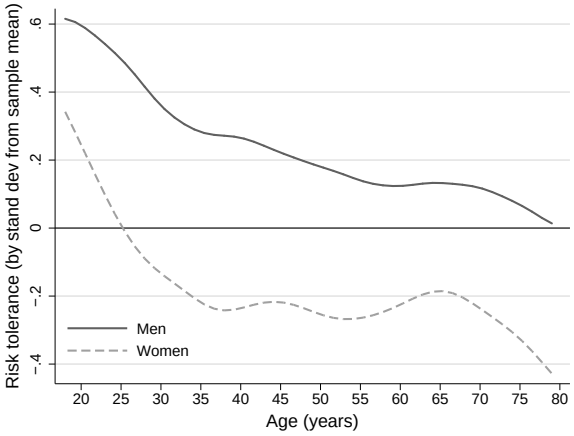
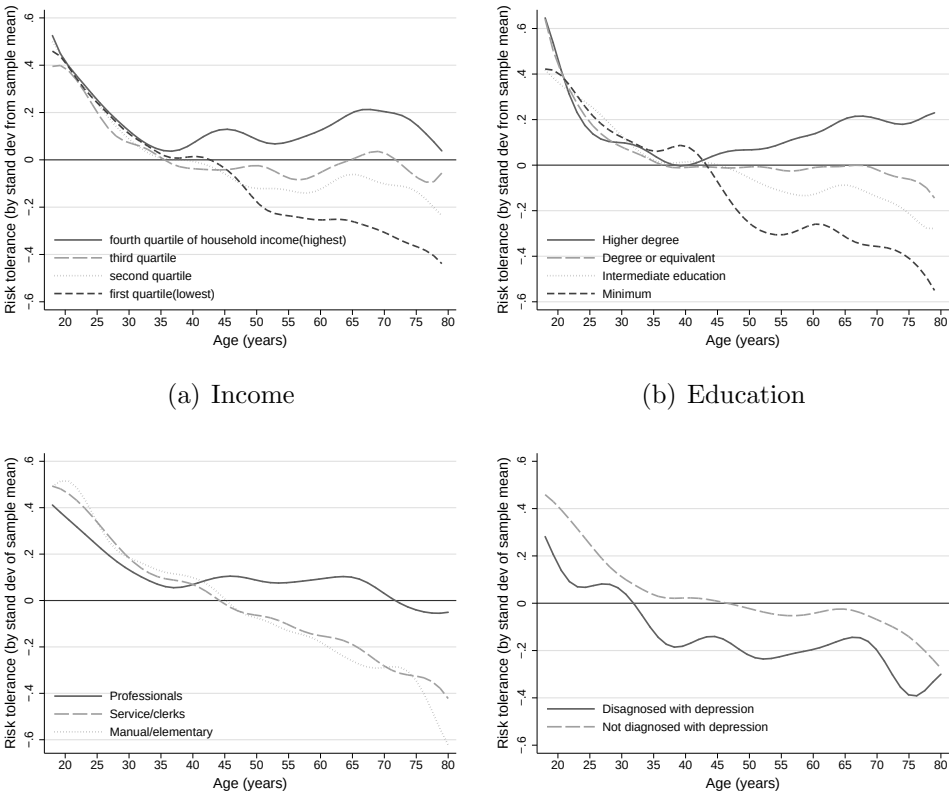


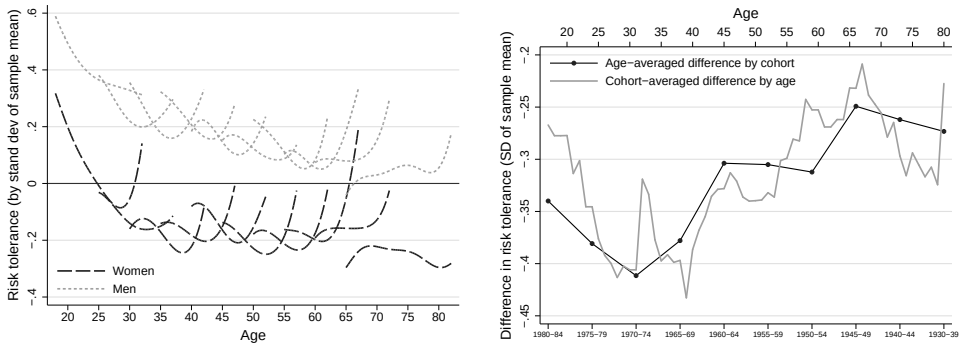
Figure 1. : Risk attitudes over the lifecycle, by gender



(a) Income (b) Education

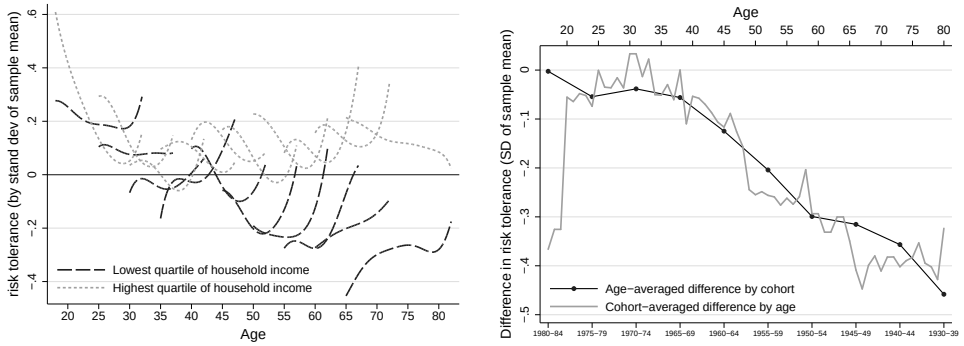
(c) Occupation (d) Depression

Figure 2. : SES and health gradient in the evolution of risk attitudes



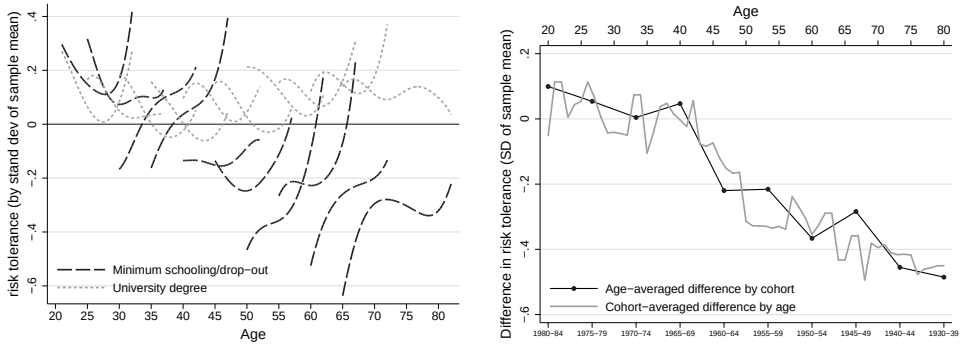
(a) Profiles (b) Differences

Figure 3. : Age-cohort profiles between men and women (non-parametric estimates)



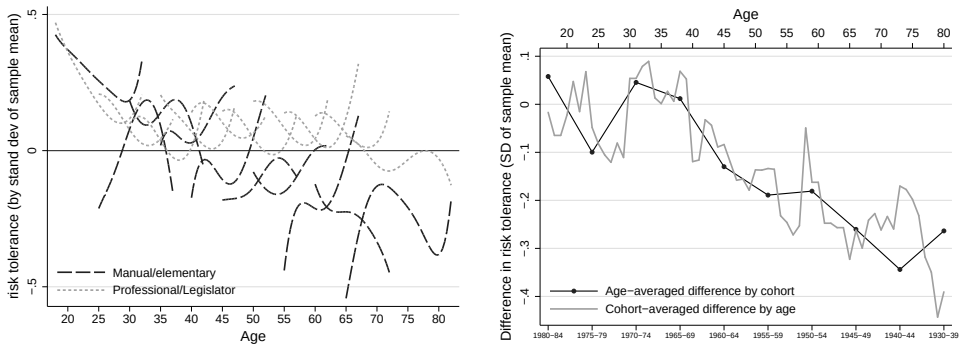
(a) Profiles (b) Differences

Figure 4. : Age-cohort profiles by highest and lowest quartile of household income (non-parametric estimates)



(a) Profiles (b) Differences

Figure 5. : Age-cohort profiles by high and low levels of education (non-parametric estimates)



(a) Profiles (b) Differences

Figure 6. : Age-cohort profiles by highly-skilled and unskilled occupations (non-parametric estimates)

ONLINE APPENDIX - NOT FOR PUBLICATION*

Table A1—: Summary of Literature Review

Paper	Data	Sample Size	Methodology	Findings	Contributions/ Drawbacks
Tymula et al. (2013)	1) Lottery experiments including 320 choices(160 gain, 160 loss) with certain(risky) or unknown(ambiguous) probabilities; 2) A demographic, financial and psychological profile(gender,education, household wealth, numeracy, IQ)	135 healthy subjects, including 33 adolescents(age 12-17), 34 young adults(21-25), 32 midlife adults(30-50), and 36 older adults(65-90)	1) Model free analysis; 2) Model based analysis: first build a model including individual risk and ambiguity attitudes, and stochasticity, then use maximum likelihood method to estimate the parameters	1)Older adults generate lowest income in the experiments; 2) Older adults choose dominated choices most often;3)Older adults are more inconsistent(not random) in their choices;4)In the gain domain, adolescents and older adults are more risk averse, and adolescents are more ambiguity tolerant, i.e. risk attitudes show an inverted U-shape with age in the gain domain. In the loss domain, older adults are more risk seeking and ambiguity averse;5)The results are robust controlling for socioeconomic and demographical variables, and to model free analysis, and differences in risk and ambiguity attitudes were not caused by some systematic differences between the groups in total wealth, education, IQ, or numeracy scores.	1)Sample size too small;2)Participants only have 10s for each trial;3)Use parents' education level as adolescents' education level;4) Use household wealth as adolescents' wealth;5)Exceptionally high proportion of midlife adults and older adults have advanced graduate degrees, so the sample may not be representative;
Dohmen et al. (2011)	1) The 2004 wave of German Socio-Economic Panel(SOEP), including detailed personal and household information, and a general risk question; 2) A field experiment (using the exactly same sampling methodology with SOEP(targeted random walk method), but a different subject pool to avoid participants from SOEP) including a questionnaire as in SOEP and a lottery experiment	1)22,019 individuals over age 17 in 11,803 different households; 2) 450 subjects	1) Interval regression; 2) Principle components analysis; 3) Probit model	1)Being male, height, parental education level, household income, life satisfaction are significantly positively correlated with risk attitudes, while age, being widowed, bad subjective health status, being out of the labor force and number of children are significantly negatively correlated with risk attitudes; 2)Answers to the general risk question can well predict actual risk-taking behaviour, even controlling for a wide range observable characteristics; 3) Effects of gender, age, height, and to some extent, parental education, on risk attitudes are similar and significant across contexts, after adding additional controls;4) Risk attitudes are highly and significantly correlated across contexts, and around 60% of individual risk attitudes s explained by one principle component, indicating a stable common underlying risk trait;5) The general risk question is the best all-round predictor of risk attitudes, but the risk question in specific context is a stronger measure in that context;	This study validated the often used survey data as a good measure of real risk preferences, and indicated that experiments with lottery questions, which is also very often used in the area, may not be very effective in indicating risk preferences in non-financial contexts; The coefficient of answers to the general question on value of safe option at switching point if statistically, but not economically significant.

Table A1—: Summary of Literature Review

Paper	Data	Sample Size	Methodology	Findings	Contributions/ Drawbacks
Dohmen et al. (2010)	Cognitive ability, risk attitudes and personal profiles from a representative sample	452 participants (age 17 and older)	Interval regression method	Higher cognitive ability is associated with greater willingness to take risks, controlling for individual characteristics such as gender, age, and height, as well as important economic variables including education, income, and liquidity constraints.	Cognitive ability are mainly related to processing speed, and may not be representative
Dohmen et al. (2014)	1) The Dutch DNB household survey(DHS) from 1993-2001, 6 financial risk questions were included each year; 2) 2004, 2006, 2008-2011 waves of the German Socio-Economic Panel (SOEP);	1) 35,173 observations (aged 16 onwards) in total for DNS; 2) 120,954 observations (aged 17 onwards) for SOEP	1) The two data sets were analysed in parallel; 2) GDP growth rate used as proxy for calendar time effect, as GDP growth is not linearly correlated with time periods, but is positively correlated with average attitudes;	1) By pooling all years together and plotting average risk attitudes on age, the authors found a negative linear age effect on risk attitudes, and that men are more risk taking than women;2) Age coefficients of regressing risk attitudes on age, controlling for cohort effect and calendar time effect, are significantly negative and of similar size for both data sets; 3) After controlling for cohort effect and calendar time effect, the slope of the age pattern of risk attitudes are approximately linear, which becomes flatter after age 65; 4) After controlling for cohort effect and calendar time effect, difference of risk attitudes between men and women rises sharply until age 25, and stays positive and stable after that; 5) Age effects are significantly negative using fixed effect model and controlling for calendar time effect	The non-response rate for young people is rather high in the Dutch data set, with 40% of women younger than age 30 have non-missing observations on all six questions, and the response rate for men increases linearly from 40% at age 30 to about 70% at age 80;
Donkers, Melenberg and van Soest (2001)	First wave of Dutch CentER Savings Survey (CSS) drawn in 1993, including 8 risk questions and detailed background information	3949 individuals aged 16 and above	Semiparametric estimation and structural model based on Cumulative Prospect Theory	Age and being female have negative effects on risk attitudes, while income and education level are positively correlated with risk attitudes	Survey questions are answered online by the respondents themselves instead of by personal interviews, so respondents may answer with less care;
Baltes and Lindenberger (1997)	Composite sample combining younger adult sample and a subsample of BASE (age 25-101);	315(171(age 25-69), 144(age 70-101));	Visual acuity, auditory acuity and 5 cognitive abilities are measured, and then linear regression is used for analysis;	1) Vision, hearing and cognitive abilities all show clear negative age effects; 2) The negative age effects on cognitive abilities are extremely well predicted by individual differences in vision and hearing;	Cohort effects are not controlled;

Table A1—: Summary of Literature Review

Paper	Data	Sample Size	Methodology	Findings	Contributions/ Drawbacks
Frederick (2005)	CRT and risk preferences data obtained from mostly undergraduate students with a questionnaire including CRT and several lottery questions	3,428 respondents	A three-item "Cognitive Reflection Test" (CRT) is used as a simple measure of one type of cognitive ability	1) In the domain of gains, the high CRT group are more willing to gamble, even when the gamble has lower expected value. This suggests that correlation between cognitive ability and risk preferences in gains is not only due to higher computation skill; 2) In the domain of losses, the high CRT group is less risk seeking; 3) Males score significantly higher in CRT than females; 4) Females are significantly more risk averse than males, controlling for CRT scores;	Participants are mostly university students with many similar characteristics, so more variance should be observed using representative sample
Burks et al. (2009)	Cognitive skills, risk attitudes (lottery experiment), and personal profiles from a sample of trainee tractor-trailer drivers at a big U.S. trucking company	1,066 individuals	Constant relative risk aversion utility function used to measure risk aversion	1) People with higher cognitive skills(CS) are more willing to take calculated risks in the domain of gains; 2) People with higher CS are less risk taking in the domain of losses; 3) Individuals making choices close to risk neutrality have significantly higher CS than those making choices farther from risk neutrality	Sample may not be representative
Benjamin, Brown and Shapiro (2013)	Paid lottery experiments and demographic information from students in a Chilean high school	92 senior students	Cognitive ability is measured by standard math score; Ordered probit model	The effect of math score on risk attitudes is positive, and marginally statistically and economically significant, controlling for gender and average income of the neibourhood	Sample not representative; Preference measure may not be general

Table A1—: Summary of Literature Review

Paper	Data	Sample Size	Methodology	Findings	Contributions/ Drawbacks
Bonsang and Dohmen (2012)	Survey of Health, Ageing and Retirement in Europe (SHARE) that includes both a question on financial risk preference and measures of cognitive ability(episodic memory, verbal fluency and numeracy) for a representative sample of individuals aged 50+ in 11 European countries	11,662 observations	1) 2)Correcting for attenuation bias that results from measurement error in the cognitive skills measure by using the lag of the measured cognitive score as an instrument for the noisy contemporaneous cognitive skills measure	1) Older cohorts are less willing to take financial risks than younger cohorts;2)Cognitive abilities decline with age;3)By comparing age effects on risk attitudes in a regression framework with and without controlling for cognitive abilities, the authors found that about two fifth of the age-related cross-sectional difference in risk attitudes can be explained by cognitive abilities; After correcting for attenuation bias, the age effect is reduced by about 70%, and is captured by cognitive abilities. These findings suggest that the difference in willingness to take risks between cohorts can be traced to age related differences in cognitive functioning.	Answers to financial risk question may not be representative of a person's general risk attitude
Carney, Cuddy and Yap (2010)	Field experiment where participants were randomly assigned to do high or low power poses, then different indicators of power were measured	Forty-two participants (26 females and 16 males)	Risk preferences, feelings of power, and hormone levels were compared to determine whether the power-pose could make people more powerful	high-power poses caused an increase in testosterone compared with low-power poses, which caused a decrease in testosterone; high-power poses caused a decrease in cortisol compared with low-power poses, which caused an increase in cortisol; high-power posers were more likely than low-power posers to be risk seeking; high-power posers reported feeling significantly more "powerful" and "in charge"	Sample size too small;

Table A2—: Number of Observations with Retrospective Occupations

	Without	With	Difference
Work not listed	3455	2530	941
Not working	37899	26115	11839
Unemployed	2611	1505	1186
Total	43965	30150	13815

1) There are 43965 observations without occupation information using 2004-2012 waves, and they are allocated into the above three categories according to their labor force status. Then we use all waves from 1984 and try to capture more occupation information from the earlier waves. After this, only 30150 observations are without occupation information, i.e. 13815 observations are with retrospective occupations.

2) For the observations with age above 30 in "not working", 63.82% are female, which are likely to be housewives.

Table A3—: Occupation Reassignment

	Freq.	Percent	Cum.
0	30,150	22.2	22.2
1	54,474	40.11	62.31
2	32,382	23.84	86.16
3	13,468	9.92	96.07
4	4,249	3.13	99.2
5	902	0.66	99.87
6	168	0.12	99.99
7	14	0.01	100
Total	135,807	100	

Table A3 shows the number of occupations that individuals have had. For individuals who have had more than one occupations, we assign the highest one as their life-long occupation in the order "legislators > professionals > technicians > clerks > craft > service > operators >skilled agriculturist > elementary". Among the 51183 observations that have been reassigned occupations, 8566 are considered as high jumpers (legislators or professionals who have had occupations in service, elementary or craft).

Table A4—: Number of observations in each age cohort in the cohort analysis

All	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84
2004	2549	1719	1442	1797	2075	2178	2073	1576	1337	2056
2006	2578	1787	1495	1835	2018	2183	2086	1615	1326	2267
2008	2213	1591	1322	1592	1778	1919	1832	1414	1171	1938
2009	2263	1696	1406	1732	1873	1990	1940	1459	1212	1963
2010	2028	1573	1323	1592	1730	1799	1722	1322	1095	1722
2011	2285	1735	1514	1792	1943	2016	1883	1451	1189	1893
2012	2191	1718	1517	1754	1924	1968	1876	1422	1189	1822
Total	16,107	11,819	10,019	12,094	13,341	14,053	13,412	10,259	8,519	13,661

Cohorts 35-39 and 80-84 are of 9 and 8 year intervals respectively, while other cohorts are of 5 year interval.

Table A5—: Number of observations in each age cohort in the cohort analysis by gender

Female	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84
2004	1,278	866	700	935	1,081	1,114	1,062	834	720	1,038
2006	1,299	903	727	972	1,067	1,142	1,070	860	729	1,174
2008	1,139	797	654	843	951	990	945	754	636	1,022
2009	1,171	856	696	915	1,003	1,021	1,006	778	661	1,029
2010	1,045	787	663	850	927	931	893	701	607	913
2011	1,164	881	767	963	1,032	1,047	1,000	781	667	1,032
2012	1,118	882	762	953	1,032	1,042	1,009	765	673	973
Total	8,214	5,972	4,969	6,431	7,093	7,287	6,985	5,473	4,693	7,181
Male	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84
2004	1,271	853	742	862	994	1,064	1,011	742	617	1,018
2006	1,279	884	768	863	951	1,041	1,016	755	597	1,093
2008	1,074	794	668	749	827	929	887	660	535	916
2009	1,092	840	710	817	870	969	934	681	551	934
2010	983	786	660	742	803	868	829	621	488	809
2011	1,121	854	747	829	911	969	883	670	522	861
2012	1,073	836	755	801	892	926	867	657	516	849
Total	7,893	5,847	5,050	5,663	6,248	6,766	6,427	4,786	3,826	6,480

Cohorts 35-39 and 80-84 are of 9 and 8 year intervals respectively, while other cohorts are of 5 year interval.

Table A6—: Number of observations in each age cohort in the cohort analysis by education

No qualification	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84
2004	627	272	226	241	223	245	244	218	169	660
2006	611	285	210	239	207	242	229	196	161	561
2008	491	233	180	186	175	204	189	167	145	326
2009	500	236	194	187	175	198	194	167	152	295
2010	435	209	177	162	157	168	164	141	119	247
2011	547	247	220	211	191	218	197	179	145	278
2012	497	242	209	197	177	212	192	169	149	254
Total	3,708	1,724	1,416	1,423	1,305	1,487	1,409	1,237	1,040	2,621
University Degree	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84
2004	470	425	372	502	583	509	456	315	165	23
2006	490	430	371	518	574	520	469	368	250	73
2008	439	403	336	453	505	466	419	339	272	171
2009	432	416	352	481	532	485	451	363	319	250
2010	405	406	333	457	495	442	408	339	307	300
2011	425	440	352	492	509	494	451	337	322	395
2012	419	452	359	477	502	476	447	345	324	466
Total	3,080	2,972	2,475	3,380	3,700	3,392	3,101	2,406	1,959	1,678

Cohorts 35-39 and 80-84 are of 9 and 8 year intervals respectively, while other cohorts are of 5 year interval.

Table A7—: Number of observations in each age cohort in the cohort analysis by income

Lowest income	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84
2004	952	489	248	277	357	450	515	447	468	620
2006	970	573	294	318	341	428	484	429	442	807
2008	808	452	283	271	268	298	356	312	322	659
2009	852	509	324	302	272	307	342	298	314	662
2010	728	445	313	286	255	258	292	255	245	564
2011	819	508	349	323	302	279	311	283	266	604
2012	710	477	358	357	284	259	302	247	276	564
Total	5,839	3,453	2,169	2,134	2,079	2,279	2,602	2,271	2,333	4,480
Highest income	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**75-79**	**80-84**
2004	345	443	567	639	601	483	386	239	197	416
2006	366	416	553	681	665	541	431	282	198	392
2008	344	393	464	620	637	543	437	296	186	365
2009	313	395	464	680	708	602	508	315	232	374
2010	303	386	437	632	674	604	455	314	220	346
2011	348	410	474	656	769	710	545	340	251	375
2012	324	391	438	639	746	724	572	358	282	387
Total	2,343	2,834	3,397	4,547	4,800	4,207	3,334	2,144	1,566	2,655

Cohorts 35-39 and 80-84 are of 9 and 8 year intervals respectively, while other cohorts are of 5 year interval.

Table A8—: Number of observations in each age cohort in the cohort analysis by occupation

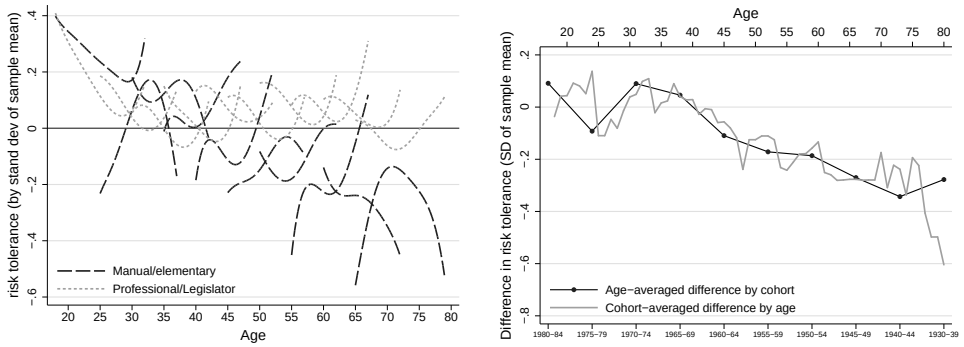
Low occupation	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84
2004	240	163	141	150	170	153	135	79	49	73
2006	210	149	143	150	162	162	142	77	53	93
2008	181	137	122	126	140	138	129	70	42	76
2009	168	126	126	150	152	153	145	80	54	90
2010	141	118	116	132	142	132	124	71	44	74
2011	118	106	119	148	182	162	137	86	60	95
2012	100	96	109	139	179	169	141	92	68	97
Total	1,158	895	876	995	1,127	1,069	953	555	370	598
High occupation	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84
2004	549	770	791	1,043	1,259	1,298	1,213	937	781	883
2006	527	729	782	1,053	1,214	1,305	1,230	960	778	1,001
2008	473	672	706	933	1,076	1,175	1,096	865	714	949
2009	444	655	683	983	1,115	1,186	1,127	876	733	974
2010	404	620	654	917	1,029	1,072	1,012	796	668	873
2011	363	590	647	967	1,092	1,168	1,067	843	694	949
2012	313	542	608	918	1,056	1,108	1,047	804	673	905
Total	3,073	4,578	4,871	6,814	7,841	8,312	7,792	6,081	5,041	6,534

Cohorts 35-39 and 80-84 are of 9 and 8 year intervals respectively, while other cohorts are of 5 year interval.

Table A9—: Size effects[a] of age, socioeconomic status, and health after removing individuals who have had three or more occupations

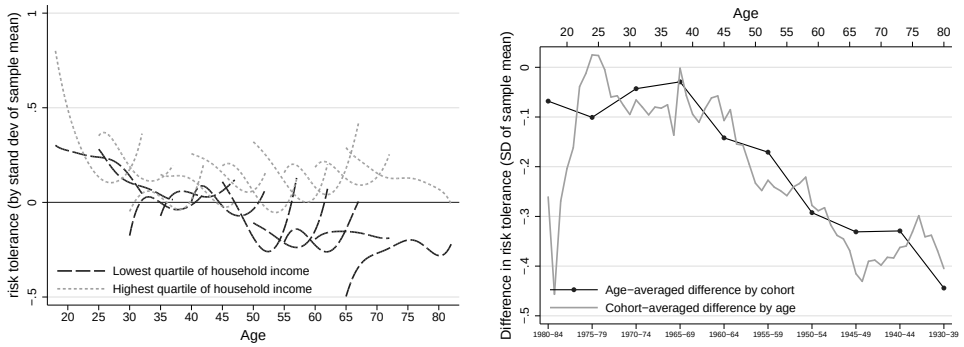
	Model (1) High Risk		**Model (2) Zero Risk**		**Model (3) Levels of risk**	
	Logit	RE	Logit	RE	OLS	FGLS-RE
Age groups - Base: Age 36-40						
Age below 20	2.18***	2.76***	0.39***	0.29***	1.15***	1.00***
Age 20 to 25	1.80***	2.26***	0.46***	0.38***	0.80***	0.72***
Age 26 to 30	1.30***	1.49***	0.64***	0.56***	0.39***	0.38***
Age 31 to 35	1.13**	1.22***	0.80*	0.76*	0.19***	0.16***
Age 41 to 45	0.98	0.92	1.06	1.06	-0.01	-0.04
Age 46 to 50	0.91*	0.84**	1.36***	1.36**	-0.10*	-0.15***
Age 51 to 55	0.89*	0.81***	1.69***	1.80***	-0.19***	-0.22***
Age 56 to 60	0.81***	0.67***	1.74***	1.96***	-0.27***	-0.36***
Age 61 to 65	0.82***	0.64***	1.85***	2.27***	-0.28***	-0.43***
Age 66 to 70	0.73***	0.56***	1.99***	2.49***	-0.36***	-0.50***
Age 71 to 75	0.67***	0.48***	2.16***	2.77***	-0.47***	-0.60***
Age 76 and above	0.55***	0.37***	2.86***	3.84***	-0.83***	-0.88***
Education - Base: university						
Higher vocational degree	0.82***	0.79***	1.47***	1.74***	-0.20***	-0.17***
Apprenticeship	0.79***	0.75***	1.68***	2.10***	-0.28***	-0.26***
No qualification	0.75***	0.72***	2.35***	3.56***	-0.51***	-0.44***
Household income quartiles - Base: lowest						
Second	1.04	1.06	0.79***	0.81***	0.15***	0.09***
Third	1.07*	1.09*	0.65***	0.62***	0.20***	0.13***
Highest	1.34***	1.35***	0.52***	0.51***	0.40***	0.23***
Occupation - Base: Professional						
Legislators	1.62***	2.09***	0.85	0.81	0.51***	0.49***
Technicians	1.08	1.07	1.03	1.08	0.08*	0.05
Clerks	1.06	1.04	1.25*	1.34*	0.09	0.02
Service	1.18**	1.27**	1.34**	1.49***	0.13*	0.1
Skilled agricultural worker	1.01	1.04	1.64**	2.09**	-0.02	-0.04
Craft	1.09	1.07	1.2	1.43**	0.11*	0.02
Operator	1.1	1.08	1.55***	1.82***	0.04	-0.05
Elementary worker	1.22**	1.23*	1.68***	2.21***	0.04	-0.08
Work not listed	1.24**	1.32**	1.11	1.37	0.20**	0.06
Not working	0.91	0.87*	1.76***	2.32***	-0.19***	-0.24***
Unemployed	1.42***	1.33*	1.80***	2.19***	0.30**	0.1
Health conditions - Base: None						
Cancer	1.03	1.05	0.98	0.95	0.04	0.05
Depression	0.78***	0.68***	1.20**	1.25*	-0.30***	-0.31***
Stroke	1.06	1.11	1.24*	1.39*	-0.07	-0.11
High blood pressure	0.84***	0.79***	0.85***	0.81***	-0.07**	-0.06*
Dementia	0.88	1.02	1.85***	2.55***	-0.63***	-0.60***
Mean Risk[b]	0.198	0.198	0.062	0.062	4.373	4.373

The sample size is 117006 person-year observations in each model. All models control for age, gender, marital status, children, being a foreigner, and the annual GDP growth rate (in %). [a] Columns 1-4 report Odds ratios. Columns 5-6 report marginal effects (linear regression models). [b] Mean risk refer to sample proportions in columns 1-4 and levels of risk attitude in columns 5-6 * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$



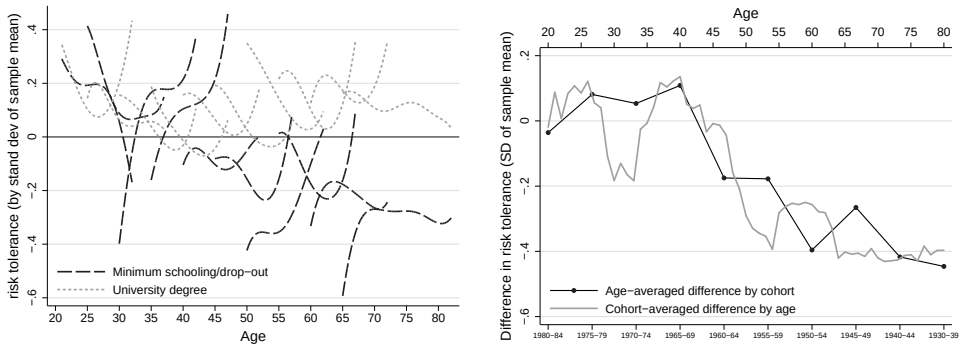
(a) Profiles (b) Differences

Figure A1. : Age-cohort profiles by highly-skilled versus unskilled occupations (non-parametric estimates)**(After removing individuals who have had three or more occupations)**



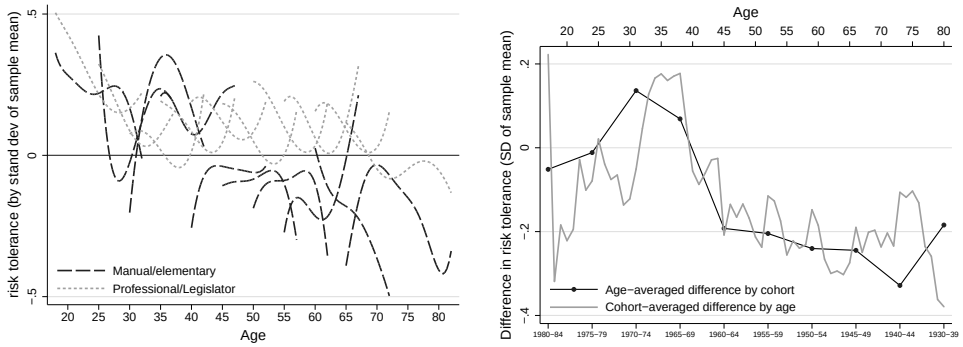
(a) Profiles (b) Differences

Figure A2. : Age-cohort profiles between individuals with highest and lowest quartile of household income (non-parametric estimates)**(After removing individuals who have less than six years of data available)**



(a) Profiles (b) Differences

Figure A3. : Age-cohort profiles by high and low levels of education (non-parametric estimates)**(After removing individuals who have less than six years of data available)**



(a) Profiles (b) Differences

Figure A4. : Age-cohort profiles by highly-skilled versus unskilled occupations (non-parametric estimates)**(After removing individuals who have less than six years of data available)**