Network for Studies on Pensions, Aging and Retirement

NETSPAR ACADEMIC SERIES

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DP 11/2015-057

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Abstract

This paper investigates how risk attitudes change over the life course. We study the age trajectory of risk attitudes all the way from early adulthood until old age, in large representative panel data sets from the Netherlands and Germany. Age patterns are generally difficult to identify separately from cohort or calendar period effects. We achieve identification by replacing calendar period indicators with controls for the specific underlying factors that may change risk attitudes across periods. The main result is that willingness to take risks decreases over the life course, linearly until approximately age 65 after which the slope becomes flatter.

Keywords: Risk attitudes, age, period, cohort

JEL codes: D03, D8, J1

* This research was supported by a grant from the Volkswagen Stiftung, Netspar and Handelsbankens forskningsstiftelser. We thank Lex Borghans, Michela Coppola, Ryanne van Dalen, Hauke Heekeren, Peter Mohr, Irene Nagel, Anders Stenberg, Bas ter Weel and Christoph Wunder for valuable comments.
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Risk Attitudes Across the Life Course*

1. Introduction

How do risk attitudes vary over the life course? Are risk attitudes stable or do they change with age? Do cohorts differ regarding their risk attitudes? Do risk attitudes change across time periods? Addressing these questions is of great importance, particularly in an aging society. Several studies have documented that fundamental economic attitudes affect individual decision making in a myriad of contexts. Risk attitudes have a key impact on economic decisions (e.g., savings and investment decisions, labour market outcomes), demographic outcomes (e.g., fertility decisions) and socio-political behaviour (e.g., voting). Systematic changes in aggregate risk attitudes in an aging society would have far-reaching consequences for economic, political and social outcomes.

This paper studies the age profile of risk attitudes. For the analysis, we use data from two different sources: the Dutch DNB Household Survey – a panel data set that contains questions about risk attitudes every year since 1993 – and six waves of the German Socio-Economic Panel Study (SOEP), which contain information about risk attitudes and span eight years.[1]

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We received valuable comments from the editor Frederic Vermeulen, two anonymous referees, Lex Borghans, Michela Coppola, Ryanne van Dalen, Hauke Heekeren, Olivier Marie, Peter Mohr, Irene Nagel, Nicolás Salamanca, Anders Stenberg, Bas ter Weel, Christoph Wunder, and participants of the ESRC Workshop on Preferences and Personality in Stirling (Scotland) and the DUHR seminar at Maastricht University. This research was supported by a grant from the Volkswagen Stiftung. Golsteyn acknowledges support from Handelsbankens forskningsstiftelser. Dohmen acknowledges support from the Network for Studies on Pensions, Aging and Retirement (Netspar). In this paper, we use data from the CentERdata databank and the SOEP. The data can be accessed by applying to the SOEP (DIW, Berlin) and to CentER Data (Tilburg University). The programs for replicating the results in this study are available on request.

[1] In addition, we use macro-economic indicators from various other sources.

Even with panel data that span several years, age profiles are typically difficult to identify because they may also reveal changes across cohorts or periods of observation. It is not possible to control for age, birth year and period of observation at the same time because age is a perfect linear combination of birth year and survey period. A priori, there is reason to believe that age, cohort and survey period may all be related to stated risk attitudes to some extent, however, so none of these variables can be excluded from the model. When people grow older they may become less willing to take risks due to biological ageing processes, as is suggested, for example, by evidence that cognitive ageing is associated with declining willingness to take risks (Bonsang and Dohmen, 2015). The period of observation may also affect risk attitudes. Calendar time effects might arise, for example, because events change expectations and thereby affect expected life-time wealth. Dohmen *et al.* (2006) show that unexpectedly good performance of the German soccer team in the FIFA World Cup 2006 improved economic perceptions and expectations. Likewise, events such as the financial crisis might affect the wealth level of many households, who as a consequence may have become more risk averse. Malmendier and Nagel (2011) provide evidence that recent experiences affect risk attitudes, but they also report compelling evidence for cohort effects as people who experienced the Great Depression are less willing to take financial risks compared to those who did not experience the economic downturn. Falk and Kosse (2015) show that breastfeeding duration is related to the formation of attitudes and provide evidence suggesting that variation in breastfeeding patterns induces cohort effects in risk attitudes.

We address this age-period-cohort identification problem along the lines suggested by Heckman and Robb (1985) by substituting determinants of risk attitudes that depend on calendar time but do not change linearly with calendar time for period dummies. We assume that risk attitudes would be related to calendar time because of the business cycle. Bucciol and Miniaci (2013) demonstrate that willingness to take risk is positively correlated with fluctuations in GDP. In our main specification, we therefore use GDP growth to capture such period effects. Since there is age variation that can be exploited for each observation period of the survey data, and since the relationship between calendar time and GDP growth is not linear, the model is identified. The main results of this exploration indicate that willingness to take risks decreases with age. The decreasing pattern is linear until approximately age 65, after which the slope becomes flatter. Various robustness analyses corroborate this finding.

Our paper contributes to the literature by providing detailed age profiles for risk attitudes from young adulthood until old age. Negative cross-sectional relationships between risk taking and age have been reported in other studies (e.g., Barsky *et al.*, 1997; Donkers *et al.*, 2001; Dohmen *et al.*, 2011). Analyses of changes in risk attitudes with age based on panel data are, however, quite rare. One exception is Sahm (2012), who investigates the profile of risk attitudes among elderly birth cohorts (i.e. the 1931-1947 birth cohorts). She finds a modest decline in risk with age over this older age range. Our study is different in that it addresses the question of how risk attitudes vary over the entire age range starting from early adulthood.[2] Studying variation in risk attitude among youth is important because it adds perspective to the size of the variation of risk attitude among elderly. Looking at younger birth cohorts is also important in itself. So far, there is little and inconclusive evidence of the development of risk attitudes early in life. Tymula *et al.* (2012), for example, compare lottery choices of a sample of 33 young adolescents to lottery choices of 32 adults, and find that adolescents are more risk averse. Moreover, Tymula *et al.* (2013) show that adolescents and elderly individuals are more risk averse than their midlife counterparts in a sample of 135 individuals, but do not disentangle cohort, period and true age effects. We analyse the age pattern of risk attitudes using two large representative samples and control for cohort and

[2] Our empirical approach also differs from Sahm's (2012) analysis in the sense that we use a flexible functional form (i.e. a set of dummies for age) to estimate age patterns.

period effects. Our results reveal that the willingness to take risks declines throughout life. This decline appears to become less pronounced from around age 65 onwards.

The remainder of the paper is organised is as follows. Section 2 discusses the data. Section 3 reports the results. Section 4 analyses the robustness of the results. Section 5 concludes.

2. Data

We use two data sets. The first is the DNB Household Survey, a representative panel data set collected by CentER Data at Tilburg University in the Netherlands.[3] The second data set is the German Socio-Economic Panel Study (SOEP).[4] Using two data sets allows us to test the robustness of our results across two different samples. In addition, both data sets have specific benefits, which we will exploit in the analyses.

The data collection of the DNB Household Survey takes place at the household level. Each member of the household who is above 16 years of age can participate. The data set is representative of the Dutch population. The data have been collected on a yearly basis since 1993. We use data from all available years, 1993-2011. Each year, on average around 5,100 people participate in the survey.[5]

To measure risk attitudes we use 6 questions that were posed to the participants in each of the 19 years that the survey took place. As far as we know, no other data set contains information on risk attitudes for such a long time period.[6] Participants in the survey were

[3] http://www.centerdata.nl/en/TopMenu/Projecten/DNB_household_study/
[4] http://panel.gsoep.de/soepinfo2010/
[5] The number of participants per survey year was lower during 1998-2000 than in the other years. Since 2000, the number of respondents has been fairly stable.
[6] Self-reported measures of risk attitudes are often used in the literature. Dohmen *et al.* (2011) find that self-reported willingness to take risks correlates significantly with risk aversion measured in a lottery choice experiment and with risky behaviour.

asked to indicate their levels of agreement with the following statements on a 7 point Likert scale, ranging from (1) “totally disagree” to (7) “totally agree”:

1. I think it is more important to have safe investments and guaranteed returns, than to take a risk to have a chance to get the highest possible returns.
2. I would never consider investments in shares because I find this too risky.
3. If I think an investment will be profitable, I am prepared to borrow money to make this investment.
4. I want to be certain that my investments are safe.
5. I am becoming more and more convinced that I should take greater financial risks to improve my financial position.
6. I am prepared to take the risk to lose money, when there is also a chance to gain money.

We reverse the scales for statements 1, 2, and 4 so that for all statements a higher category on the scale is related to more willingness to take risks. The appendix contains a frequency table for each of the statements (Table A1). Next, we pool the data from all years and take the principal component of the answers to these 6 statements. Cronbach’s Alpha, a measure of the reliability of the six-item scale, is 0.68. Factor analysis reveals that the eigenvalue is above unity for only one factor, from which we conclude that one latent factor underlies the six statements. Our measure of risk attitudes is the principal component of the statements, standardised to have a mean of zero and a standard deviation of one. We standardise the variable so that we can compare the results of the analysis from the Dutch data to the analysis of the SOEP data.

We select participants who have non-missing answers on all six statements as well as on sex and birth year, and who were younger than 80 years of age. This leaves us with 35,173 observations in the pooled sample. Most excluded observations are due to missing observations on the six statements. We discuss potential selectivity of this non-response with respect to age in the results section. 57% of the sample is male and the average age is 48.9 years (standard deviation 14.4).[7] On average, participants stay for 3.3 years in the sample (standard deviation 3.2). Table 1A shows that panel attrition is high, but also that a considerable number of respondents remain in the panel for a longer time period.

The second data set we use is the SOEP, a large and representative panel study of the adult German population with more than 20,000 respondents per annual wave, living in more than 11,000 households. Of particular importance for our analysis is that six waves of the data contain survey measures of risk attitudes, which have been shown to be valid predictors of risk taking in a large-scale field experiment with a representative subject pool (see Dohmen *et al.*, 2011). The measure of risk attitudes included in the data reads:

> 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.'

We standardise this measure to have a mean of zero and a standard deviation of one.

We select participants who have non-missing answers to the risk question, sex, and birth year, and who were younger than 80 years of age. This leaves us with 120,837 observations in the pooled sample. 48% of the sample is male and the average age is 48.4

[7] Average age increased each year by approximately 1 year but dropped in 2000 by approximately 4 years and in 2005 by 2 years due to refreshment of the sample.

years (s.d. 16.8).[8] Over the 6 years we use, participants are on average observed 3.5 times (standard deviation 2.1). Table 1B shows that attrition is lower in the SOEP than in the DNB Household Survey. More than half of the respondents who started in 2004 or earlier are still in the panel in 2011.

-- Table 1 --

We provide parallel analyses for the two data sets. This allows us to investigate whether the patterns we detect are robust across the two data sets. There are several specific advantages of each data set that we will exploit. The SOEP is a very large representative panel survey and it contains a measure for risk attitudes that has often been used in the literature. The Dutch data are also representative, but contain fewer observations. The measure of risk attitudes in the Dutch data is not as general as the SOEP measure. The Dutch measure is more concerned with financial risk attitudes, while the German is concerned with risk attitudes in general, i.e. across domains of life.[9] An advantage of the Dutch data is that the risk questions are asked every year since 1993, while in the SOEP the risk question is only included in the 2004, 2006, 2008, 2009, 2010 and 2011 waves of the data.

3. Results

3.1. Exploring the Risk Trajectories across the Age Range

We first present the averages for risk attitudes by age. We pool all years available in the samples and plot the average risk attitude conditional on age and a 95% confidence interval.

[8] The samples in 2008 and 2009 were somewhat smaller than those in 2004 and 2006. Average age increases each year with approximately half a year due to refreshment of the sample.
[9] The German data also contain a question regarding financial risk attitudes but that measure is not included in all waves of the data, making it less suited for the analysis of this paper. The 6th question in the Dutch data seems to correspond most closely to the question on financial risk attitudes in the SOEP. We find that both these questions yield downward sloping patterns across age, consistent with the patterns we report in the result section.

Figure 1A and Figure 1B plot risk attitudes by age for men and women using the Dutch and the German data, respectively. The figures show a clear negative age pattern that is approximately linear. At all ages, men are more willing to take risks than women.

-- Figure 1 –

As noted in the data section, the response rate to the risk questions is lower in the Dutch data than in the German data. Investigating this non-response further, it appears that respondents below 30 years of age respond less often to the statements than older respondents.[10] The response rate is rather low for women younger than 30 years of age, but is stable over the life course for women older than 30 years of age. About 40% of women in the latter age range have non-missing observations on all six items of the risk scale. For men, the response rate increases linearly from 40% at age 30 to about 70% at age 80. Comparing these patterns with the results in Figure 1, it does not seem plausible that our results are driven by selective non-response. Our results on average willingness to take risks show no kinks below and above age 30 and do not show a diverging pattern between men and women across age, despite differences in non-response patterns by gender. For selective non-response to drive our results, older men would have to be more likely to answer the statements if they are more risk averse. This is highly unlikely.

Another indication that selective non-response is not likely to be important is the high similarity of the age patterns in the Dutch and German data. In the German data, the non-response rate does not vary with age as much as in the Dutch data but the German and the Dutch age patterns are very similar. Furthermore, those who do not respond in one year often do respond in the next year. If we compare the distributions of their risk attitudes in that year

[10] The respondents typically skip the entire module of risk questions.

to the risk attitudes of respondents who had also responded in the previous year, we do not find significant differences. This again indicates that it is implausible that there is selective non-response in the Dutch data.

In order to address the potential concern that our survey questions pick up age effects in risk perception rather than in risk attitude, we turn to a different data set, the SOEP Cross Sectional Study 2005, which contains data from an incentivised lottery choice experiment with a subject pool that is representative of the adult population living in Germany (see Dohmen *et al.* 2011). This experiment presents risk in terms of objective probabilities and stakes. We find similar age patterns when using the real-stakes lottery measure compared with the survey measure (see Table A2 in the appendix). Reassuringly, but not surprisingly, the age pattern in this additional data set is also similar to the age patterns in the SOEP data.[11]

The SOEP Cross Sectional Study also allows addressing another potential concern, namely that changes in investment horizon over the life course might drive changes in risk attitude. The following question was asked in that survey: ‘Some people think more and others less about their future. When making decisions, how often do you consider the future in 1 year, the future in 5 years, and the future in 10 years?’ The answers ranged from 1 ‘very often’ – 5 ‘never.’ Using these measures to control for planning horizon, we estimate a significant negative age effect. In fact, life course trajectories of risk attitudes that are adjusted for differences in planning horizon and are virtually identical to those that are not.[12]

A key question is whether the pattern in Figure 1 is due to a negative age effect on risk attitude or due to a positive cohort effect. Because of the identity age ≡ calendar time – birth

[11] For a comparison of the size of the age effects see Appendix B, in which we discuss the similarity of the age effects obtained from linear models using the SOEP and DNB Household Survey.
[12] The fact that our estimates suggest at best a minor impact of planning horizon on the development of risk attitudes over the life course is not surprising. We find that planning horizon does not strongly depend on age until age 60. Only at older ages we observe that individuals attach less weight to the future. Yet, in our samples most individuals are still considerably younger than 60 (the average age is 49 years and 48 years in the Dutch and German data respectively; the fraction below 60 is 74% and 71% in the Dutch and German data respectively). In addition, it is very plausible that remaining life expectancy for the majority of individuals in our sample is sufficiently long, such that differences in expected amortization periods do not play an important role.

date, it is not possible to discriminate between these potential effects and estimate unrestricted age effects on risk attitudes while controlling for time and cohort effects.

3.2. Controlling for Period and Cohort Effects

Heckman and Robb (1985) suggest substituting for age, period or cohort effects with variables that pick up the underlying reason for changes with age, period or cohorts.[13] Identification rests on the assumption that the proxies do not vary linearly with the excluded variable.

In our main specification, we estimate a model with risk attitudes as the dependent variable and as independent variables a full set of age and cohort dummies, and we substitute calendar time effects with GDP growth rates.[14] Using the Dutch Household Survey data, Bucciol and Miniaci (2013) have documented that GDP growth is associated with risk attitudes measured by the same survey questions that we use.[15] Their finding is corroborated by Figure 2, which plots GDP growth and average risk attitudes. In both the Dutch and German data, there appears to be a positive relationship between GDP growth and average risk attitudes. It is clear that the cyclical pattern in GDP growth cannot be captured well by a linear time trend. To the extent that changes in GDP growth capture changes in risk attitudes that are related to calendar time, we can identify age and cohort effects by age and cohort dummies when controlling for GDP growth. We cluster the standard errors using respondents' ID.

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[13] Heckman and Robb (1985) called this the proxy variable approach. O'Brien (2000) used proxies for cohorts and termed it the APC-characteristic model. Several other approaches to this identification problem have been proposed in the literature. In the appendix we show that these approaches have serious limitations.

[14] GDP growth is measured in the same year as the survey was held. The Dutch and German GDP growth rates are taken from The World Bank (see http://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?cid=GPD_30, retrieved on October 22, 2013)

[15] While the focus of their work is on the relationship between risk attitudes and economic upturns and downturns, the focus of ours is on the pattern of risk attitudes across age. The authors note as a side result that age is related to risk attitudes, but their analysis does not control for potential cohort effects.

-- Figure 2 –

Figure 3 presents the main result, plotting the estimates of the age patterns with a full set of age indicators, cohort dummies, and controls for GDP growth. The slope is approximately linear until age 65, after which the slope becomes flatter.

-- Figure 3 –

In order to get a sense of the magnitude of the relationship between risk attitudes and age, Table 2 presents the estimates of a linear regression specification with independent variables: (1) age and cohort; (2) age, cohort and GDP growth. The results suggest that a one-year increase in age is related to a decrease in risk attitudes of 0.024 standard deviations in the Dutch data and 0.022 standard deviations in the German data. Controlling for GDP growth in the regression does not greatly affect the age coefficient in the Dutch or the German data. Both age coefficients remain significantly negative and of similar size. In the Dutch data, the coefficient on GDP growth is somewhat larger than the corresponding coefficient in the German data. The difference between men and women also remains similar.

-- Table 2 –

Our results suggest that risk attitudes decrease by about 0.023 standard deviations for each additional year of age. The size of this effect is substantial: an increase of 10 years in median age of a society leads to a reduction in mean risk attitudes of 0.23 standard deviations.[16] Such a change amounts to approximately half of the difference in risk attitudes between men and women (see Table 2). We can also translate this age effect into an effect on life outcomes, using earlier studies that relate risk attitudes to life outcomes. E.g., using Table 6 from Dohmen *et al.* (2011), an increase in median age of 10 years, and the resulting difference in risk attitudes, would imply 2.5% less investment in stocks and about 6% less self-employment.[17] These calculations serve as an indication that the relationship between risk attitude and age is substantial. An obvious caveat is that the ceteris paribus assumption we implicitly make in the calculations may not hold. For instance, if a society becomes more risk averse, the demand for risk loving people may increase. Whether changes in society actually occur as the result of a decrease in aggregate risk attitudes may be the subject of future research.

4. Robustness Checks

4.1. Controlling for Education and Income

In our main specification, we do not include education, income, wealth or other such factors for two reasons. First, previous work (e.g., Dohmen et al. 2011) has shown that the relationship between age and risk attitude remains similar when controlling for a host of socio-economic characteristics, including education, income and wealth. Second, we prefer a specification without such controls, which are arguably endogenous, because we are

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[16] Median age in society varies substantially between countries and across time within countries. The Netherlands and especially Germany have high median ages. Currently, median age is 46 in Germany and 42.4 in the Netherlands (source: http://www.indexmundi.com/germany/demographics_profile.html, retrieved 20 December 2014). Median age has increased by 10 years in the last 30 years in the Netherlands (source: http://www.statista.com/statistics/276734/median-age-of-the-netherlands-population/, retrieved 20 December 2014) and projections show that median age in Germany will increase by 9 years by the mid-2040s (source: https://www.destatis.de/EN/Publications/Specialized/Population/GermanyPopulation2060.pdf?__blob=publicationFile, retrieved 20 December 2014).

[17] In their table, all measures of risk attitudes are standardised, so we can multiply the coefficients with 0.23 in order to find how much a 10 year increase in median age would affect the variables. E.g. for investment in stocks: 0.029*0.23=0.007, implying 0.7 percentage points less investment in stocks. Evaluated at the mean of 0.341, this implies ((0.334-0.341)/0.341) *100= 2.5 percent less investment in stocks. Similarly, this would imply ((0.079-0.084)/0.084)*100 6 percent less self-employment.

interested in the sum of direct and indirect effects of age on risk attitudes. Yet, it is interesting to assess whether the estimated life course trajectory of risk attitudes is robust to controlling for education or income.[18] In Figure 4 we plot the estimated age patterns in risk attitudes when controlling for education and income in the Dutch and German sample. These estimated age patterns are remarkably similar to the age patterns in Figure 3, which are not adjusted for education and income.[19]

-- Figure 4 –

4.2. Alternatives for GDP Growth

We use GDP growth in our main specification. One may argue, however, that risk attitudes might be more strongly related to lagged GDP growth than to current GDP growth. In addition, 2009 (the recession) is an extreme value of GDP growth relative to the GDP growth rates in the other periods. Figure 5 shows that we obtain virtually identical results in the Dutch data and small (insignificant) changes in the German data if we (1) use lagged GDP growth, or (2) exclude the year 2009 from the estimation.

-- Figure 5 –

Instead of GDP growth we could also have used other indicators of economic conditions.[20] To investigate the robustness of our results we use instead of GDP growth (1)

[18] Note that we do not attempt to answer the question why risk attitudes are related to age or whether risk attitude trajectories are heterogeneous (i.e. whether risk attitudes change more with age for some groups than for other groups).

[19] Schurer (2014) also investigates in a recent working paper whether some groups are more likely to change risk preferences across age than others.

[20] We use GDP growth in our baseline estimation because of all the measures we investigated this indicator correlates most strongly with risk attitudes in the German data. In the Dutch data, the strength of the correlations is similar across the indicators. To be specific, the correlation between risk attitudes and GDP growth controlled

stock market returns (i.e. the DAX or AEX index) and (2) yearly unemployment rates.[21] Figure 6 reveals that the estimates remain robust. The slope in the graphs remains significantly negative. Given that we only use 6 periods in the German data, it is not surprising that the German estimates seem more sensitive to changes in the specifications.

-- Figure 6 –

4.3. Fixed Effect Estimations

The longitudinal character of the data also allows us to estimate fixed effect models. In this analysis, the estimates of age effects are identified only from within person changes. By construction, the fixed effect specification controls for cohort effects so we do not include these in the model.

Table 1 already gave descriptive information about the data; but for the fixed effect estimation it is relevant to show information about the number of times individuals were observed in the panels and the average number of calendar years between their entrance and exit. Table 3 gives the statistics. In the Dutch data, 1760 individuals were observed 6 times or more. On average the difference between their entrance and exit is 10.8 years. In the German data, 11,106 individuals were observed 6 times (6 is the maximum number: the number of waves in which the risk attitude question was asked). They stayed from 2004 to 2011 (i.e. 8 years) in the panel.

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for age and cohort effects is 0.120 in the German data and 0.046 in the Dutch data. The correlations between risk attitudes and lagged GDP growth, unemployment rates, and stock market returns are 0.027, 0.025, 0.030 in the German data and 0.046, -0.045, 0.059 in the Dutch data, respectively. All correlations are highly statistically significant.

[21] We use the DAX and AEX index measured at the last day of the calendar year. Source DAX: http://www.boerse-frankfurt.de/en/equities/indices/dax+DE0008469008/price+turnover+history/historical+data#page=53, Source AEX: http://nl.wikipedia.org/wiki/AEX, Source unemployment rate: Bureau of Labor Statistics (http://www.bls.gov/fls/country/germany.htm). All retrieved at 25 December 2014. We also use the monthly DAX rates as a robustness check. The age trajectory of risk attitudes becomes more negative as a result.

-- Table 3 –

Figure 7 documents that the age effects are also significantly negative in this model. They are similar in the German sample but smaller in the Dutch sample relative to the earlier analyses in which we pooled the data across years. Figure 7 also shows the fixed effects estimates for the restricted sample of respondents who were continuously interviewed for eight years in the German data and at least eight years in the Dutch data. The age gradient for the ‘long-term’ respondents is similar to that for the full sample of respondents in both data sets.

-- Figure 7 –

4.4. Two Alternative Models

We also follow two alternative approaches to identify parameters in an age-period-cohort model, which have been suggested by Deaton and Paxson (1994) and Browning, Crawford and Knoef (2012). Deaton and Paxson (1994) impose the restrictions that the period effect is orthogonal to a trend and sums to zero. Browning, Crawford and Knoef (2012) build on a set-identification result in the linear age-period-cohort model with a bounded dependent variable. Intuitively, only a set of parameters can explain an outcome variable that has a bounded range because conditional probabilities are bounded by the law of iterative expectations. Browning, Crawford and Knoef (2012) propose using the maximum-entropy method to point identify the parameters.

In Figure 8, we show that the patterns using either of the two techniques corroborate our earlier findings. The patterns using these two methods are quite similar to the patterns in the baseline estimation in the Dutch data. In the German data, the two methods yield a smaller but still significantly negative slope.

-- Figure 8 –

4.5. Using Substitutes for Cohort Effects

In our baseline estimations, we use substitutes for period effects. We could also have chosen to substitute for cohort effects instead. We took the former approach because it is natural to think that risk attitudes in periods are affected non-linearly by macro-economic conditions, while this is not obvious for risk attitudes across cohort. It is also difficult to establish at which time in their lives cohorts may be affected by macro-economic circumstances. Nevertheless, in Figure 9, we use inflation at age 18 as a substitute for cohort effects. In this analysis, we include dummies for each survey year. The analysis delivers qualitatively similar results in the sense that risk attitudes decline across age.

-- Figure 9 –

5. Conclusions

This paper investigates how risk attitudes change over the life course. Understanding the relationship between risk attitudes and age is important for making predictions about what happens in society when its population is aging. Age patterns are generally difficult to identify because they may also reveal changes across cohorts or periods of observation. Our results indicate that risk attitudes decline with age when taking calendar time and cohort effects into consideration. A possible implication of this finding is that societies become more risk averse as a consequence of population aging.

Additional supporting information may be found in the online appendix to this article:

Online Appendix B. Additional results.

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Table 1A.
Panel Attrition by Starting Year

Year of first observation	Number of observations (after selections)	% remaining in following years																		Average amount of times observed
		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	
1993	2775	72.5	53.0	38.2	24.9	9.8	9.3	5.0	8.0	6.8	5.5	6.0	5.4	5.3	5.2	4.6	3.7	3.6	3.3	3.7
1994	895		51.6	30.4	23.1	11.3	10.8	6.0	9.2	8.0	6.4	8.2	7.7	7.3	7.3	7.0	6.5	6.3	7.2	3.1
1995	807			44.9	30.7	17.0	15.4	7.7	11.5	8.6	8.3	9.3	8.3	7.6	7.7	6.3	5.6	5.0	5.1	3.0
1996	566				43.5	19.3	15.0	9.9	14.1	10.2	8.7	10.1	8.5	9.0	8.7	8.1	7.6	6.9	7.1	2.9
1997	373					31.4	22.0	12.9	17.7	14.5	12.6	13.9	11.5	12.9	12.3	11.3	11.0	7.5	8.3	3.0
1998	200						38.5	20.0	23.5	18.5	15.5	19.5	18.0	13.5	16.5	15.0	13.5	13.5	12.0	3.4
1999	215							28.4	36.3	26.5	22.3	25.1	23.7	22.3	22.3	19.5	20.0	17.7	15.8	3.8
2000	480								57.7	41.5	31.9	36.0	30.0	26.9	25.0	25.0	22.5	19.6	19.2	4.4
2001	931									48.2	37.9	40.3	33.9	29.4	29.4	27.4	24.2	22.0	20.5	4.1
2002	365										46.6	50.4	32.9	32.1	31.5	25.2	20.3	18.4	20.3	3.8
2003	384											65.6	49.5	41.1	38.5	36.7	32.8	29.4	29.2	4.3
2004	436												57.6	47.0	42.4	36.0	35.1	28.0	26.4	3.7
2005	506													51.0	45.5	33.8	28.9	24.3	22.5	3.1
2006	244														63.1	50.4	39.3	36.5	31.1	3.2
2007	237															48.1	35.9	35.0	32.5	2.5
2008	212																58.5	48.1	42.0	2.5
2009	195																	60.0	52.8	2.1
2010	445																		61.6	1.6
2011	300																			1.0

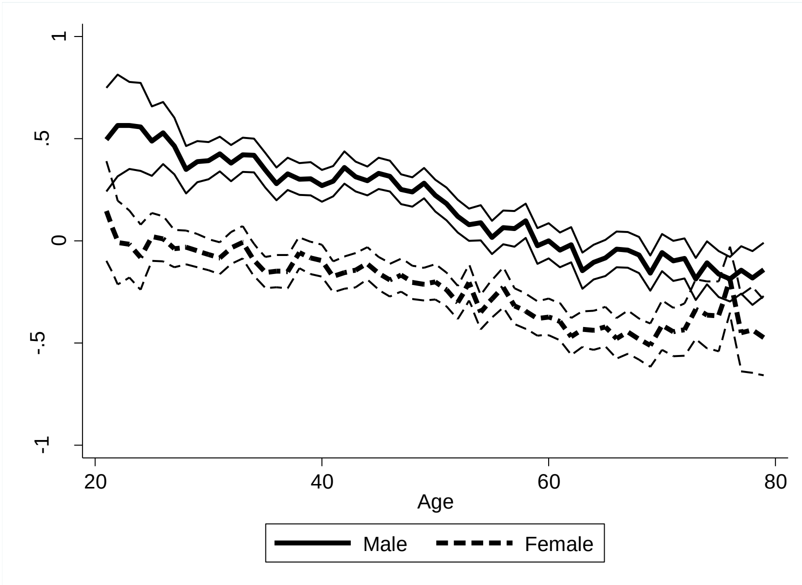
Source: DNB Household Survey

Table 1B.
Panel Attrition by Starting Year

	Number of observations (after selections)	% remaining in following years					Average amount of times observed
Year of first observation		2006	2008	2009	2010	2011	
2004 or earlier	21425	84.0	72.0	65.7	60.0	55.1	4.4
2006	3656		69.7	62.5	55.2	51.2	3.4
2008	1103			83.9	72.0	64.8	3.2
2009	2565				72.6	13.1	1.9
2010	865					36.6	1.6
2011	5272						1.0

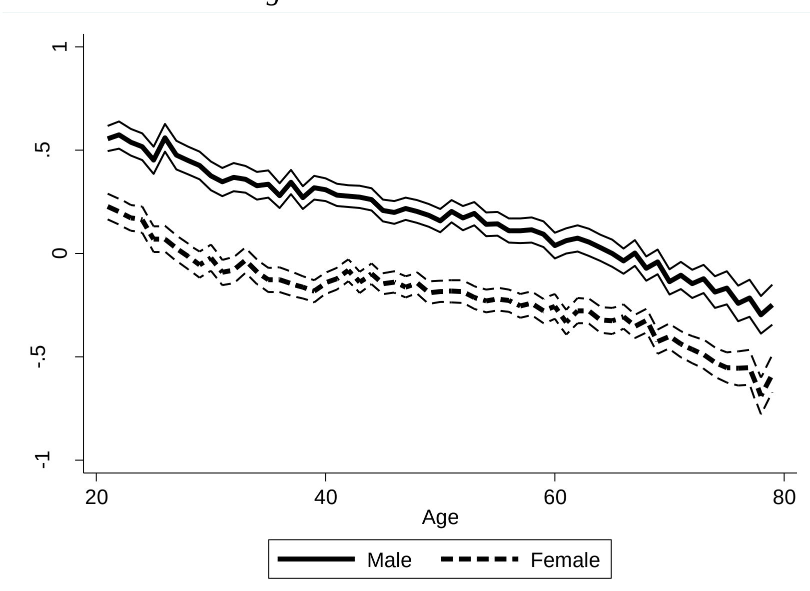
Source: SOEP

Fig. 1A.
Risk Attitudes across Age



Source: DNB Household Survey

Fig. 1B.
Risk Attitudes across Age

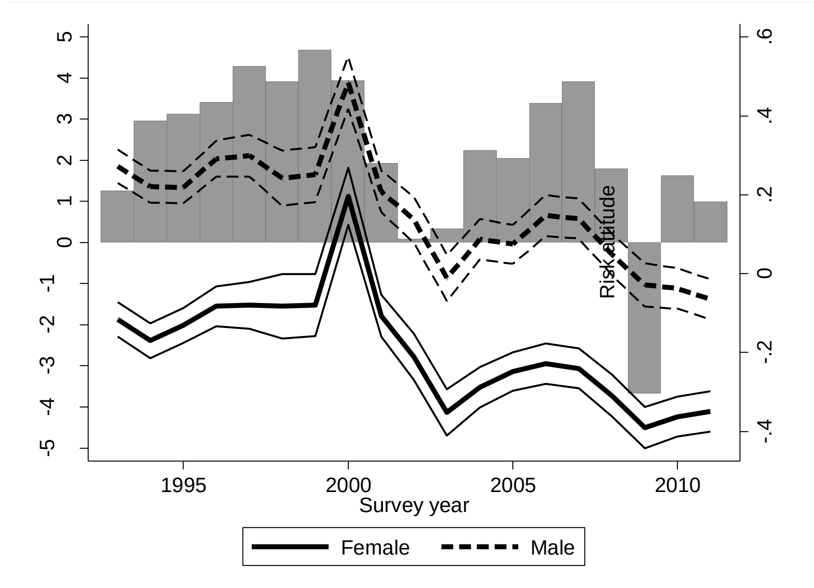


Source: SOEP

Note: Both figures show mean risk attitude conditional on age. The figures also include 95% confidence intervals. In both figures, risk attitude is standardised (using the full sample) to a mean of zero and a standard deviation of one.

Fig. 2A.

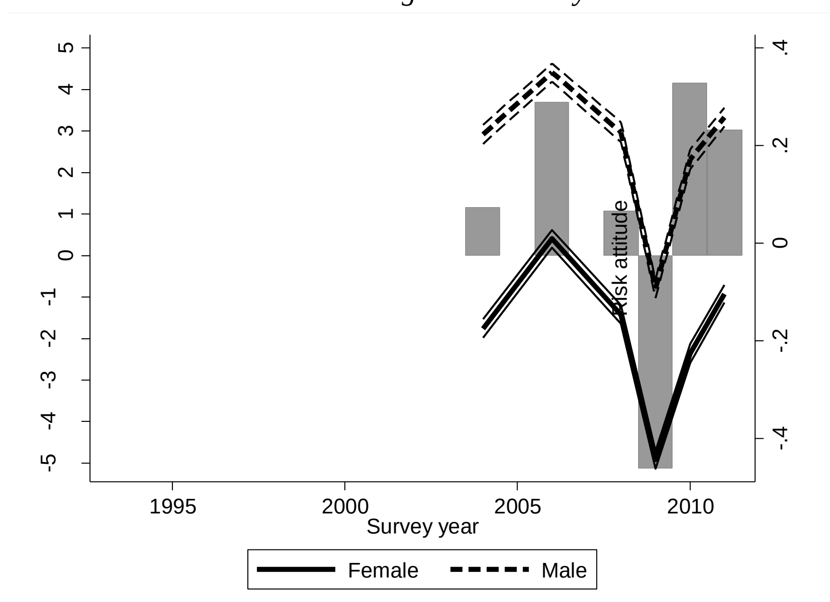
GDP Growth Rate and Risk Taking across Survey Years



Source: DNB Household Survey

Fig. 2B.

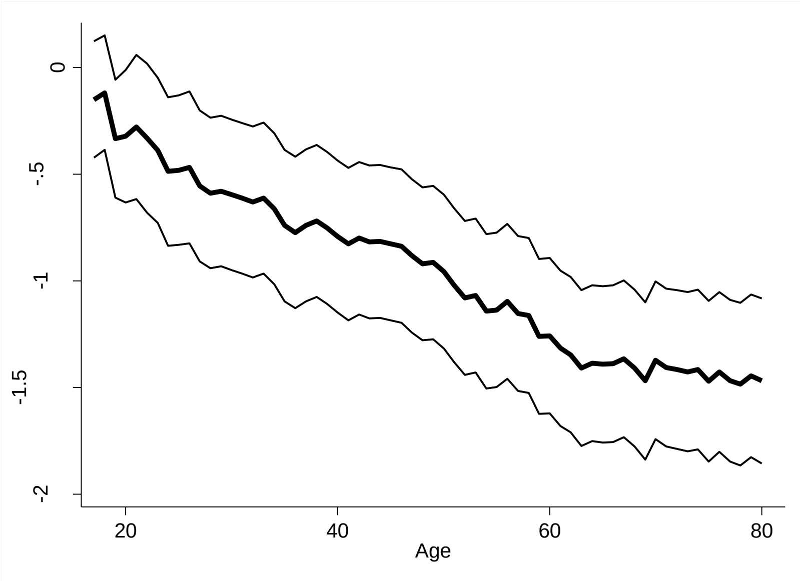
GDP Growth Rate and Risk Taking across Survey Years



Source: SOEP

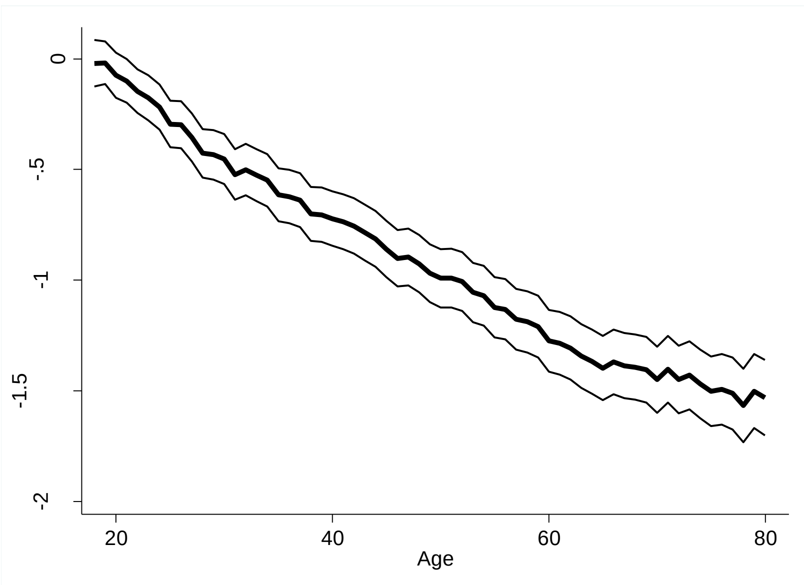
Note: The figures show GDP growth rates (bars) and average risk attitude conditional on survey year (lines). The lines also include 95% confidence intervals. In both figures, risk attitude is standardised (using the full sample) to a mean of zero and a standard deviation of one.

Fig. 3A.
Age pattern Estimated with Flexible Functional Form Controlled for Cohort and Period Effects



Source: DNB Household Survey

Fig. 3B.
Age pattern Estimated with Flexible Functional Form Controlled for Cohort and Period Effects



Source: SOEP

Note: In both figures, risk attitude is standardised (using the full sample) to a mean of zero and a standard deviation of one. The figures show the values of the age dummies of a linear regression model with risk attitude as the dependent variable and as independent variables a full set of age and cohort dummies and the annual GDP growth rate. The figures also include 95% confidence intervals.

Table 2A.

Linear Regressions of Risk Attitudes on Age, Cohort, and Period

	(1)	(2)	(3)	(4)
Age	-0.024***	-0.021***	-0.022***	-0.019***
	(0.001)	(0.001)	(0.001)	(0.001)
Birth year	-0.014***	-0.011***	-0.013***	-0.009***
	(0.001)	(0.001)	(0.001)	(0.001)
GDP growth		0.026***		0.026***
		(0.002)		(0.002)
Male			0.532***	0.534***
			(0.053)	(0.053)
Male*Age			-0.003**	-0.003**
			(0.001)	(0.001)
Constant	29.169***	22.858***	25.361***	19.111***
	(2.422)	(2.433)	(2.322)	(2.334)
Observations	35,173	35,173	35,173	35,173
R-squared	0.040	0.043	0.095	0.097

Notes: DNB Household Survey. The dependent variable is risk attitudes, standardised to mean zero and standard deviation one (using the full sample). Robust standard errors clustered by respondent's ID in parentheses, *** p<0.01, ** p<0.05, * p<0.1

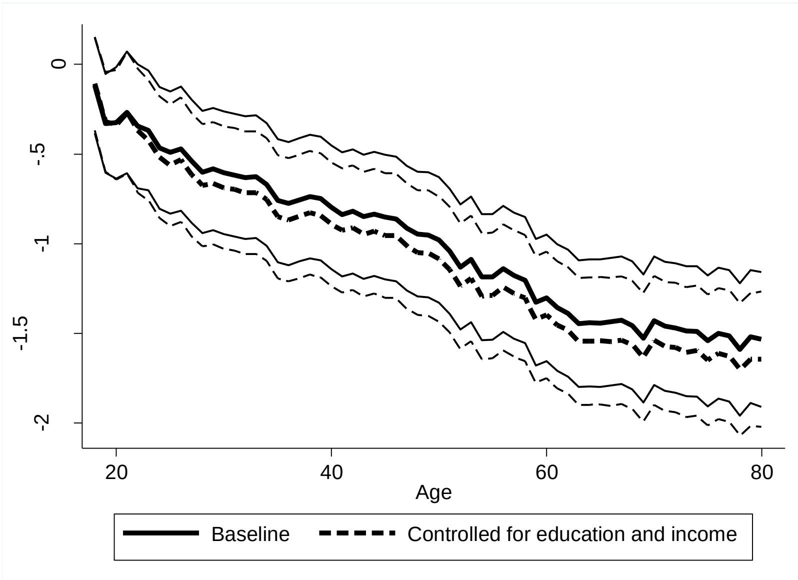
Table 2B.

Linear Regressions of Risk Attitudes on Age, Cohort, and Period

	(1)	(2)	(3)	(4)
Age	-0.022***	-0.022***	-0.022***	-0.021***
	(0.001)	(0.001)	(0.001)	(0.001)
Birth year	-0.010***	-0.010***	-0.010***	-0.009***
	(0.001)	(0.001)	(0.001)	(0.001)
GDP growth		0.039***		0.039***
		(0.001)		(0.001)
Male			0.426***	0.428***
			(0.025)	(0.025)
Male*Age			-0.001**	-0.001**
			(0.001)	(0.001)
Constant	21.128***	20.169***	20.133***	19.169***
	(2.200)	(2.198)	(2.171)	(2.168)
Observations	120,837	120,837	120,837	120,837
R-squared	0.044	0.058	0.078	0.093

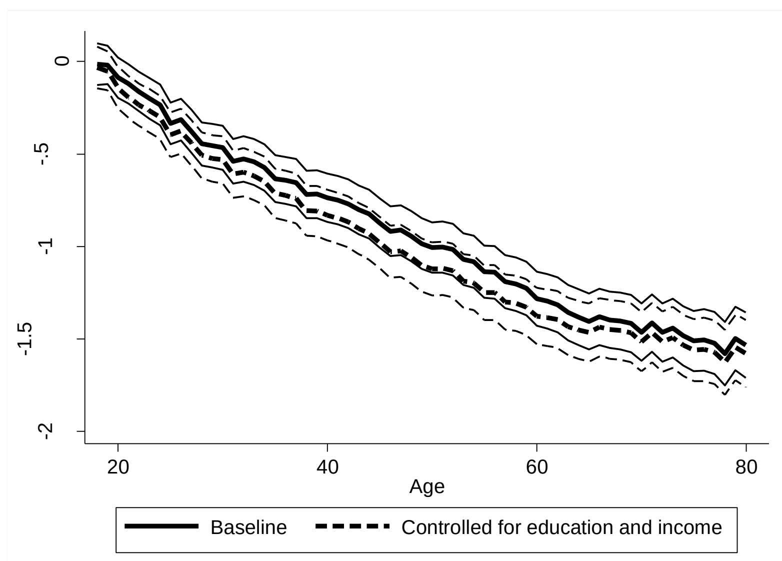
Notes: SOEP. The dependent variable is risk attitudes, standardised to mean zero and standard deviation one (using the full sample). Robust standard errors clustered by respondent's ID in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Fig 4A.
Controlling for Education and Income



Source: DNB Household Survey

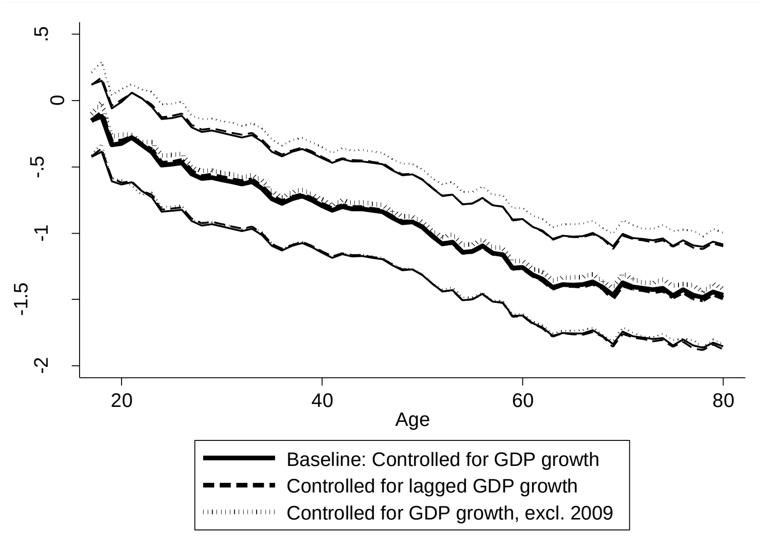
Fig 4B.
Controlling for Education and Income



Source: SOEP

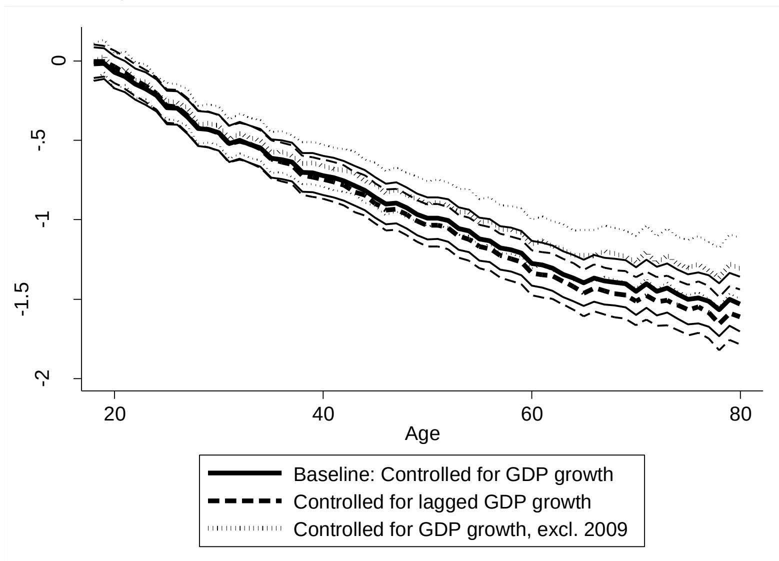
Note: In both figures, risk attitude is standardised to mean zero and standard deviation one (using the full sample). The figures show the values of the age dummies of a linear regression model with risk attitude as the dependent variable and as independent variables a full set of age and cohort dummies and variants of the annual GDP growth rate. The figures also include 95% confidence intervals.

Fig. 5A.
Variants of GDP Growth



Source: DNB Household Survey

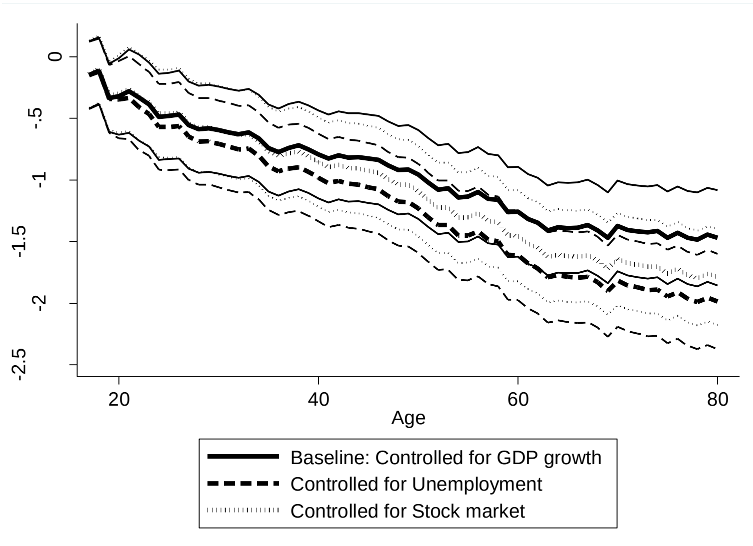
Fig. 5B.
Variants of GDP Growth



Source: SOEP

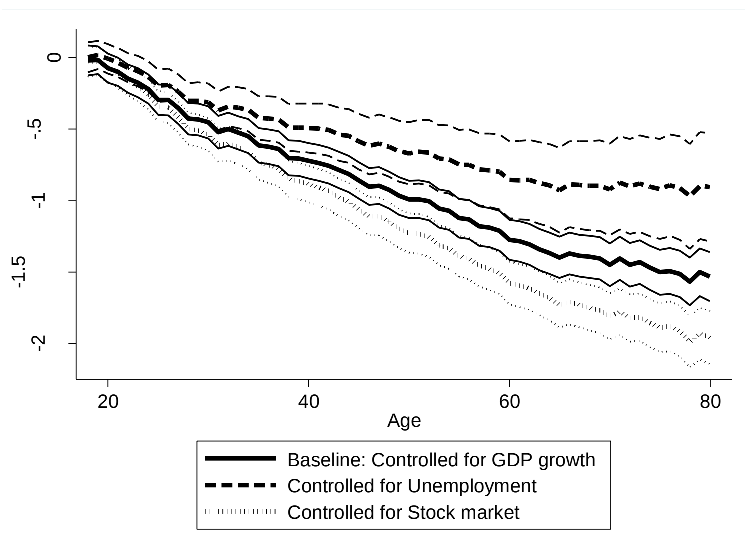
Note: In both figures, risk attitude is standardised to mean zero and standard deviation one (using the full sample). The figures show the values of the age dummies of a linear regression model with risk attitude as the dependent variable and as independent variables a full set of age and cohort dummies and variants of the annual GDP growth rate. The figures also include 95% confidence intervals.

Fig. 6A.
Using Unemployment or Stock Market Returns as Substitute for Economic Conditions



Source: DNB Household Survey

Fig. 6B.
Using Unemployment or Stock Market Returns as Substitute for Economic Conditions



Source: SOEP

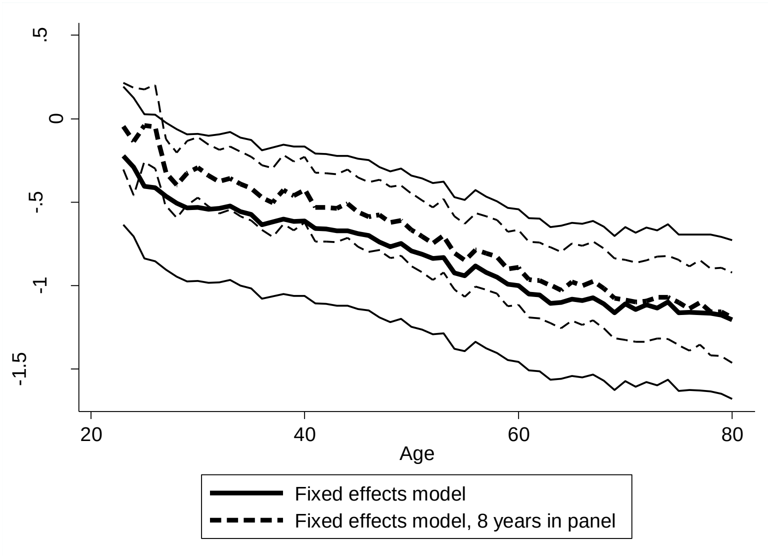
Note: In both figures, risk attitude is standardised (using the full sample) to mean zero and standard deviation one. The figures show the values of the age dummies of a linear regression model with risk attitude as the dependent variable and as independent variables a full set of age and cohort dummies and respectively the annual GDP growth rate (baseline), the annual unemployment rate, or the stock market returns. The figures also include 95% confidence intervals.

Table 3

Number of Times and Years Individuals are Observed in the Panels

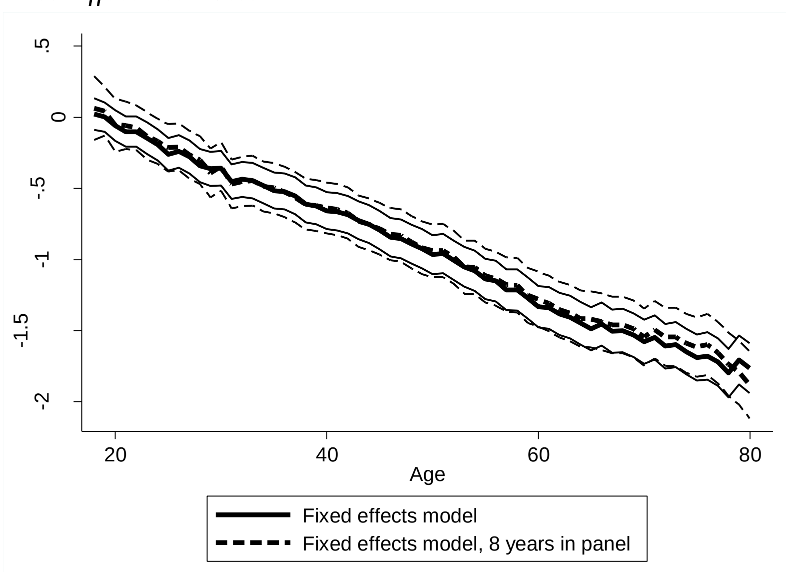
	DNB		SOEP	
Number of times observed in panel	Number of individuals	Average number of years from first to last year of observation	Number of individuals	Average number of years from first to last year of observation
6 or more	1,760	10.8	11,106	8.0
5	575	5.8	3,537	6.7
4	922	4.8	2,304	5.4
3	1,251	3.5	2,087	4.5
2	2,287	2.3	5,187	2.6
1	3,771	1.0	10,665	1.0

Fig. 7A.
Fixed Effect Estimates



Notes: DNB Household Survey.

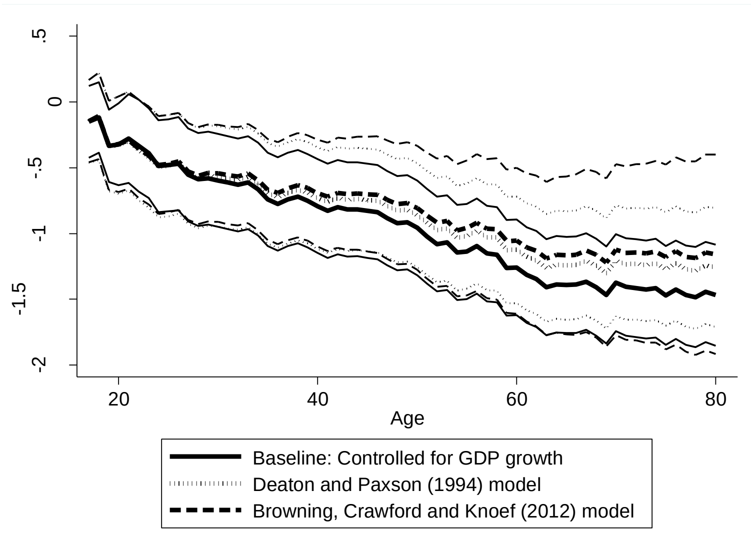
Fig. 7B.
Fixed Effect Estimates



Notes: SOEP.

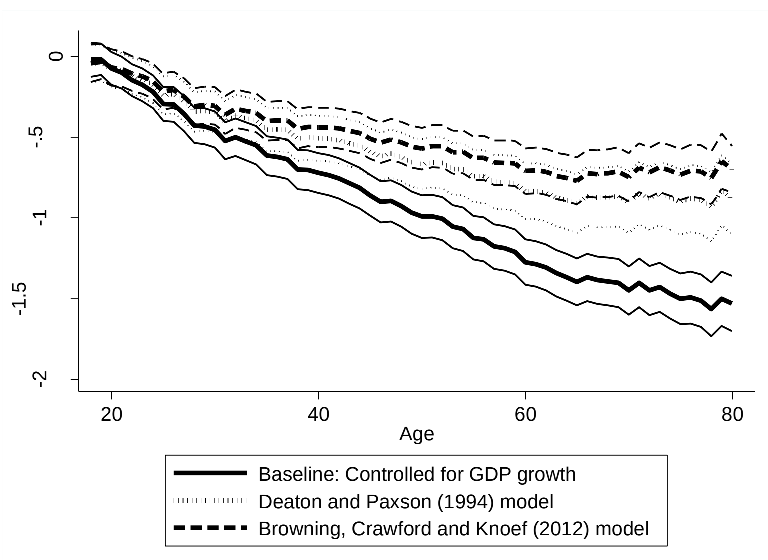
Note: In both figures, risk attitude is standardised (using the full sample) to mean zero and standard deviation one. The figures show the values of the age dummies of a linear regression model with risk attitude as the dependent variable and as independent variables a full set of age dummies and the annual GDP growth rate with person fixed effects. The solid line shows the trajectory for the full sample. The dashed line shows the trajectory for those who stay at least 8 years in the sample. The Dutch graph shows the results from age 23 onward, as there were not enough observations below the age of 23 when selecting on those who stayed 8 years or more in the panel. The figures also include 95% confidence intervals.

Fig. 8A.
Two Alternative Estimation Techniques



Source: DNB Household Survey

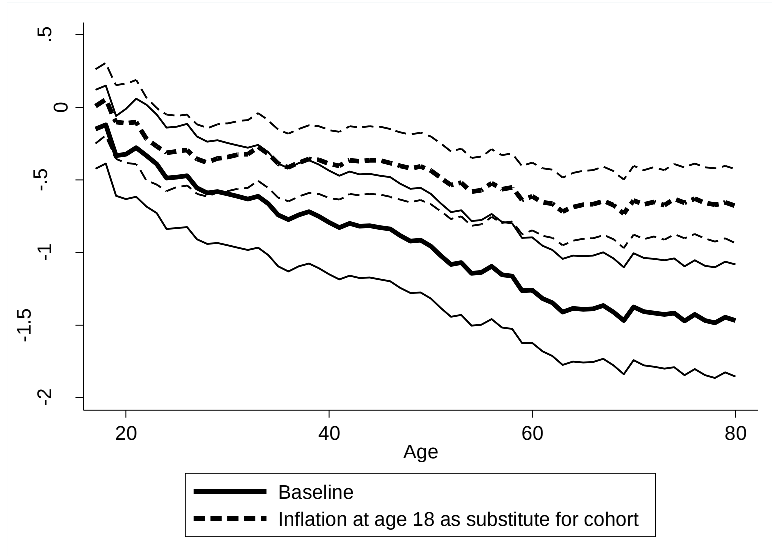
Fig. 8B.
Two Alternative Estimation Techniques



Source: SOEP

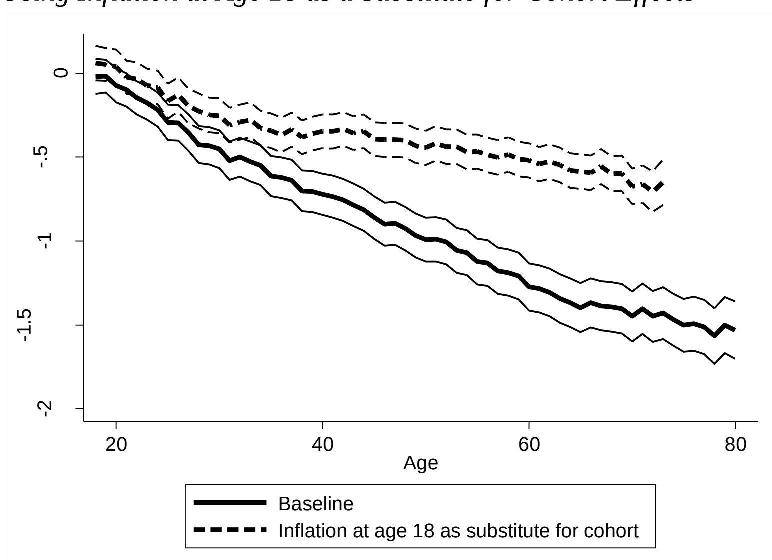
Note: In both figures, risk attitude is standardised (using the full sample) to mean zero and standard deviation one. The solid lines show the values of the age dummies of a linear regression model with risk attitude as the dependent variable and as independent variables a full set of age and cohort dummies and the annual GDP growth rate. The dotted and dashed lines show the Deaton and Paxson (1994) and Browning, Crawford and Knoef (2012) models, respectively. The figures also include 95% confidence intervals.

Fig. 9A.
Using Inflation at Age 18 as a Substitute for Cohort Effects



Source: DNB Household Survey

Fig. 9B.
Using Inflation at Age 18 as a Substitute for Cohort Effects



Source: SOEP

Note: In both figures, risk attitude is standardised (using the full sample) to mean zero and standard deviation one. The solid lines show the values of the age dummies of a linear regression model with risk attitude as the dependent variable and as independent variables a full set of age and cohort dummies and the annual GDP growth rate. The dashed lines show the values of the age dummies of a linear regression model with risk attitude as the dependent variable and as independent variables a full set of age and period dummies and the inflation rate at age 18. For Germany, inflation rates were available only from the year 1956 onward. The figures also include 95% confidence intervals.

Appendix A. Additional tables

Table A1.
Raw Scores of the Risk Questions in the DNB Household Survey

Answer categories	Q1	Q2	Q3	Q4	Q5	Q6
	%	%	%	%	%	%
1 Totally disagree	23.4	20.9	42.0	25.4	28.1	31.1
2	26.9	15.4	19.0	29.8	20.9	21.5
3	17.8	11.8	10.9	22.2	14.0	14.7
4	15.0	16.5	12.7	14.7	19.8	18.5
5	6.8	12.4	8.4	3.5	10.0	9.5
6	4.0	11.4	4.9	1.5	5.1	3.5
7 Totally agree	6.1	11.6	2.2	2.8	2.1	1.3

Note: The order of questions 1, 2, and 4 was reversed.

Table A2.
Age Patterns in a Pre-Test Sample Using the Survey Risk Question and a Real-Stakes Lottery Risk Measure

	(1)	(2)	(3)	(4)	(5)	(6)
					SOEP	
	Survey risk measure Men	Experimental risk measure Men	Survey risk measure Women	Experimental risk measure Women	Survey risk measure Men	Survey risk measure Women
Age	-0.010***	-0.009**	-0.016***	-0.013***	-0.013***	-0.012***
	(0.003)	(0.004)	(0.004)	(0.003)	(0.000)	(0.000)
Constant	0.564***	0.493**	0.637***	0.568***	0.822***	0.395***
	(0.183)	(0.192)	(0.179)	(0.174)	(0.012)	(0.012)
Observations	215	215	237	237	57,960	62,877
R-squared	0.038	0.030	0.080	0.054	0.049	0.041

Notes: Columns 1-4 report evidence from a pre-test sample (see Dohmen *et al.* 2011). Columns 5-6 use the SOEP. The dependent variables are risk attitudes measured by the survey question and a real-stakes lottery measure. Both are standardised to a mean of zero and a standard deviation of one (using the full sample). Standard errors are reported in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Online Appendix B.

Two Alternative Approached to the Age-Period-Cohort Identification Problem

The age-period-cohort identification problem has received much attention in the literature (e.g., Mason and Fienberg, 1985; Heckman and Robb, 1985; Ameriks and Zeldes, 2004; Hall *et al.*, 2007[22]; van Landeghem, 2012; Wunder *et al.*, 2013). In this appendix, we discuss two alternative approaches to the identification problem proposed in this literature.

B1. No period and/or no cohort effects

One approach that is often implicitly taken is to estimate age effects assuming that there are no period or cohort effects. The choice about which of the variables to exclude often depends on the character of the data. In a cross-sectional study in which time is fixed, one would for instance need to assume that there are no cohort effects to identify age effects. Fixed effect estimates using longitudinal data would conflate age and time effects. Age effects are then estimated by assuming that time effects do not play a role.

Tables B1 and B2 show regressions of risk attitudes on (1) age, (2) age and survey year, and (3) age and birth year with linear specifications of all independent variables. The first column – a regression of risk attitudes on age – gives a statistically significant negative age coefficient, which is similar in both data sets. A one-year increase in age is related to a decrease in risk attitudes of 0.010 standard deviations in the Dutch data and 0.012 standard deviations in the German data. The second column indicates that if we control for period but not for cohort, the age coefficient remains robust in both data sets. Notice that the fit of the regression increases

[22] Hall *et al.* (2005) give an intuitive description of the problem: 'identification of such relationships has proved to be problematic largely because of the obvious impossibility of observing two individuals at the same point in time that have the same age but were born in different periods' (p. 2).

more in the Dutch data. The third column in which we control for birth year but not for period gives an age coefficient that is also negative, but around twice the size of the earlier estimates.[23] This result shows that the estimate of the age effect depends on the assumptions made about the excludability of cohort and/or period. To be more precise: age, survey year and birth year are linearly dependent: survey year = birth year + age. Including survey year and age in the regressions: $Y = \beta_1 * age + \beta_2 * survey\ year + e$, does not yield the same age coefficient as if we substitute survey year for (birth year + age): $Y = \beta_1 * age + \beta_2 * (birth\ year + age) + e$. Rearranging gives: $Y = (\beta_1 + \beta_2) * age + \beta_2 * (birth\ year) + e$. That is, if β_1 and β_2 have the same sign, the age coefficient is larger in absolute terms in the latter specification. Therefore, the coefficient estimates in column 3 (column 5) can be calculated based on the coefficient estimates in column 2 (column 6). This illustrates that the linear age-cohort-period model is not point identified.

[23] Notice also that the fit of the regression in the second and third specification is the same and that the coefficient of period in the second and cohort in the third column are the same.

Table B1.
Linear Regressions of Risk Attitudes on Age, Period and Cohort

	(1)	(2)	(3)	(4)	(5)	(6)
Age	-0.010***	-0.009***	-0.024***	-0.010***	-0.010***	-0.022***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Survey year		-0.014***			-0.013***	
		(0.001)			(0.001)	
Birth year			-0.014***			-0.013***
			(0.001)			(0.001)
Male				0.543***	0.532***	0.532***
				(0.054)	(0.053)	(0.053)
Male*Age				-0.003**	-0.003**	-0.003**
				(0.001)	(0.001)	(0.001)
Constant	0.498***	29.169***	29.169***	0.283***	25.361***	25.361***
	(0.028)	(2.422)	(2.422)	(0.035)	(2.322)	(2.322)
Observations	35,173	35,173	35,173	35,173	35,173	35,173
R-squared	0.030	0.040	0.040	0.087	0.095	0.095

Notes: DNB Household Survey. The dependent variable is risk attitudes, standardised to mean zero and standard deviation one (using the full sample). Robust standard errors clustered by respondent's ID in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table B2.
Linear Regressions of Risk Attitudes on Age, Period and Cohort

	(1)	(2)	(3)	(4)	(5)	(6)
Age	-0.012***	-0.012***	-0.022***	-0.012***	-0.012***	-0.022***
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)
Survey year		-0.010***			-0.010***	
		(0.001)			(0.001)	
Birth year			-0.010***			-0.010***
			(0.001)			(0.001)
Male				0.427***	0.426***	0.426***
				(0.025)	(0.025)	(0.025)
Male*Age				-0.001**	-0.001**	-0.001**
				(0.001)	(0.001)	(0.001)
Constant	0.598***	21.128***	21.128***	0.395***	20.133***	20.133***
	(0.013)	(2.200)	(2.200)	(0.017)	(2.171)	(2.171)
Observations	120,837	120,837	120,837	120,837	120,837	120,837
R-squared	0.043	0.044	0.044	0.078	0.078	0.078

Notes: SOEP. The dependent variable is risk attitudes, standardised to mean zero and standard deviation one (using the full sample). Robust standard errors clustered by respondent's ID in parentheses, *** p<0.01, ** p<0.05, * p<0.1

B2. Exclude an additional dummy

A second approach, proposed by Mason *et al.* (1973), is to have a model with dummy variables for age, period and cohort in which – besides the reference categories for age, period and cohort – one additional dummy for age, period or cohort is excluded from the model. The assumption that needs to be made in this case is that the additionally excluded group is the same as the reference group. This seems to be a more innocent assumption than assuming away period or cohort effects completely. Although this approach seems more innocent than the first approach, our results show large differences in estimates for different sets of excluded period or cohort dummy variables.

In order to see which reference and additional categories are most similar in terms of risk attitudes, we investigated the average risk attitudes in the cohorts and periods.[24] Average risk attitudes are, for example, similar for cohorts 1931 and 1932 and for cohorts 1990 and 1994. Average risk attitudes are also similar in the periods 1996 and 1997 and in the periods 2006 and 2007.[25]

Figures B1a and B2b show what happens to the age patterns if we exclude these sets of cohorts and periods one by one from the regressions. Figure B1a plots the age dummies of regressions with risk attitudes as the dependent variable and as independent variables a full set of age dummies, period dummies and cohort dummies, excluding one reference category for age, one for period, and the two different sets of two cohort dummies. Figure B1b plots the age dummies of regressions with risk attitudes as the dependent variable and as independent

[24] One could also think about different ways of comparing risk attitudes across periods or cohorts. Instead of comparing the average risk attitudes as we did, one could for instance compare a combination of the mean and the standard deviation or compare risk attitudes while controlling for other variables.

[25] There are many more similar pairs of cohorts and periods. For clarity of exposition, we limit ourselves to the combinations we indicate here.

variables a full set of age dummies, cohort dummies and period dummies, excluding one reference category for age, one for cohort, and the two different sets of two period dummies.

Both figures show that the differences in the estimates are large depending on which set of cohorts or periods is excluded from the regression.

Fig. B1a.

Two Risk Patterns across Age, Excluding Cohorts with Similar Average Risk Attitudes

Source: DNB Household Survey

Fig. B1b.

Two Risk Patterns across Age, Excluding Cohorts with Similar Average Risk Attitudes

Source: DNB Household Survey

Note: The figures show the value of the age dummies in linear regressions with standardised (using the full sample) risk attitude as the dependent variable and a full set of dummies for age, cohort and period as independent variables, excluding 4 dummy variables: one reference category for age, one for cohort, one for period, and one additional dummy for cohort in Figure B1a and for period in Figure B1b. The reference and additionally excluded cohorts (B1a) and periods (B1b) are chosen based on their similarity in average risk attitudes. For clearer exposition, confidence intervals are not reported.