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**Thesis**

To obtain the academic degree
Master of Science

# *The Age Profile Behind Portfolio Risky Holdings*

*Evidence from ERGO Group AG in Germany*

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# Restricted Note

**As this thesis contains confidential information it will be inaccessible for the public for the five years after submission to the Examinations Office**.

# Abstract

The objective of the following paper consists of analysing the relationship between age and equity portfolio holdings for a sample of customers from ERGO Group AG. There are two variables of importance to this study: first, the likelihood of participating in the equity market at a certain age, and, second, the weight of the financial portfolio that is allocated to such asset class. Additionally, the age effect is divided in time effects and year of birth effects. Four main conclusions are drawn from the analysis. First, aging is associated with both a decrease in the probability of participating in the equity market and in the equity portfolio share. Second, there are significant differences in the likelihood of investing in the equity market between different generations. Nonetheless, throughout the 10-years considered in this study, the participation rate of each birth cohort remains quite constant. Third, and in contrast to the previous result, the equity fraction of the portfolio is not affected by different birth years. At last, it is shown that a quadratic specification provides a better fit for the age profile than a linear pattern, suggesting that individuals' equity behaviors assume an inverted U-shaped pattern over the lifecycle. In particular, in 2017, it was predicted that the likelihood of entering the equity market peaks when individuals are 26 years old, while the fraction of the portfolio allocated to equities reaches its maximum at 78% for 41-year-old subjects.

**Keywords:** equity portfolio, age effects, birth cohort effects, period effects, time effects, lifecycle portfolio theory

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# List of Abbreviations

| | |
|---|---|
| CRRA | Constant Relative Risk Aversion |
| DAI | Deutsches Aktieninstitut |
| DAX | Deutscher Aktien Index |
| DW | Newspaper *Deutsche Welle* |
| G7 | Group of Seven countries (Canada, France, Germany, Italy, Japan, United States of America, United Kingdom) |
| ISIN | International Securities Identification Number |
| NASDAQ | National Association of Secutiries Dealers |
| NEMAX | Neuer Markt Aktien Index |
| OECD | Organisation for Economic Cooperation and Development |
| ZEW | *Zentrum für Europäische Wirtschaftsforschung* (Center for European Economic Research) |

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# 1 Introduction

Knowing how investors' portfolios are composed is a central issue for economists, legislators, and managers. German investors, in particular, are known for having an aversion to owning equities when compared to other developed nations. This phenomenon is known as "börsenscheu", which translates to "market shy". Consecutively, the fraction of German households' portfolios allocated to equities has been the lowest within the European Union since 1997, with the exceptions of Slovakia, Latvia and Greece occasionally hitting inferior percentages between 2008 and 2012. Within the most developed nations worldwide, Germany has also had a very low allocation to equities, as evident in Appendix I (Organisation for Economic Cooperation and Development [OECD], 2018).

Dr. Gerrit Fey, the head of Capital Markets Affairs in the *Deutsches Aktieninstitut* (DAI) – a finance-industry organization representing shareholders' interests – points to the fact that Germany has maintained a sound pension system throughout the years. For this reason, "we are not taught that building our own fortunes will allow us to enjoy some extra income later in life", he stated in an interview given to *Deutsche Welle* (DW), Germany's international broadcaster, "you have these ingrained behavioral patterns in Germany that show a large aversion to risk" (Cottrell, 2016).

Yet, the picture seems to be changing. With interest rates nearing zero, an increasing life expectancy, and an aging population, German households seem to be slowly rising the equity portion of their financial portfolios (Annuß, 2017; Deutsche Bundesbank, 2015; OECD, 2018)

ERGO Group AG, a subsidiary of one of the largest insurance groups in Europe, Munich RE, has been contributing to this change by giving their clients great control over the allocation of their assets and full transparency regarding the composition of the offered funds (Bajpai, 2016). At ERGO Group AG, customers are advised on their investments based on their background, preferences, and overall risk profile (ERGO Group AG, 2018). With German investors finally becoming less "market shy", it becomes crucial to understand whether this transition is the result of a macroeconomic phenomenon or if there are other factors behind customers' portfolio allocation decisions that financial advisors need to consider.

One essential factor that should be taken into account is how individuals change their portfolio allocations as they age. A common advice is to reduce risk as one gets older since retirees may not have the luxury to see the market bounce back after a drop. During the 80s, financial advisors started using the "100 minus your age" rule of thumb to give counselling to their customers. Following this rule, if an individual was 60 years old, she should invest 40% of her portfolio in equities while the remaining 60% should be allocated to treasury bonds and other relatively safe instruments (Kurt, 2018).

However, Kurt (2018) names two reasons why this rule no longer applies. First, the average investor lives longer nowadays. In particular, in Germany, the life expectancy has increased 3.9 years over the last twenty years only (World Bank, 2018). Second, returns on treasury bonds are not as high as they were in the past. Today, a German 10-year treasury bond yields 0.33% annually, whereas back in 1980 investors could expect a return from 7% up to 9% (Investing, 2018). Consequently, it appears that following traditional advisory guidelines is likely to leave customers unsatisfied, and potentially left with insufficient funds.

Some fund institutions have amended their rules to meet the new economy. For instance, the Vanguard Target Retirement 2030 Fund has roughly 76% of its funds allocated to equities, and targets individuals in their 50s – resembling a "126 minus your age" rule (Vanguard, 2018). Notwithstanding, more than knowing the recipe for adjusting outdated principles, the most important element still lies in determining whether individuals follow such pieces of advice and effectively decrease the portion of their risky investments with age. Therefore, the research question that motivates this thesis is:

*How do individual's risky portfolio holdings change with age?*

Due to several underlying structural issues and significant geographic differences, opinions amongst financial advisors, economists, and researchers within the academic community diverge. Consequently, this thesis aims to contribute to the understanding of portfolio risk allocations throughout one's lifetime with an additional research element.

## 1.1 Motivation

There are three main reasons that hinder the results concerning the age effects in a portfolio's risky share that were attained so far, and thus motivate this thesis.

First, as Fagereng, Gottlieb, and Guiso (2017) point out in their study of Norwegian households' portfolio allocations, longitudinal data on investors' portfolios is not readily available and it is often incomplete. Thus, empirical evidence is commonly derived from cross-sectional data and is usually subject to self-reported measurement errors (p. 4).

Cross-sectional data is collected at a single point in time, for a certain group of individuals. Therefore, while it is suitable to capture a snapshot of the impact of age in portfolio allocations, it is not appropriate to trace the individuals' portfolios throughout time. For this reason, authors have used several survey waves and combined their answers to build panel data (Ameriks & Zeldes, 2004; Coile & Milligan, 2009; Spicer, Stavrunova, & Thorp, 2016). Yet, this procedure does not allow them to follow a single individual's portfolio, only to compare the behaviors observed between the dates when the survey was distributed. Additionally, measurement errors – arising from poor question wording in surveys, or wrong assumptions and estimations made by the respondents – may be correlated with age, and obstruct the real impact of ageing (Peytchev & Peytcheva, 2007, p. 3869).

Second, as seen before, not every investor, especially in Germany, holds equities in their portfolio: in 2017, only 15.7% of the German population above 14 years old invest in equity funds (DAI, 2018). Those investors that hold stocks have different risk profiles from those that have always chosen to invest in less risky assets (Veld-Merkoulova, 2011). Consequently, age and other explanatory factors may impact the two groups of investors differently. Therefore, there is a necessity to model two dependent variables: the decision to include risky investments in one's portfolio, and, if ever deciding affirmatively, the corresponding portfolio weight.

Third, since *birth year = current year – age*, determining whether an individual decreases its share of risky holdings with age requires disentangling three time-related effects, also known as the age-time-cohort problem (Ameriks & Zeldes, 2004; Schulhofer-Wohl, 2018).

For example, if a sample containing only individuals with 50 years old had been collected from a database from 2004 to 2006, the sample would effectively contain individuals that were born in 1954, 1955, and 1956, and were fifty years old in 2004, 2005, and 2006, respectively. However, it is not given that all fifty-year-old individuals of the sample will behave equally regarding their risky holdings. As Spicer et al. (2015) outlined in their research on the age effects in the risky asset holdings of retired Australian households, these differences are correlated with age but are not caused by ageing. Instead, they arise due to the differences in birth years or generations. This is called the *birth cohort effect or generational effect*.

Additionally, it may be the case that investors of every age were all experiencing abnormal conditions during the observation period, such as increasing stock market prices which may have influenced their portfolio allocations in that moment. Notwithstanding, this effect is also not caused by individuals getting one year older in that specific year, but due to the environment at that time that affects every subject regardless of their age. This is called the *time effect* or *period effect*.

Once the effects have been separated, it is possible to conclude whether portfolio allocation to risky assets changes with an individual's age. This is called the *age effect*.

## 1.2 Objectives & Outline

The main objective of this thesis is to analyze the lifecycle behavior of individuals' portfolio risky holdings. This objective was subdivided in three underlying targets. First, to investigate whether the age profile observed in the sample matches the theoretical predictions of well-established lifecycle models. Second, to compare the results obtained in the analysis with the practical insights attained by other authors in distinct geographies, attesting or not for the dissimilar character of the German investor. Third, to isolate the time and generational effects, in order to verify whether there is a decreasing age pattern that is common to all the individuals in the sample, as traditionally advised by financial planners.

To conduct the analysis, data was collected from ERGO Group AG transaction database. Customers may allocate their money to twenty-eight different funds. Through a detailed

and complete categorization of their funds based on risk, volatility, equity component, and planning horizon, ERGO Group AG offers its investors the opportunity to make informed investment decisions.

As of 2017, 225 portfolios of customers aged between 20 and 80 years were randomly selected. Their respective shares allocated to risky funds were tracked for a period of 10 years. Since the database contains the actual transactions of each client account, as well as customer background data, it is possible to trace the evolution of the risky portfolio share as individuals age without interruptions and therefore to eliminate the measurement error arising from self-reported figures. Lastly, the results complement the existing research by offering novel insights into a geography where investments and participation in risky assets do not follow the typical patterns of other developed nations: Germany (OECD, 2018; Guiso, Haliassos & Jappelli, 2003).

The paper is organized into three main sections, an introduction, and a conclusion. Section 2 contains an introduction to risky portfolio holdings in Germany. Section 3 provides a brief description of the main economic theories on portfolio models, their assumptions and subsequent amendments before proceeding to the review of empirical findings and the hypotheses that will be debated in this thesis. Section 4 contains information regarding the variables used, as well as sample descriptive statistics. The model specifications that were used to address the age-time-cohort problem are discussed in Section 5. Section 5 also displays the outcomes of the hypotheses' tests and provides a critical evaluation for the results obtained. Section 6 delivers the concluding remarks and delivers a reformed age rule to guide financial advice.

# 2 Characteristics of Portfolio Risky Holdings in Germany

It is by claiming "Germany has a tradition of promoting the formation of household wealth" that Börsch-Supan and Essig (2003) approach the motives that make the country such a peculiar place for stockholdings (p. 111). Nonetheless, portfolio structure in Germany has been undergoing several changes over the past five decades. Namely, from 1959 to 2009, an increase in investments in mutual funds from 3% to 14% and in retirement plans from 22% to 34% has been reported. This is in line with the idea that a large share of the population has concurrently started requesting pensions in this period (Ramb & Scharnalg, 2011).

At the same time, interest in stock holdings seems to have diminished with stock allocation decreasing from 19% to 4% of the financial portfolio. The 2008 financial crisis and the burst of the New Economy bubble in 2001 may have been responsible for motivating such behavior (Ramb & Scharnalg, 2011). The German reunification in 1990 delayed the low growth rates that by then had already reached the other developed nations, but in 1993 the country's economy also took a downturn (Börsch-Supan & Essig, 2003).

However, the motives that explain the low interest in the stock market date back to the decade of the 1950s. After the war, taxes and policies were adjusted in order to incentivize the reconstruction of the country. These favorable conditions were later extended to the East upon the reunification. The availability of different subsidies with relatively high rates for long-term savings plans made investing in the stock market rather unattractive (Börsch-Supan & Essig, 2003). However, owed to the introduction of stock-based incentive schemes, equity investments started to become more popular in the 1960s (Burghof & Hunger, 2003).

Though it was only in the 1990s that the stock market in Germany started being deregulated. While the other member states were in the process of adjusting to the new European directives so as to conform to the new single market place, Germany was showing some resistance. Nonetheless, the lowering of the transaction costs in 1990, the centralization of the stock markets in 1993, and the expansion of the Frankfurt stock exchange during the same decade, gave the German stock market a new meaning internationally (Börsch-Supan & Essig, 2003).

In 1995, Deutsche Post and Deutsche Telekom, two of Germany's largest companies, were privatized. When the initial public offering of Deutsche Telekom took place one year later, Germany was amid a period of intensive stock advertising. The campaign of Deutsche Telekom particularly incentivized people to buy the company's shares earlier in exchange for better offers. The shares were called the "people's stocks", in German, "Volksaktien".

Afterwards, the relevance of stock investments slowly declined until 1997, when the Deutsche Börse AG, the private company responsible for the Frankfurt Stock Exchange, opened the *Neuer Markt*, the "new market" (Ramb & Scharnalg, 2011). This was one of the largest stock markets introduced in Europe in the 1990s (Burghof & Hunger, 2003).

Up until then, the stock market in Germany had been organized in three categories: Official Trading (*Amtlicher Handel*), the Regulated Market (*Geregelter Markt*), and the Unofficial Regulated Market (*Freiverkehr*). The *Neuer Markt* represented a new segment which consisted of small and medium sized growth firms (Burghof & Hunger, 2003). Firms falling in this category had to obey different compliance rules, such as to provide quarterly financial reports in English and according to international accounting standards. The intention of these regulations was to increase transparency, and thus participation in this equity segment. Accordingly, investors expected higher returns coming from the "new market" category. Indeed, the *Neuer Markt Aktien Index* (NEMAX50), an index including the 50 largest stocks in the *Neuer Market*, went from a minimum of 1000 Deutsche Mark when the segment was first introduced, to an all-time high of 9631.53 Deutsche Mark in 2000 (Kiss & Stehle, 2002). During this period, the portfolio stock allocation increased by 15% (Ramb & Scharnalg, 2011). At the same time, there were several reforms to the income tax. In 1999, capital gains arising from the sale of companies' reserves began to be tax-exempt. Such favourable tax treatment was potentially one of the reasons for the spike in the returns of the *Deutscher Aktien Index* (DAX) by the end of the same year (Figure $K_1$ in Appendix K). Stocks and mutual funds were also tax-exempt when individuals would keep them for longer than 6 months. This restriction was meant to prevent investors from investing based on speculation. Though in 2000 the minimum duration of the "speculation period" was extended to 2 years. In parallel, taxes on other assets, such as housing, and life insurance plans, were further decreased (Börsch-Supan & Essig, 2003).

In spite of the favorable tax treatment, investments were crushed in September 2001 as a result of the bursting dotcom bubble. Compared to the bursting in the U.S., this shock was even stronger than the impact felt in the National Association of Securities Dealers Automated Quotations (NASDAQ). At the time, the NASDAQ was where most of electronic stocks were registered at the time. Today, it is still one of the largest American stock exchanges. The sudden change in valuation and the subsequent bankruptcies left investors discredited with the equity market (Kiss & Stehle, 2002). Consequently, the portfolio stock allocation dropped by 5% – partly due to the decrease in prices, but also due to the selling of shares. In 2002, the *Neuer Markt* segment was abolished (Burghof & Hunger, 2003).

The percentage of the portfolio allocated to equities suffered a very mild recovery from 2003 to 2008. Yet, the 2008 financial crisis lead to another drop in the portfolio stock components and since then the fraction has remained stable around 3.5%. Moreover, German investors have shown a preference for rather liquid and safer assets, with roughly 20% of their portfolios allocated to time and savings deposits (Deutsche Bundesbank, 2015).

In contrast, the allocation to mutual fund shares increased from 3% in 1959 to 14% in 2011. This may be justified by a higher need to diversify investments and an increase in demand for old-age pensions as incentivized by the *Riester-Rente* ("Riester pension"). (Ramb & Scharnalg, 2011). The Riester pension was introduced in 2002 in order to compensate retirees from cuts in the German Statutory Retirement Insurance System (*Gesetzliche Rente*) and to incentivize them to secure private pension plans. At that point, the public retirement system was actually covering for 85% of the retirement earnings of 85% the German working population. Such stability provided by the state was likely to lead to the redundancy of holding risky assets in private portfolios (Börsch-Supan & Essig, 2003). It might not be a coincidence that the countries with stable public pension systems also have small stock markets (Börsch-Supan & Winter, 2001).

Before that, in 1992, the German state had already attempted to level the gap between the young and older households by doing a few adjustments to the pay-as-you-go social security system. These changes included increasing retirement age, and providing benefits based on net income, as opposed to gross wages. Despite the low impact of these adjustments, the possibility of receiving lower retirement benefits made private pension

plans and the inclusion of direct and indirect stockholdings in the financial portfolios increasingly valid options (Börsch-Supan & Essig, 2003). Börsch-Supan and Brugiavini (2001) actually project that by 2050 the German households will have a much more diversified financial portfolio through a large portion of indirect investments held in equities.

Interestingly enough, within households' mutual fund investments, German households have allocated 27% of their portfolios to equity funds in 2015, which is mainly dedicated to foreign businesses. Though when looking at their direct share investments, households bought predominantly German issuers' paper, suggesting that they would rather let more knowledgeable investors manage riskier equity investments than holding direct stakes. Simultaneously, transferrable deposits, the most liquid component of the portfolio, have been increasing since 2009 to 22% share of the total portfolio in 2015 (Annuß, 2017).

In sum, all the above described behaviors – a historically low share allocated to stocks in spite of a favorable tax treatment, savings subsidies, an overarching pay-as-you-go pension system, a high preference for professionally handled equity investments, and for liquidity – signal the low risk appetite of the average German investor (Deutsche Bundesbank, 2015).

With the recent low-interest rate environment, however, the income that German households earn on bank deposits has decreased (Annuß, 2017). Since bank deposits represent a substantial part of the financial portfolio, this may incentivize individuals to invest in higher-yielding riskier investments so as to keep their usual consumption levels. This thesis will bring to light whether such suspicion is verified for the sample of German customers under analysis.

# 3 Theoretical Background and Hypotheses

Section 3 offers contrasting views on the effect of age in financial portfolios. The aim of this section is to first lay out the most important theories underlying the research question, and, secondly, to provide the methodologies and the main empirical results of authors that have investigated similar topics. Along this process, special emphasis is made on how these researchers treated time and cohort effects as this will be crucial for deriving the hypotheses that will be discussed later on.

## 3.1 Theoretical Models of Portfolio Lifecycle Behavior

There has been some controversy between financial advisors and some of the most acknowledged authors regarding portfolio choices throughout a person's lifetime. According to Samuelson (1969), the "lifetime model reveals that investing for many periods does not itself introduce extra tolerance for riskiness at early, or any, stages of life" (p. 240). Merton (1969) also worked on lifetime portfolio selection and extended Samuelson's model to the continuous time case. Mossin (1968), who wrote a renowned paper on multi-period portfolio choices, investigated whether the portfolio weights allocated to each asset remained the same in every period. In this case, an investor would only rebalance their portfolio to maintain the same proportions over time. According to these authors, not only individuals participate in the risky asset market at all times, but also the portfolio fraction allocated to these assets is age-invariant. In fact, the composition of the optimal portfolio should always be the same throughout the lifetime of an individual. Such result is true under very limiting assumptions: asset returns are independent and identically distributed, an individuals' risk aversion is constant over time, and there is no labor income neither non-tradeable assets.

Outside formal methods of portfolio optimization, several scholars suggested that investors in fact do rebalance their portfolios towards safer assets, especially around retirement age, and have proposed reforms to the lifecycle portfolio theories advanced by Samuelson (1969), Merton (1969), and Mossin (1968). Merton (1971) addressed some of the critics that immediately followed his publication, and extended his model to include wages, the uncertainty of life expectancy, and the option of defaulting on risk-free assets.

The inclusion of "wage income" is particularly important as it behaves like a risk-free asset which is capitalized over the individual's life. This means that the present value of future earnings decreases as one gets older. The idea of the model is that an individual has a two-asset portfolio: the riskless wage income, and the risky asset. Therefore, there is an incentive to take on risky investments when young, as they will be balanced against a large present value of wage income, and to reduce them as the capitalized value of the risk-free asset diminishes (Merton, 1971). It is thus suggested that there is a shift towards safer assets when getting older. Moreover, the model still entails that every individual invests in the stock market even though it is clear that not everyone invests in the equity markets. In particular, in Germany, around 84.3% households choose to refrain from doing so (DAI, 2018). Furthermore, the model suggests that the largest fractions of risky assets would be held by very young individuals, which does not seem to be the case.

Subsequent models have emerged with more feasible assumptions. Campbell and Viceira (1999) investigated the consequences of not having identically distributed returns throughout time. The same authors (2003) suggested that the cost of participating in the stock market may be the reason for the closed model inconsistencies. Such cost could be enough to dissuade young subjects from investing in equities early in life. However, after a certain amount of wealth accumulated throughout time, the participation cost would be less discouraging (pp. 171-172). When relaxing the assumption that labor income is riskless, the total wealth of young individuals is too small to protect them against potential oscillations in their earnings. In this scenario, at a young age, subjects would prefer to hold less risky shares in their portfolios (Guiso, Japelli, & Tertlizzese, 1996).

Dammon, Spatt, and Zhang (2004) have also made their contribution towards bringing the models of Merton (1969) and Samuelson (1969) closer to the realm of reality by including capital taxes. In this case, because taxes on capital gains are absolved upon one's death, they conclude that the optimal equity share would actually be increasing with age. An important note, though, is that these authors continued to assume that investors' utility functions exhibit constant relative risk aversion (CRRA). This imposes that individuals' risk aversions only change alongside changes in wealth. Nevertheless, it has been shown that there are other demographic variables, namely age and gender, that also influence individuals' risk tolerances (Halek & Eisenhauer, 2001). The absence of a multi-period optimal portfolio model with widely-accepted assumptions strengthens the

need to look into the findings of empirical research in order to understand the age profile behind portfolio risky holdings.

## 3.2 Empirical Estimates of Age Effects

The literature stream on how individuals would change their portfolio allocations with age quickly gained momentum during the 1990s in the United States. This research interest was born out of the concern that stock prices were rising because the Baby Boomers, the largest generation in the U.S., began to save for retirement (Poterba, 2001). This suggested that the demographic composition of a nation, namely, how many people were entering adulthood or starting to retire, deviated the portfolio decisions of the population towards the behavior of the most numerous age cohort. For this reason, it became fundamental to understand the ageing patterns in asset allocations.

As a consequence, economists, researchers, and policy-makers began to anticipate what would happen when a large fraction of the population would effectively start to withdraw from the stock market. On this matter, Yoo (1994) found that the returns of several assets would fall with an increase in the population between 45 and 54 year olds. Similarly, Brooks (2004) by running a simulation of how the risk premium would change in response to intense population growth, reported that the return on risky assets would increase when the largest cohort was in the early years of its working life, and decrease when it was reaching retirement. All in all, these findings seem to be consistent with the idea that the risky holdings are decreasing with age, at least, at a single point in time. Authors that followed continued to study the age profiles of the population using cross-sectional data but used different geographies and varied their definitions of "total portfolio" and "risky assets".

### *3.2.1 The Cross-Sectional Age Effect*

Heaton and Lucas (2000) analyzed the portfolio composition for U.S. households. In their study, the total portfolio assumed different characterizations. The portfolio was first composed by deposits and the most liquid investments in stocks, bonds. The alternative characterizations also included real estate assets, pension schemes and less liquid

financial instruments. Under any of the portfolio definitions, their results showed that individuals increased the share of their portfolios allocated to stocks around retirement age, but at the same time the portion held in privately owned businesses decreased. These findings are not in contradiction with Merton's (1971) idea of rebalancing the portfolio towards less risky levels with ageing, since owning private businesses is riskier than holding other companies' stocks.

In Australia, Kohler, Connelly, and Smith (2004) concluded that indeed older households held less risky assets. Riskless assets, in their definition, were given by low-risk bonds and deposits. In contrast, younger households were more likely to hold riskier investments, such as stocks.

In the Netherlands, Veld-Merkoulova (2011) also took a snapshot of the financial investments of Dutch households. Using stocks, options, real estate, and mutual funds as a proxy for risky financial assets, more evidence was found that the risky asset share of the portfolio decreases as age increases.

Independently of the geography, and of the definition of risky assets, households seemed to follow the advice commonly given by financial advisors: to decrease the allocation to risky assets per each additional year of age and therefore implying that the age coefficient would have to be negative. Nonetheless, Cardak and Wilkins (2009) took the analysis one step further, and added age dummies to their regression model.

They reported that the effect of age on risky holdings for individuals between 24 and 54 years old was relatively stable. For subjects between 55 and 69 years old, the age coefficient increased. At 70 years old, the age effect declined, but the coefficient remained positive at every age (Cardak & Wilkins, 2009). The idea that the share of risky assets would not linearly vary with age was not new. Bergantino (1998) had already reported evidence of a hump-shaped investment pattern: households below 40 years old would draw funds from the financial markets, mainly through mortgagees; households between 40 and 60 years old would give credit to the financial markets, essentially via retirement plans; those above 60 years old would again retain credit, but only by selling off the assets previously accumulated.

All the above results were based on snapshots of a sample of households' portfolios at a single point in time. Since it is not possible to follow an individual's lifecycle portfolio

allocation throughout time, these findings assume that every subject would make the same financial decisions when reaching a certain age. Including age dummies in the specification, however, shows that findings based on this type of data may be hiding the true lifecycle age patterns. Therefore, in order to grasp the direction of the age effect for each of the customers, using the longitudinal dataset of ERGO customers' equity portfolios from 2007 until 2017, the analysis of this thesis starts off by testing the following dual hypothesis:

**Hypothesis 1**

*$H_0$: There are no differences in individual equity portfolio allocations between different ages*

*$H_{1a}$: Individual equity portfolio allocations increase with ageing*

*$H_{1b}$: Individual equity portfolio allocations decrease with ageing*

Using panel data was also what Chiappori and Paiella (2011) did when examining how individuals' portfolio would change with individuals' wealth in Italy. They recognized that if individuals are heterogeneous with regards to the risky asset share that they hold, using cross-sectional data may lead to wrong conclusions. For example, concluding that the fraction of risky holdings is higher for individuals that are 50 years old than for those that are 25 years old, does not mean that throughout the lifecycle, there will be an increase in risky holdings between the ages 25 and 50.

The authors define risky assets as the holdings of stocks, shares, corporate bonds, and mutual funds, recorded by their market value at the end of the year. The study uses data collected from eight waves of the Survey on Household Income and Wealth between 1989 and 2004. So as to appropriately isolate the changes in the fraction of risky assets, the authors use the consumer price index of the last year in the sample in order to eliminate variation due to inflation. The authors note that there was an accentuated increase in the stock market participation in the 90s which they justify with the privatizations that started in Italy around 1993. These privatizations slowed down two years after which is consistent with the stationary behavior of stock participation that the authors found between the subsequent survey waves. Additionally, they reported that, since 1990, the average of the share allocated to risky assets equals 60% of the total financial portfolio (Chiappori & Paiella, 2011).

Even though the study sheds little light on the effect of ageing, their findings are important to the course of this thesis for three reasons. First, the authors accurately identify the problem of using cross-sectional data to derive conclusions that are potentially time-varying. Second, the authors are able to justify changes in the stock market participation with changes in the social and economic context during which individuals made their portfolio decisions. This is an important insight that will lay down the ground for the discussion in this thesis in Section 5. Third, by trying to estimate changes in portfolio risky holdings with changes in wealth, their research identifies a clear problem: measurement error in (self-reported) survey answers is correlated with wealth, which may invalidate the regression estimates. This is a problem that is also verified between age and measurement error since older individuals may be more likely to give wrong estimates than younger subjects. The results obtained in this thesis, however, are not expected to be affected by errors of this nature.

### *3.2.2 Birth Cohort and Time Effects*

When studying the age effects, however, another concern has emerged. Namely, there is no reason to assume that individuals born in different birth years allocate their assets identically. Shorrocks (1975) made the first progress towards the understanding of birth cohorts' ageing patterns by using panel data. "The existence of a hump savings characteristic is a statement about the asset behavior of an individual or cohort over its lifespan" claimed the author and proceeded to explain that any pattern that is uncovered for a certain age cohort in a given year cannot be extrapolated to draw conclusions on other individuals' behavior in different years (Shorrocks, 1975, p. 157). The problem lies on the impossibility to estimate time, cohort, and age effects simultaneously because birth cohort is indeed a linear function of age and time (Poterba, 2001).

As an example, individuals that lived their mid-working lives during the Great Depression may hold lower stock holdings throughout all their lifecycle than younger generations. This would be representative of a cohort effect. Yet, it may be the case that due to an intense period of financial advertising, such as the privatizations in Italy throughout the 90s, every investor increased their stock holdings. In this case, the effect would be given by a time effect. Given that age, time and cohort effects are correlated, one can only

regress two of them. Either to allow for time effects or cohort effects is a choice that investigators must take depending on the research object.

For example, Poterba and Samwick (2001) studied the cohort and age effects in the portfolio lifecycle allocation. In particular, the scholars investigated the ownership and the allocation of financial assets for an American sample in the years 1983, 1989, and 1992, assuming no time effects. They reported reasonably stable ageing effects on both participation and allocation to equities in the households' portfolio. This suggests that individuals did not follow the traditional advice to decrease their stock holdings as they got older. More importantly, their research did indeed prove that there were significant cohort effects in the fraction allocated to equities for all years of the data and that these effects were stronger for older cohorts.

For instance, baby boomers held more equities and also invested more in refined financial instruments than the previous generations. The authors justified these changes with individuals' exposure to periods of intense financial advertising and either low or high historical returns (Poterba & Samwick, 2001). Accordingly, baby boomers pursued their careers during the bearish market of the 90s and have been characterized as the generation that wants to be in the investment forefront. Despite the perspective of retirement, this cohort does not seem to move away from equity investments (Wallick, Shanahan, & Tasopoulos, 2013).

Understanding the birth cohort effects is crucial to understand how portfolios change depending on the demographics of the population. When the older cohorts have a different risk attitude than the younger cohorts, then evidence on the share of risky assets will change as the older cohort starts to shrink and the younger cohort grows up (Sommer, 2005). In order to determine whether the equity portfolio allocations of customers at ERGO are also influenced by generational effects, the second hypothesis of this thesis is:

**Hypothesis 2**

*$H_0$: There are no differences in equity portfolio allocations between different birth cohorts*

*$H_2$: There are differences in equity portfolio allocations between different birth cohorts*

The findings reported by Poterba and Samwick (2001) are also in accordance with other research results that estimated age and time effects instead of age and cohort effects. The

assumption in this case is that there are no differences associated with different birth years. This was also the restriction used by the aforementioned authors Heaton and Lucas (2000) when reporting a decreasing age profile.

More recently, Malmendier and Nagel (2011) showed that individuals who have lived through low stock market returns have a lower willingness to undertake risky investments, are less likely to hold stocks and invest a lower share of their portfolios in equities. Liquid assets invested in stocks, either directly or via mutual funds, are used as a proxy for risk-taking behavior.

Since the authors were only interested in knowing how risk-taking behavior changes with changes in the stock and bond market prices, and were not interested in estimating the cohort effects, they controlled for year and age effects simultaneously. Controlling for year effects eliminates changes in the stock holdings arising due to time trends or arising from changes in overall market prices, which include other assets besides stocks. Controlling for age effects isolates the lifecycle pattern in stock allocations. This way, they were able to examine how stock allocations changed as a function of the S&P500 market index returns.

Apergis (2015) further showed that business cycles impact investors' risky investments differently: subjects decreased a higher fraction of their holdings in light of a recession than the amount increased during a boom. These results incentivized the need to estimate time effects in equity portfolio allocations. Therefore, the third hypothesis is described as follows:

**Hypothesis 3**

*$H_0$: There are no differences in individuals' equity portfolio allocations between the different years covered in the analysis*

*$H_3$: There are differences in individuals' equity portfolio allocations between the different years covered in the analysis*

Using individuals' stock holdings in 1989, 1992, 1995, and 1998 in the United States, Ameriks and Zeldes (2004) marked a turning point in the literature where stock shares were recognized conditional on participation, no self-reported data was used, the analysis was built on panel data, and both time and cohort effects were estimated.

When excluding time effects, the authors showed evidence that the equity share of the portfolio would increase with age for every birth cohort. However, this result is contradictory to the idea that individuals reduce the portion held in stocks when approaching retirement age – an average of 64 years old in the US at the time of the study (Newport, 2018). Furthermore, the authors suspected that their results were influenced by the high stock market returns of the period. Therefore, on a second formulation, they excluded cohort effects, and estimated time and age effects. They reported evidence that conflicted with previous authors, who proposed a negative impact of age in portfolio risky shares when including time effects. However, Ameriks and Zeldes (2004) concluded that it is only expected that different investigators will reach different conclusions when estimating time and age effects simultaneously because results will depend on the sample period being analyzed. For instance, it is shown that for the period between 1987 and 1992, the age pattern for the equity share follows an inverted U-shape, but for the years 1995 to 1999, the age profile is actually declining.

Furthermore, the authors explored three different variables: equity share, participation rates, and equity share conditional on participation. Their findings showed that participation in the stock market was hump-shaped, peaking for subjects with 49-58 years old, but that the conditional stock holdings were somewhat constant throughout one's lifecycle. This suggests that most of the changes observed in the equity share, that do not impose any restriction on participating in the equity market, come from the decision individuals make regarding whether to invest in stocks in their portfolios or not to invest at all – rather than from the decision of *how much* stock to hold (Ameriks & Zeldes, 2004). This is a crucial insight that has lead the analysis of this thesis to distinguish between two dependent variables: the equity share of the portfolio and the decision to participate in the equity market.

### *3.2.3 The Hump-Shaped Age Pattern*

The previous findings point to the idea that individuals do not decrease their equity share per each additional year of age, but rather that this share peaks at some point in their lifecycle. Coile and Milligan (2009) confirmed this suspicion.

Using six waves of the Health and Retirement Study (HRS) survey, the authors looked at individuals born between 1931 and 1941 (55-90 years old). The static results for 2002 show that stock ownership is rather stable with age at around 30% of total asset holdings. The authors then divided the subjects in 20 birth cohorts, with two birth years in each group. They reported that the ownership of financial assets peaks between 54 and 56 years old for almost every cohort, but also that older cohorts hold consistently less portions of financial assets than younger cohorts (Coile & Milligan, 2009).

The results show evidence that the age profile is not as linear as financial planners describe it, and the lifecycle pattern seems to follow a hump-shaped line. These findings lead to the fourth and last hypothesis of this thesis:

**Hypothesis 4**

*$H_0$: There are no differences in the amount of variation explained in the equity portfolio allocation between a linear and a quadratic age profile*
*$H_4$: A quadratic age profile explains more variation in the equity portfolio allocations of the individuals in the sample*

These findings seem to be according to the models that relax the assumption that labor income is risk free (Guiso et al., 1996). At a young age, an individuals' wealth does not provide them with enough safety against income uncertainty. Therefore, the share allocated to the risky assets will peak when the wealth accumulated is enough to endure a possible drop in the value of the equity portfolio, essentially when an individual has achieved a stable working life status. The decline from the peak onwards may be explained by the need of older households to retain their wealth in order to afford consumption during their retirement.

Accordingly, Fagereng et al. (2017), using data from Norwegian Tax Registry (NTR), show that participation in the stock market peaks at 60% at age 45, stays relatively stable, and, when retirement age is reached (65 years old), it starts declining. Contrary to Ameriks and Zeldes (2004), the authors found that the conditional risky share declines with one's age. The magnitude of the results, though, does not seem plausible.

For the Norwegian household, the fraction of risky assets stabilizes slightly below 50% of the total portfolio at around 25 years old and decreases so slowly that when one hits retirement age, the share is still equal to 40%, only stabilizing at 30% afterwards

(Fagereng et al., 2017). Nonetheless, when looking at the fraction held in shares and other equities by the Norwegian households reported by the OECD (2018) for the period of the study (1995-2009), the average equals 20.7%. Even when taking into account investments in mutual funds, which are included in the authors' definition of risky holdings, the corresponding weight never exceeded 26.7% of the households' financial portfolios (OECD, 2018).

This raises the suspicion that the findings may have been inflated. Seeing that the data was obtained through the tax authorities' register, individuals may feel motivated to omit certain asset holdings so as to reduce their own tax obligations. Consequently, the total portfolio may contain unreported safe assets, which would have explained abnormally high proportions of risky asset holdings. In any case, the results seem far from being appropriate to explain how risky holdings vary with age in *market shy* Germany. Consequently, this thesis is also concerned with the potentially different age profiles that may arise in the German market.

Guiso et al. (2003) examined the stock market participation and the share allocated to stocks of several European countries in 1998, and do indeed confirm that most of the national results were not valid beyond borders. Germany scored amongst the bottom three countries, together with France and the Netherlands, with only 17% of households investing in equities. Participation in the stock market peaks for German individuals at the age of 60 years. Despite that, when looking at the fraction held in stocks, the authors found a puzzling result: Germany is the only European country showing negative age coefficients which are barely significantly different from zero. This result suggests that the portfolio equity shares are rather stable throughout one's life.

The stockholding behavior of the German households has caught the attention of several other researchers. However, since the answers of the Income and Expenditure Survey (EVS) waves are not easily accessible, and there is no publicly available source containing panel data on individuals' portfolios, the studies dedicated to this geography have been scarce. Moreover, as most studies date back to the decade of the 1990s, the findings disregard the Eastern German population (Börsch-Supan, Reil-Held, & Schabel, 2002).

Eymann and Börsch-Supan (2001) focused on the portfolio composition adjustments after the reunification of Germany and reported that the investment behavior followed the same tendencies observed in the other developed nations, with the exception of the "risky" holdings. For Germany, the interest in this asset class developed between 5 to 10 years after the other countries. Safe deposits with banks, savings, and domestic bonds have assumed a very central role in individuals' financial portfolios in Germany, with stocks being rather unpopular (Börsch-Supan & Essig, 2003).

Sommer (2005), however, reported that there would be a declining share allocated to savings accounts and an increasing interest in mutual fund shares. These changes are more accentuated for the lower age brackets. Moreover, the authors showed that the savings share of the portfolio hits its minimum at age 55 – the average retirement age – and starts increasing from that point onwards. This age pattern mirrors the behavior that would be expected for the risky portfolio share.

Furthermore, concerning the generational effects, the younger birth cohorts seem to have been increasing their participation in the financial securities market, while the retired cohorts displayed a constant age pattern instead and kept a stable share allocated to savings (Sommer, 2005). It has been shown that individuals in Germany do not invest their wealth away in the late years of their lifecycle (Börsch-Supan, Reil-Held, & Schabel, 2002). A reason for this behavior has been put forward by Abel (2001) who explained that older households may prefer to hold on to their wealth so as to provide for their successors. Nevertheless, with an ageing population this decision has enormous consequences for the financial portfolios in Germany.

Börsch-Supan (1996) raised the attention for the dependency problem a while ago and predicted that by 2030 the amount of people aged 60 years old and older would represent 37% of the German population, almost double the elderly population in 1980. It was effectively this prospect that lead the state to increase the incentives for the pursuit of private saving plans. Effectively, if individuals intend to keep their life standards throughout retirement years, voluntary savings will have to increase (Metzger, 2017). Therefore, it will be interesting to investigate whether this incentive has reached the younger cohorts, and whether there is an increase in the stock market participation as an alternative method of privately securing funds for the retirement ages. The next Section

describes the data used in the analysis presented in this thesis, and offers the first insights into the evolution of portfolio risky holdings.

# 4 Data

The data used in the following analysis was provided by ERGO Group AG. The dataset contains information on the transactions of 225 individuals. Every new transaction is registered on a daily basis. For the purpose of this study, the analysis is truncated to a period of 10 years, from 2007 to 2017. As an insurance company, ERGO Group AG offers a wide range of investment opportunities to its clients. In the transactions collected for the following study, there were movements in 28 different funds. Each of the funds was divided according to four classes: equity, debt, mixed (multi-asset funds), and money funds. Further details on this classification are provided in Appendix A.

## 4.1 Collection and Preparation of Data

A search-engine filter was introduced in order to collect a random sample of customers that had active accounts in 2007. In order to avoid survivorship bias, the customers that died or deactivated their accounts in the following years have remained in the sample. With the objective of obtaining a balanced age panel, a second search filter was introduced to collect the transactions of customers falling within a specified birth year. The birth cohorts were organized in 12 different groups, each covering 5 years: 1934 to 1938, 1939 to 1943, 1944 to 1948, 1949 to 1953, 1954 to 1958, 1959 to 1963, 1964 to 1968, 1969 to 1973, 1974 to 1978, 1979 to 1983, 1984 to 1988, and 1989 to 1993. Such arrangement covers individuals with ages from 24 years old to 80 years old as of 2017. Subsequently, 20 individuals were randomly selected from each of the cohort groups. Finally, the transaction history was obtained for each subject.

The database provides information on the date of the account movement, the transaction amount in EUR and in shares, as well as the name and identification number of the fund associated with the operation. If the sign of the transaction is positive, the customer has reinforced his position. Likewise, if the sign is negative, the client has withdrawn or reallocated his investment.

In order to study how customers altered their equity investments throughout the lifecycle, the share allocated to the equity funds was tracked during the 10 years considered in this study. The value of the total portfolio was calculated by summing the investments from

all the asset classes by the end of each year. Individuals containing portfolios never exceeding €10 were eliminated. Subjects with portfolios above €50,000 as of 2017 were found to be outliers, and thus also removed from the sample. In sum, 15 subjects were excluded from the analysis, and 225 individuals remained. Moreover, subjects that were below 20 years old by 2007 were also excluded since, in most cases, these customers' depots were opened by their parents. As their parents take the risk for such investment, the observations for these individuals would reflect the age profile of the parents and bias the analysis.

At a 95% confidence level, the final sample size of 225 individuals allows do draw conclusions on the number of ERGO customers born between 1997 and 1934 with a ±6.51% margin of error. As for the German population, the sample size allows to make inferences on the population born between 1997 and 1934 within a 6.53% confidence interval. Details on the derivation of the significance of the sample size are provided in Appendix B.

The investments in each of the fund classes are calculated between 2007 to 2017. Therefore, each individual contributes with 11 observations to the panel data. The panel is strongly balanced, containing 2,475 observations in total.

To calculate the year-end position in each of the asset categories, the share value of the transactions was added per year and per asset class for each customer. For example, the year-end position for a customer who bought 20 shares in October 2016 in fund MEAG ProInvest, an equity fund, and that sold 5 shares of the same fund two months later, equals 15 shares plus the remaining shares that were accumulated until then. If the customer holds investments in more than one equity fund, these are summed together so as to calculate the total position in the equity funds' class.

In order to prevent the analysis from being influenced by fluctuations in the market prices, the calculations described above were made using the number of shares, rather than their monetary value. To calculate the position value by the end of the year, the accumulated number of shares of each fund was multiplied by the corresponding closing annual prices of the same fund.

## 4.2 Benefits and Limitations

The data used in this thesis provides a solid ground to conduct an analysis of individuals' lifecycle investment patterns for three main reasons. First, it is possible to track the same customers and their transactions over a decade. Other researchers that have studied how individuals' investments evolve with age have compared samples from different years, without the possibility to follow each subject across the length of the study (Poterba & Samwick, 2001; Ameriks & Zeldes, 2004).

Second, the data is free of measurement errors, which typically occurs in self-reported survey data. The fact that the database is operated by one of the largest insurance groups in Europe increases the legitimacy of this data source. As each of the transactions is linked to a customer request and is thoroughly processed by a company representative or partner, it would be highly unlikely that a transaction was not accurate to the client's intentions.

Third, the database provides both information on the amount of the transaction and on the number of shares. Consequently, it is possible to assess the individuals' transactions by comparing their value at the same point in time, for the different years of the analysis.

On the other hand, the data suffers from four main limitations. First, the sample is kept to a manageable size since the process to attain the output is not fully automated. Therefore, the results are very sensitive to changes in the investment behavior of each subject. Second, the results are also influenced by variations in the market prices. Measuring the equity share as a percentage of the total portfolio aims to deal with this issue but does not eradicate it completely. It may still happen that the prices of the equity funds rise, while the prices of the debt funds decrease. This would give the illusion that the portfolio share allocated to equities would have increased when there was no active rebalancing from the client side.

Third, customers may have portfolios outside ERGO Group AG. Therefore, claiming that an individual does not participate in the stock market may be highly inaccurate if the subject holds equity investments through another enterprise. As it is not possible to verify if a client has stakes outside ERGO Group AG, the results obtained in this study accommodate this limitation, while cautioning for the fact that the notion of total portfolio used in the analysis is not representative of an individual's total financial wealth.

Lastly, customers at ERGO Group AG may choose to be advised by financial professionals. There are two channels through which a client may receive advice: online or in person. In both cases, the customer is asked several questions regarding his risk profile and long-term objectives. The advice provided aims to closely match the customers' preferences. Nonetheless, because the decision to invest is not a completely independent decision, counselling introduces noise to the portfolio allocation decisions. For instance, Faig and Shum (2005) found that households that had received professional advice were more likely to invest in the equity market. Due to the aforementioned limitations, the results obtained in the following analysis are purely academic and should not be extended to support conclusions on the portfolio preferences of the German investors.

## 4.3 Variables

The following analysis aims to study the behavior of two different **dependent variables**: *the decision to participate* in the equity market and the *conditional equity share* of the portfolio which is only valid for the individuals that have invested in the equity funds at least once from 2007 to 2017. The distinction between these two variables is needed so that the results obtained on the equity share pattern will not be pushed towards lower values due to the individuals that allocate zero percent of their portfolio to equities throughout the whole period under consideration. The term *equity share*, when not accompanied by the word "conditional", refers to the equity share held by the total sample, thus including the individuals that have never invested in the equity funds.

The decision to invest in equity funds, also referred to as *equity participation,* is positive for the individuals that have an allocation to equity above 0% at any year covered in the sample. This variable is binomial: the individual is considered an equity investor when it equals 1, and 0 otherwise. For the customers with positive equity participation, the *conditional equity share* is defined as the total weight of the portfolio that is allocated to the 8 equity funds (Appendix A). Thus, the *conditional equity share* ranges from 0% to 100%.

Several authors have defined risky assets as the investments directly held in stocks or indirectly through mutual funds, while bonds and money market funds fall in the risk-free category (Ameriks & Zeldes, 2004). Similarly, the share allocated to equity funds,

the most volatile fund class, will be used in the following analysis as a proxy for an individual's risky holdings.

The **independent variables** used include: gender (1 for female, 0 for male), age (the age of the subject at the end of each sample year), birth cohort (the central birth year of each of the 5-year cohort groups), and time (year for which the position balance was calculated).

While the focus of the analysis lies on the equity funds, the remaining funds were instrumental to calculating the total portfolio value and are briefly mentioned in the descriptive statistics presented in the following section.

## 4.4 Descriptive Statistics

Appendix C contains the summary statistics for the total period under analysis. Table $C_1$ contains the statistics for all 2,475 observations regardless of the year. There are 93 women and 132 men in the sample. The average age is 47 years and the average equity share is 27.65%. As the equity participation is not grouped by individual, its mean only indicates that there are 816 observations that registered a positive allocation to equity.

These statistics provide a very limited interpretation of the sample because the panel features of the data are neglected. Table $C_2$ presents a better overview of the key variables by dividing them into the different years covered in the analysis. Table $C_2$ is divided into three vertical panels: the fraction of households that have at least once invested in equity between 2007 and 2017, the equity fraction of the portfolio, and the equity fraction of the portfolio conditional on having participated in the equity market. Figures 1 and 2 illustrate these results.

Concerning Figure 1, the equity participation is very low when compared to other empirical results, with less than half of the total sample never investing in equity funds. This result might also be associated with the total portfolio amount, as only the customers with higher portfolio wealth might be attracted to equities (Ameriks & Zeldes, 2004). Accordingly, in 2017, 46% of the customers that allocated the lowest amounts to the equity funds also contained the smallest portfolios in value, as shown in Appendix D.

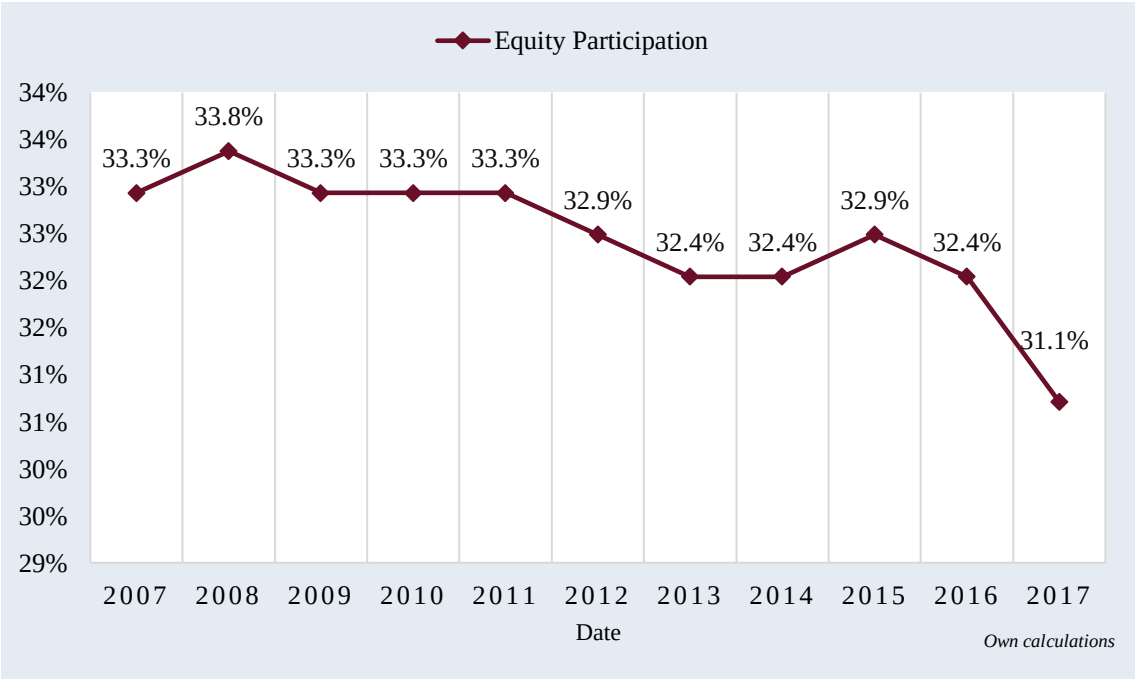


**Figure 1. Equity Participation Rate (%).** The figure plots the fraction of the sample that invested in the equity funds throughout the period under analysis, 2007-2017.

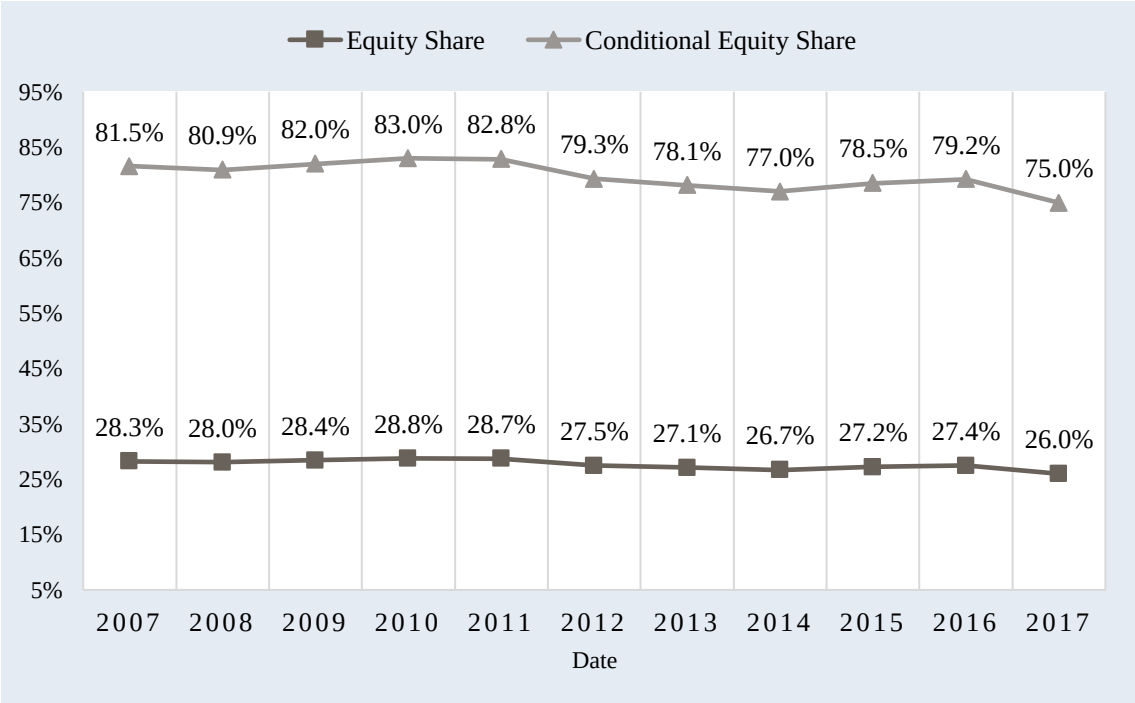


**Figure 2. Portfolio Equity Shares (%).** The figure plots the equity fractions of the portfolio of the total sample of individuals (equity share) and for those that had a positive investment in the equity funds (conditional equity share) from 2007 to 2017.

Moreover, the fraction of customers investing in equities slowly decreased, reaching 31.1% in 2017. Still, such result is higher than the average equity participation rate in Germany, which by 2017 was under 16% of the German households (DAI, 2018). This may arise because of a selection effect: when using portfolios at ERGO Group AG, the owners of these portfolios implicitly have an interest in private investments which may not be true for all German households, leading to an overestimation of the participation rate.

Another observation is that the participation rate does not change more than 3 percentage points throughout the whole decade. In particular, after the financial crisis shock, which is visible in the drop after 2008 in the returns of the DAX Index (Figure $K_1$ in Appendix K) the equity participation rate only fell by 0.5 percentage points. In contrast, from 2015 until 2017, the participation rate has registered a decrease higher than the one following 2008. Some authors suggested that the macroeconomic conditions might be suitable to explain such variations and have used lagged index stock returns to explain this behavior (Ameriks & Zeldes, 2004). Regardless of that, in this case, a negative correlation coefficient of -12% between the predecessor yearly DAX index returns and the changes in the sample participation rates suggests that these subjects may not be basing their decisions solely on the market place (Appendix E).

Pursuing a different approach, Sahm (2012) used the index of consumer index to explain changes in risk tolerance observed in hypothetical gambles. In Germany, this index is called "ZEW Indicator of Economic Sentiment" and contains the economic expectations of 300 financial experts for the next 6 months. However, observing the behavior of this index from 2007 to 2017 shows that there is no congruence between its changes and the variation in the participation rate (Figure $K_2$ in Appendix K). For example, when the economic outlook seemed to be most favorable, in 2013, the equity participation rate actually decreased from 2012 and remained constant for 2014. Equity shares and conditional equity shares also decreased in 2013.

Therefore, the overall trend of decreasing participation may be due to other reasons, such as an increase in the costs of participation over time owed to changes in risk perception (Curcuru, Heaton, Lucas, & Moore, 2010).

Figure 2 displays another striking aspect of the data: the disparity observed between equity shares and conditional equity shares. The low equity shares are driven by the 65% fraction of the sample that has not entered the equity market, making it a stronger case to study equity shares conditional on participation. Nonetheless, when individuals do invest in equities, they seem to allocate a considerably large portion of their portfolios to these assets. In fact, both variables seem to be strongly bimodal: the median equity share value is 0, but more than 50% of those that participate in the equity market choose to only contain equities in their portfolios (Appendix J). As proposed by Ameriks and Zeldes (2004), studying these individuals separately is necessary for an accurate understanding of the lifecycle equity behavior. Otherwise, a declining equity share with age may just be the consequence of an increasing likelihood of not investing in equity at all.

It should be noted once again that the patterns displayed in Figure 2 may not be completely due to customers' decisions to rebalance their portfolios. It may also be a consequence of a simultaneous price increase in the equity fund prices and price decrease of another fund class, or vice-versa.

Looking at the descriptive statistics for 2017 (Table $F_1$ in Appendix F), the average age is 51.6 years old. When it comes to gender, women have an equity participation rate of 33.3%, slightly above the 29.5% rate registered for the male subjects. The mean equity share also differs by 3%, with men investing 81%, and women 79% of their portfolios (Table $F_2$ in Appendix F).

The average portfolio value is €8,847, with 50% of the individuals holding less than €4,795. The average portfolio is divided into 40% mixed funds, 29% debt funds, 26% equity funds, and 5% money funds. This result is close to the composition of the German households' portfolio, which contained 29% allocated to shares and other equity fund investments in 2017 (Deutsche Bundesbank, 2018).

In sum, three main conclusions can be taken from this section. First, equity participation rates are considerably low, and have barely changed throughout the last decade. This is in accordance with the historical shares of German equity holdings, which have remained relatively constant since 2008. Nevertheless, while recently there has been an increase in the number of shareholders, the data shows evidence of a decreasing trend in the equity participation rate (DAI, 2018).

Second, individuals seem to have a preference for extreme choices: in 2017, 69% of the subjects had no equity in their investments while, at the same time, 21% had only equity in their portfolios. Overall, the equity investors invest a large proportion of their portfolios in equity funds. Third, there seems to exist slight gender differences in the equity investment choices, which is consistent with previous findings (Bertocchi, Brunetti, & Torricelli, 2011; Halko, Kaustia, & Alanko, 2012).

The cross-sectional summary statistics provide a solid overview of the evolution of the main variables of interest, but disregard how these change within the lifespan of the same individual. The next section decomposes the analysis in age, cohort, and time effects, and provides the results to the fundamental research question: *how do individual risky portfolio shares change with age?*

# 5 Results

This section is divided in two main parts. The first part presents the graphical evolution of both equity participation rates and conditional equity shares with age for each year of the sample. This analysis will depict if there is an age pattern for the whole collection of individuals at a single point in time, and whether this pattern is identical for each year of the sample. Nonetheless, in this arrangement, it is not possible to identify whether individuals born in different years have distinct investment preferences. For example, whether individuals aged 30 years old born in the 80s behave differently from individuals aged 30 years old born in the 70s. Therefore, the first part will end with an alternative representation of the age pattern that aims to identify whether there are visible birth cohort differences. The second part aims to formalize the graphical insights presented in the first part by fitting four different regressions to the data and by determining whether there is an inverted U-shaped lifecycle pattern.

Since there are two main variables of interest, a logit model is run for the *equity participation* followed by a panel regression of the *conditional equity share*. The departure model is as follows:

$$Conditional\ Equity\ Share_{it} = \alpha_i + \beta \cdot age_{it} + \varepsilon_{it} \quad (1)$$

where $Conditional\ Equity\ Share_{it}$ is the percentage of the portfolio of individual *i* at time *t*, $age_{it}$ is the age of the customer. Despite being a very simple specification, the $\beta$ coefficient will provide a good starting point to understand the effect of age. However, the age coefficient may include both the effect of getting older (age effects), changes in the environment that took place when the transactions happened (time effects), or differences arising from the behavior of unalike generations (cohort effects).

Adding dummies, $date_t$, for the different years covered in the analysis will allow the model to separate the age effects from the time effects. Consequently, the regression controls for economic booms and busts that may have influenced individuals' investment behavior throughout the last 10 years, and other time specific events that are not related to ageing. Thus, this specification imposes fixed time effects, and it is representative of the profiles depicted in Figures 3 and 4 in the following section.

$$Conditional\ Equity\ Share_{it} = \alpha_i + \beta \cdot age_{it} + \gamma \cdot date_t + \partial \cdot gender + \varepsilon_{it} \quad (2)$$

With the objective of determining whether there are substantial differences between the dates covered in the sample, a test of joint significance for the time effects in both dependent variables is included.

On a second moment, year of birth dummies, $cohort_i$, are added. This will allow the regression to distinguish between age and cohort effects. Due to the multicollinearity problem between age, date, and cohort, the year dummies have to be removed from this specification (Wooldridge, 2012, p. 468). Following the methodology of Poterba and Samwick (2001), a joint significance test is also applied so as to determine whether the differences imposed by the different birth years are significant. This specification imposes fixed cohort effects, and it is representative of the profiles depicted in Figures 5 and 6 in the following section.

$$Conditional\ Equity\ Share_{it} = \alpha_i + \beta \cdot age_{it} + \varphi \cdot cohort_i + \partial \cdot gender + \varepsilon_{it} \quad (3)$$

Finally, as previous findings have suggested that households' equity holdings follow an inverted U-shaped pattern peaking in the mid-end life years of an individual, a quadratic form regression is also presented (Poterba & Samwick, 2001; Coile & Milligan, 2009).

$$Conditional\ Equity\ Share_{it} = \alpha_i + \beta \cdot age_{it} + \delta \cdot age_{it}^2 + \gamma \cdot date_t + \varepsilon_{it} \quad (4)$$

In order to determine whether the hump-shaped pattern is significant, a likelihood ratio test is applied to the linear and quadratic specifications. Its results will identify the model that explains more variation in the dependent variables. The p-values for all the tests made are summarized in Appendix H.

## 5.1 Visualization of Age, Time, and Cohort Effects

Appendix G provides the participation rates and the mean conditional equity holdings grouped by age for each year of the sample. For both participation rates and conditional equity shares, figures 3 and 4 represent the age profiles with no cohort effects, while figures 5 and 6 assume no time effects.

Figure 3 depicts two peaks in the sample participation rates: the first one when individuals are between 27 and 32 years old and the second when they are between 52 and 62 years old. Approximately 60% of the total sample invests in the equity market within those age

brackets. Such behavior seems to be common to all the sample years. Nonetheless, it should be noted that for different years, different peaks in the participation rate emerge. Namely, the peak for the 2009 series occurs for subjects aged 52 years old, while in 2010 the individuals that registered the highest participation were 57 years old.

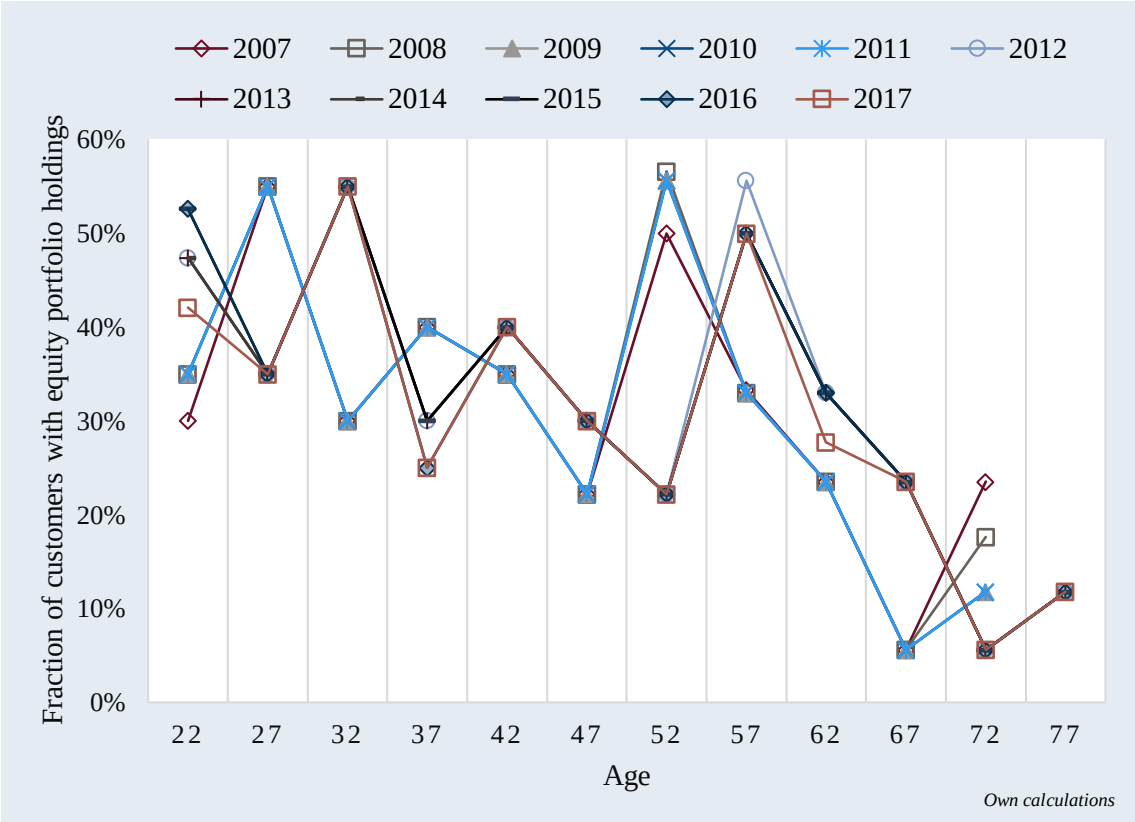


**Figure 3. Age and Time Effects in Equity Participation Rates.** The figure represents the age profile assuming no cohort effects in each of the years covered in the period under analysis. Each observation in the graph is equal to the fraction of individuals of the total sample that had investments in the equity funds at that point in time and at that age. Each observation includes individuals within a 5-year age group.

The time effects may be identified in the above graphical representation by fixing a given age and observing whether the participation rate varies for the different years. If every series provide congruent participation rates at that point, the time effects are not significant (Coile & Milligan, 2009). For instance, subjects aged between 30 to 35 years old in 2017 had a participation rate of 59%, but in 2014 only 30% of the individuals of the same age group invested in the equity market. Such result would support the existence of time effects. Nonetheless, the series seem to follow the same age profile, but with the fraction of individuals in the equity market in the years 2012, 2013, 2014, 2015, 2016,

2017 starting to decrease slightly later than the previous years. For example, in 2017 the minimum occurs at age 72 at 6%, and in 2011 the same drop occurs 5 years earlier.

The results are contradictory to Coile and Milligan (2009), who found that for households older than 55 years old in the United States, the equity participation rate was stable at around 30% for all the following ages. In this case, there is evidence of a decreasing age pattern as the participation rate starts to approach 0% for subjects aged 65 years old. However, the fraction of subjects participating in the equity market in the oldest age group seems to increase after the drop. Such observation might be related to the fact that the older population typically has higher financial wealth than younger individuals, who are still working to accumulate it. Furthermore, for the individuals who have limited funds investing into equities after retirement might have a crucial impact in the amount of financial wealth available in the later life stages (Poterba & Samwick, 2001).

In contrast, when looking at the conditional equity share in Figure 4, there are two worth-mentioning results. First, the magnitude of the time effects is smaller, as the range between the different sample years at each age decreases. Nonetheless, the series frequently crisscross each other, suggesting that the age pattern is not the same for each year.

Second, the conditional equity share is concentrated between 60% and 100% of the total portfolio for the whole period and individuals do not seem to be linearly decreasing their shares with age. Such result would mean that customers do not follow the typical advice provided by financial professionals. Moreover, tracing a line at 80% average equity share shows that there are no observations beneath it for the ages between 45 and 55 years old for any sample year. In contrast, for the individuals above and below the middle-aged group, the conditional equity share falls below 80%. For the years after 2015, individuals seem to enter a rapid increase in their equity share when they reach 40 years old. This fraction of the portfolio starts decreasing later on, from 55 years old onwards. Such result is similar to the findings of Guiso et al. (2003) who found evidence of an inverted U-shaped lifecycle pattern in equity participation peaking at 60 years old in Germany.

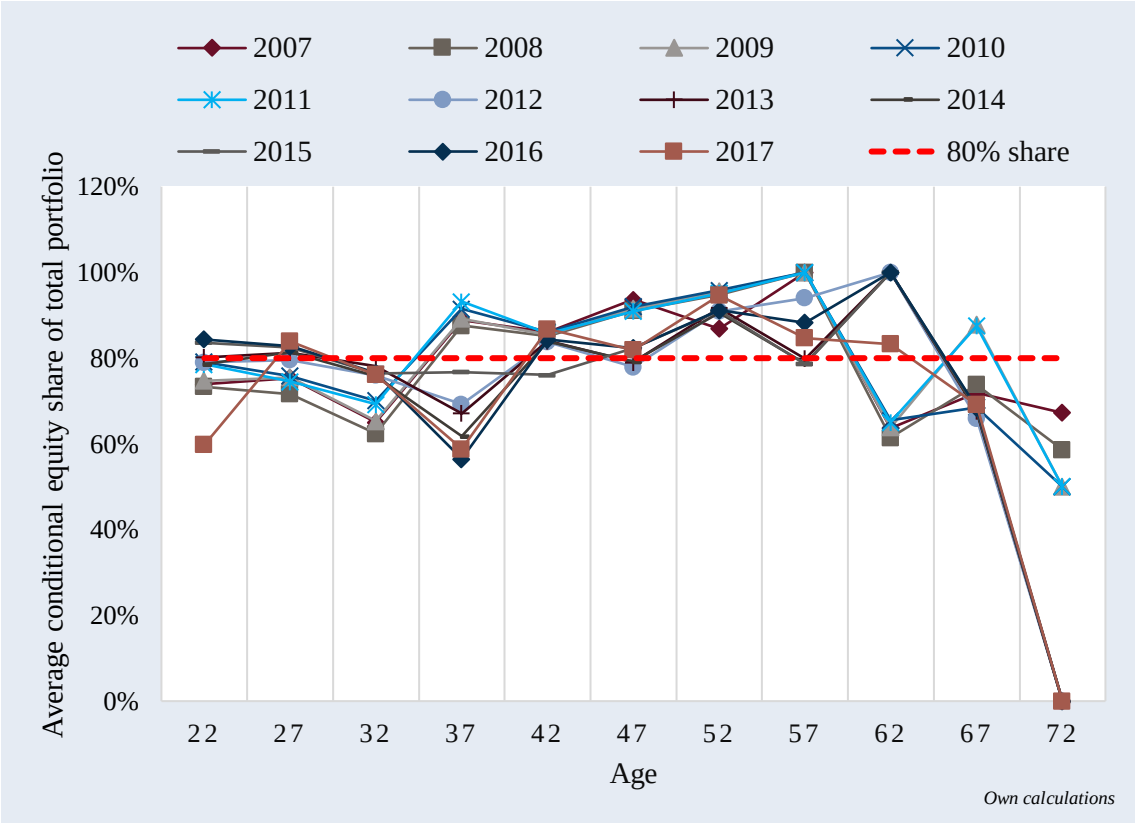


**Figure 4. Age and Time Effects in Conditional Equity Share.** The figure represents the age profile behind the conditional equity shares assuming no cohort effects in each of the years covered in the period under analysis. Each observation in the graph is equal to the mean of the equity shares for the equity funds' investors at that point in time and at that age. Each observation includes individuals within a 5-year age group.

In order to determine whether there are significant birth cohort effects, Figures 5 and 6 present the same data, grouped by birth year, instead of sample year. Similar to the procedure before, the cohort effects may be identified by the distance between the different birth year series at the same age (Coile & Milligan, 2009).

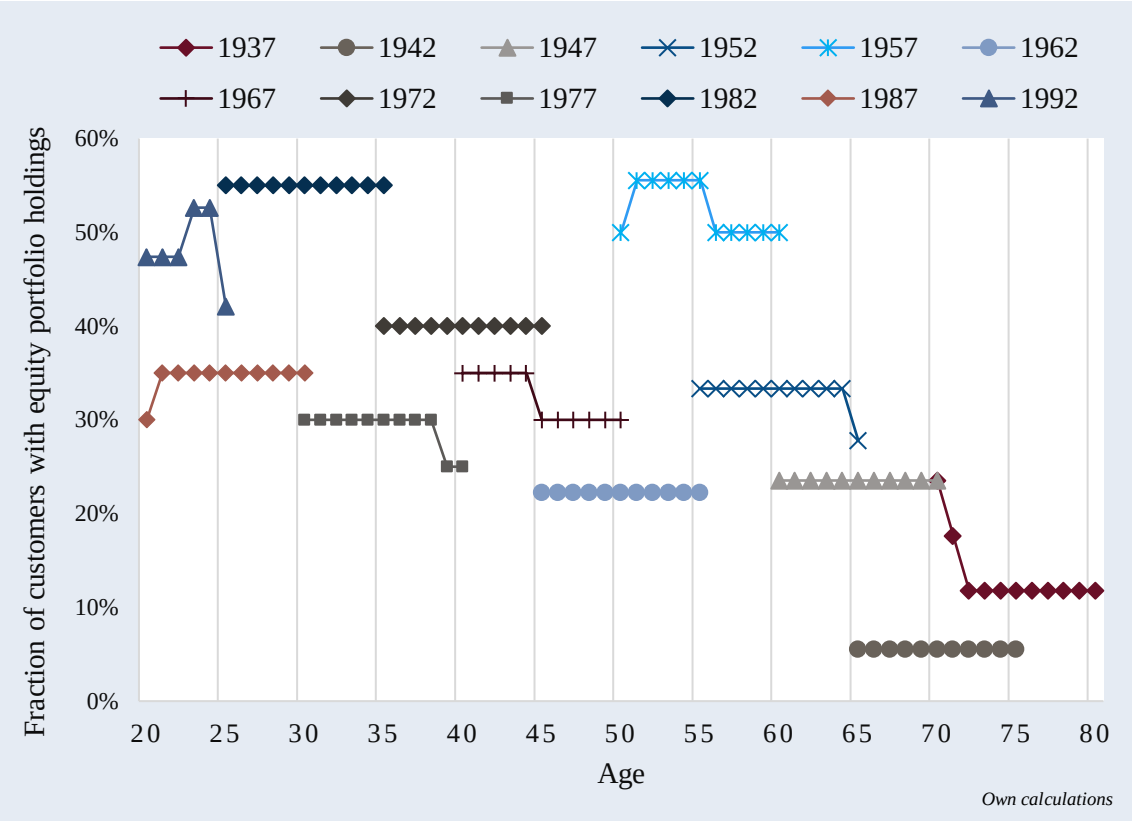


**Figure 5. Age and Cohort Effects in Equity Participation Rates.** The figure represents the age profile behind the equity participation rates assuming no time effects for each of the birth cohorts. Each observation in the graph is equal to the fraction of the individuals of the respective birth cohort that had investments in the equity funds at that age.

The birth cohort effects seem to have a considerable influence in the participation rate. For example, 50 years-old subjects born in 1962 have a participation rate of 21%, while those born five years later have a participation rate of 35%, and those born five years earlier, in 1957, have the highest participation rate, 50%. This is in opposition to the findings proposed by Spicer et al. (2016), who found that the probability of owning equities was higher for younger cohorts than for older cohorts in a sample of Australian retirees. Accordingly, one of the oldest cohorts, aged 65 to 75 years old during the last decade, registers the lowest participation rate of the sample.

Another striking observation is that most cohorts keep a constant participation rate throughout the complete 10-year period. It has been suggested that the probability of owning equities would decrease with age, and that such effect would be common to all birth cohorts (Coile & Milligan, 2009). In contrast, the individuals born in 1982, who were 25 to 35 years old in the period considered, have a participation rate constant at 55%

– the highest rate of all the cohort samples – and several other birth cohorts show evidence of a flat age pattern.

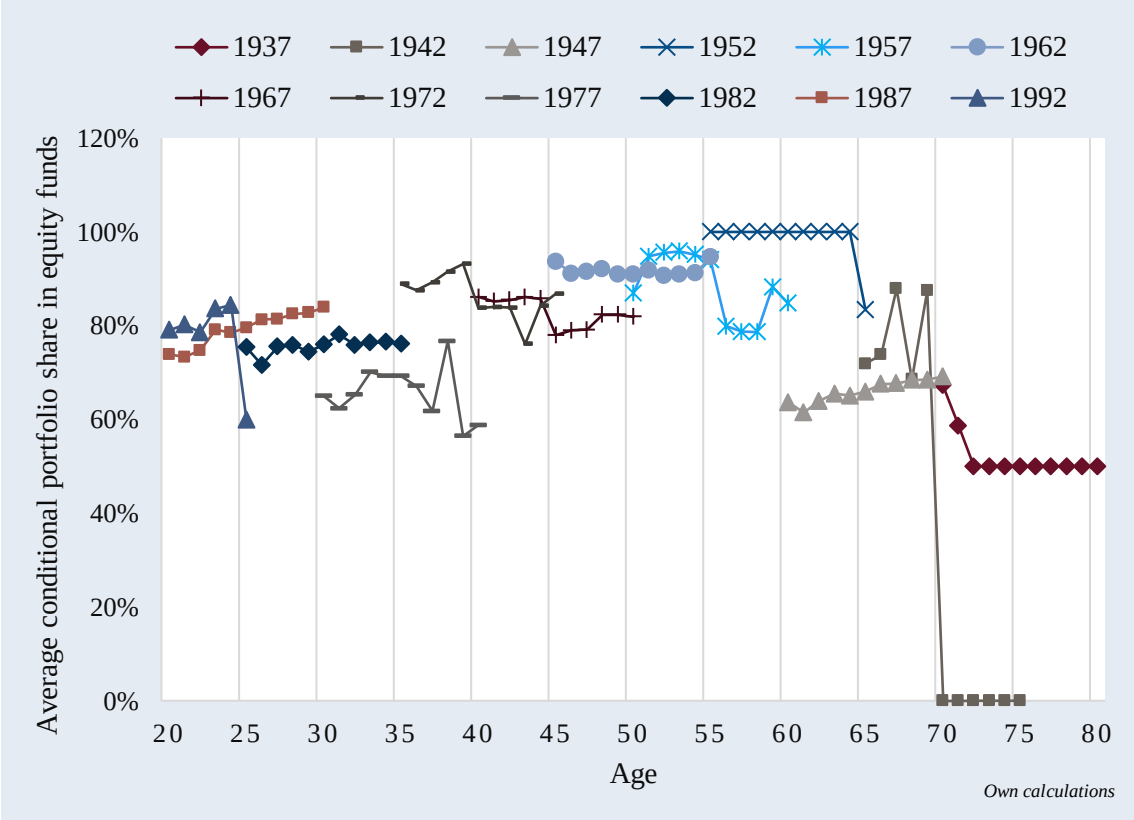


**Figure 6. Age and Cohort Effects in Conditional Equity Share.** The figure represents the age profile behind the conditional equity shares assuming no time effects for each of the birth cohorts. Each observation in the graph is equal to the mean equity share of the individuals of the respective cohort that invested in the equity funds at that age.

Concerning the conditional equity share (Figure 6), each of the time series behaves closely together at each age point, suggesting that the cohort differences may not be significant in this case. The next section will focus on investigating whether the graphical insights are indeed statistically significant in the different model specifications just mentioned.

## 5.2 Linear Regression Results for Equity Participation

The objective of this part is to formally separate age from time effects, and from cohort effects. Since equity participation is a binary variable, a logistic formulation is necessary in order to fit the results within the interval [0,1]. It is important to highlight that in this case the model is not considering the panel structure of the data. The reasoning behind this is that the individuals that have changed their decisions regarding their participation in the equity market represent an insignificant proportion of the total sample. Consequently, there is not enough variation within the subjects' lifetime to be explained by a panel regression. Therefore, the results presented concern a longitudinal logistic regression, which is time-varying but not grouped at the individual level. The results of the three different specifications concerning the equity participation variable are depicted on the left panel of Table 1.

Departing from **model (1)**, with a p-value below 0.001 it is possible to conclude that the effect of age in the equity participation rate is significant at a 99% confidence level, and that this effect is negative. Therefore, the null hypothesis is rejected at standard alpha levels in favor of hypothesis 1b – indicating that the likelihood of investing in equities decreases per each additional year of age.

The magnitude of this result is better understood when looking at its marginal effect (Table 2). Accordingly, per each percent change of age, the probability of entering the equity market decreases by 0.006 on a [0,1] scale, or 0.6%. Such result is in accordance with previous authors. Namely, Wu, Asher, and Thorp (2017) reported a decrease in the fraction of Australian retirees investing in equities at older ages. This result is also close to Spicer et al. (2015), who found that per each additional year of age, the likelihood of being in the equity market declines by 0.72 percentage points amidst the Australian pension population. Ooijen, Alessi, and Kalwij (2015) achieved similar effects in the Dutch portfolio holdings.

In the **model (2),** the dummies for each year covered in the analysis were added. This way, the age effects could be separated from the time effects. The marginal effect of age has only changed by 0.01%, which suggests that the decision to invest in equities is not influenced by any particular event that may have happened in the last decade. However, to statistically determine whether there are no time effects, the time dummies were tested

using a joint significance test. The p-value of a chi-squared test with 10 degrees of freedom is 0.9981. Since the p-value is higher than any standard alpha level, there is strong evidence to conclude that the fraction of individuals investing in equities does not change throughout the years covered in the sample, 2007 to 2017. Concluding, the null hypothesis 3, that time effects are not significant, is not rejected.

The second model also adds to the specification in model (1) by controlling for gender. Nonetheless, while previous findings have suggested that there would be considerable differences in the investment behavior between men and women (Bertocchi et al., 2011; Halko, 2012), the results on this variable are not significant. In this case, gender differences do not seem to explain the variation in equity participation rates.

**Model (3)** aims to separate age and year of birth effects. In specification (3), the age coefficient is still negative but no longer significant. This indicates that the age coefficients in the two models before were capturing the effect of the different birth years. Overall, there seems to be a positive birth cohort effect. However, certain birth cohorts, such as 1942, 1952, 1957, are significant at a 99% confidence level, while other birth years, namely 1972, do not seem to impact the decision to invest in equities. As previously suggested in the graphical representation of the different cohorts, their effect is not completely uniform. For example, being born in 1942 decreases the likelihood of investing in equities by 12 percentage points while being born in 1972 increases this probability by 21 percentage points, *ceteris paribus*.

Moreover, previous authors suggested that younger cohorts would participate less in the equity markets (Spicer et al., 2015). Confirming the observations in Figure 4, the results do not point to any increasing or decreasing cohort effect in equity participation rate. Individuals born in 1952 are more likely to invest in equities by 17 percentage points, which is higher than the marginal effect for the 1947 cohort by 9 percentage points. This would point in the direction of having a lower likelihood of investing in equities for younger cohorts. However, the trend is broken by the individuals born in 1967 whose marginal effect is smaller than the one for the years 1952 and 1957.

The joint significance test for the birth cohort dummies yields a chi-square with 11 degrees of freedom equal to 139.6, and a corresponding p-value lower than 0.001.

Therefore, the null hypothesis 2 of no birth cohort effects is rejected at a 99% confidence level.

In sum, there is an age effect that lowers the likelihood of investing in equities of approximately 0.6% per percent increase of age, which is supported at a 99% confidence level by both model 1 and 2, *ceteris paribus*. However, when disentangling age into time and birth year effects, the results point to a negligible influence of time. Moreover, when year of birth dummies are included in the third specification, the age coefficient is no longer significant. This suggests that the magnitude of the age effect evident in models (1) and (2) is fully explained by the different birth cohorts. In other words, the different equity participation rates seem to be explained by different generations, rather than different ages.

## Table 1
## Linear Model Parameters

The table reports the coefficients of the variables included in models (1), (2) and (3), as well as the respective standard errors in parentheses. The left side of the table displays the results for the logit regressions ran for the equity participation. The right side of the table present the results of the panel regression ran for the conditional equity shares.

| | Equity Participation | | | Conditional Equity Share | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (1) | (2) | (3) |
| | Age | Fixed Time | Fixed Cohort | Age | Fixed Time | Fixed Cohort |
| *Variables* | Effects | Effects | Effects | Effects | Effects | Effects |
| Age | -0.0260*** | -0.0264*** | -0.00934 | -0.00412*** | -0.00109 | -0.00607*** |
| | (0.00259) | (0.00264) | (0.0143) | (0.00133) | (0.00215) | (0.00169) |
| Date 2008 | | 0.0472 | | | -0.00540 | |
| | | (0.204) | | | (0.0251) | |
| Date 2009 | | 0.0527 | | | 0.00639 | |
| | | (0.205) | | | (0.0254) | |
| Date 2010 | | 0.0791 | | | 0.0177 | |
| | | (0.205) | | | (0.0259) | |
| Date 2011 | | 0.105 | | | 0.0174 | |
| | | (0.205) | | | (0.0265) | |
| Date 2012 | | 0.111 | | | -0.0173 | |
| | | (0.205) | | | (0.0272) | |
| Date 2013 | | 0.116 | | | -0.0277 | |
| | | (0.206) | | | (0.0282) | |
| Date 2014 | | 0.142 | | | -0.0377 | |
| | | (0.206) | | | (0.0292) | |
| Date 2015 | | 0.190 | | | -0.0216 | |
| | | (0.206) | | | (0.0304) | |
| Date 2016 | | 0.195 | | | -0.0138 | |
| | | (0.207) | | | (0.0316) | |
| Date 2017 | | 0.157 | | | -0.0549* | |
| | | (0.208) | | | (0.0330) | |
| Cohort 1942 | | | -1.159*** | | | -0.245 |
| | | | (0.387) | | | (0.337) |
| Cohort 1947 | | | 0.486 | | | 0.0993 |
| | | | (0.312) | | | (0.213) |
| Cohort 1952 | | | 0.895*** | | | 0.370* |
| | | | (0.340) | | | (0.195) |
| Cohort 1957 | | | 1.816*** | | | 0.212 |
| | | | (0.384) | | | (0.182) |
| Cohort 1962 | | | 0.261 | | | 0.242 |
| | | | (0.451) | | | (0.216) |
| Cohort 1967 | | | 0.785 | | | 0.116 |
| | | | (0.500) | | | (0.194) |
| Cohort 1972 | | | 1.077* | | | 0.115 |
| | | | (0.560) | | | (0.193) |
| Cohort 1977 | | | 0.448 | | | -0.125 |
| | | | (0.628) | | | (0.205) |
| Cohort 1982 | | | 1.576** | | | -0.0364 |
| | | | (0.689) | | | (0.191) |
| Cohort 1987 | | | 0.626 | | | -0.0156 |
| | | | (0.758) | | | (0.206) |
| Cohort 1992 | | | 1.205 | | | -0.0478 |
| | | | (0.824) | | | (0.200) |
| Gender | | 0.122 | 0.371*** | | -0.0925 | -0.0915 |
| | | (0.0886) | (0.0958) | | (0.0691) | (0.0719) |
| Constant | 0.461*** | 0.319* | -1.241 | 0.971*** | 0.897*** | 1.025*** |
| | (0.122) | (0.183) | (1.090) | (0.0659) | (0.0951) | (0.199) |
| Observations | 2,475 | 2,475 | 2,475 | 858 | 858 | 858 |
| Nr of ID | | | | 78 | 78 | 78 |
| R2 | 0.0337 | 0.0349 | 0.0845 | 0.0030 | 0.0259 | 0.1441 |

*** p<0.01, ** p<0.05, * p<0.1

## Table 2
## Logit Linear Model Margins

The table reports the marginal effect of the variables included in models (1), (2) and (3) for the logit regressions, as well as the respective standard errors in parentheses.

| *Variables* | **(1)** Age Effects | **(2)** Fixed Time Effects | **(3)** Fixed Cohort Effects |
|---|---|---|---|
| Age | -0.00549*** | -0.00556*** | -0.00186 |
| | (0.000508) | (0.000517) | (0.00283) |
| Date 2008 | | 0.00968 | |
| | | (0.0419) | |
| Date 2009 | | 0.0108 | |
| | | (0.0420) | |
| Date 2010 | | 0.0163 | |
| | | (0.0422) | |
| Date 2011 | | 0.0218 | |
| | | (0.0424) | |
| Date 2012 | | 0.0230 | |
| | | (0.0425) | |
| Date 2013 | | 0.0241 | |
| | | (0.0426) | |
| Date 2014 | | 0.0297 | |
| | | (0.0429) | |
| Date 2015 | | 0.0399 | |
| | | (0.0431) | |
| Date 2016 | | 0.0410 | |
| | | (0.0433) | |
| Date 2017 | | 0.0328 | |
| | | (0.0434) | |
| Cohort 1942 | | | -0.116** |
| | | | (0.0553) |
| Cohort 1947 | | | 0.0826* |
| | | | (0.0471) |
| Cohort 1952 | | | 0.168*** |
| | | | (0.0502) |
| Cohort 1957 | | | 0.389*** |
| | | | (0.0592) |
| Cohort 1962 | | | 0.0416 |
| | | | (0.0673) |
| Cohort 1967 | | | 0.144* |
| | | | (0.0792) |
| Cohort 1972 | | | 0.210** |
| | | | (0.0951) |
| Cohort 1977 | | | 0.0753 |
| | | | (0.101) |
| Cohort 1982 | | | 0.331** |
| | | | (0.130) |
| Cohort 1987 | | | 0.110 |
| | | | (0.130) |
| Cohort 1992 | | | 0.240 |
| | | | (0.160) |
| Observations | 2,475 | 2,475 | 2,475 |

*** p<0.01, ** p<0.05, * p<0.1

## 5.3 Linear Regression Results for Conditional Equity Share

When investigating how the equity shares change within the sample of equity investors, there is enough variation within the lifecycle of each individual. Thus, the results presented in this part are subject-specific. The objective is to determine whether there is a decreasing age pattern in the equity share as customers age. The previous three models are reapplied to the conditional equity shares and ran with random fixed effects, as suggested by the results of the Hausman test. The results for all the three econometric models are displayed on the right panel of Table 1.

As far as **model (1)** is concerned, age is significant at a 99% confidence level, with a p-value equal to 0.002. The coefficient is negative, meaning that an individual will decrease its equity by 0.41% for each year he ages. Interestingly, this result is very close to the result found by Spicer et al. (2015), who reported that per each additional year of age, individuals would decline the fraction of the portfolio allocated to equities by 0.42%.

Nonetheless, when adding date dummies to **model (2),** the age coefficient, despite still being negative, is no longer significant. This result seems to suggest that the time effect was being absorbed by the coefficient of the age variable in model (1). However, when running a joint coefficient test for the date dummies, these are not significant, which make the results obtained somewhat puzzling. The hypothesis that there are no time effects is thus not rejected at standard significance levels.

Knowing that the age coefficient in model (1) includes age effects, time effects, and cohort effects, and that age and time effects are not significant, then it would be reasonable to expect that the cohort differences are behind the magnitude of the age coefficient in model (1). Nevertheless, when the birth year dummies are added to **model (3),** these are jointly not significant, with a p-value of 0.17. Additionally, the age coefficient emerges as significant once again. This time, for each year that an individual ages, his equity share will decrease by 0.6%, *ceteris paribus.* Therefore, there seems to be an element missing that is related to the period of observations and that absorbs the significance of age in (2), but that is not explained by the different sample years in (2) nor by the different generations in (3). At last, gender is not significant in any of the models.

In sum, all the three specifications largely confirm that the likelihood of investing in the equity market and the portfolio equity share decreases with increases in age. Yet, when breaking down age in birth cohort and time effects, the significance of the age effects changes considerably between the dependent variables. The different birth cohorts explain a significant portion of the variation in the likelihood of investing in the equity market. This portion also accounts for the significance of the age coefficient when birth cohorts are not included in models (1) and (2). On the other hand, for the conditional equity shares, the birth years seem to have no influence.

As far as time effects are concerned, neither the probability of investing in equity funds nor the conditional equity shares are influenced by period differences. Such result is remarkable seeing that between 2007 and 2017 there were considerable fluctuations in the financial markets. Table 3 summarizes the contrasting results for both dependent variables.

**Table 3**
**Significance of Birth Cohort Effects and Age Effects**

The table organizes the three different models for each of the dependent variables in terms of the statistical significance obtained for the birth cohort dummies, and for the age coefficients. The results of the age effects are obtained through one-tailed t-test, while the conclusions for birth cohort effects are reached via a joint significance test. The models that fall under the *Uncertain* do not include birth cohort dummies, and thus their effect is inconclusive.

| | | **Birth Cohort Effects** | | |
|---|---|---|---|---|
| **Age Effects** | | *Significant* | *Uncertain* | *Not significant* |
| | *Significant* | None | Conditional Equity Share and Equity Participation (1); Equity Participation (2) | Conditional Equity Share (3) |
| | *Not significant* | Equity Participation (3) | Conditional Equity Share (2) | None |

One important point of the aforementioned regression results is that they are based on a linear formulation. In order to verify whether the age pattern is better described by an

inverted U-shaped curve, the next section investigates which form – linear or quadratic – explains the most variation in the lifecycle pattern of individuals' equity participation rates and portfolio shares.

## 5.4 Quadratic Regression Results

Figure 7 suggests that the fraction of one's portfolio allocated to equity peaks for individuals between 40 and 50 years old. In this scenario, age would have a positive impact in the early life stages.

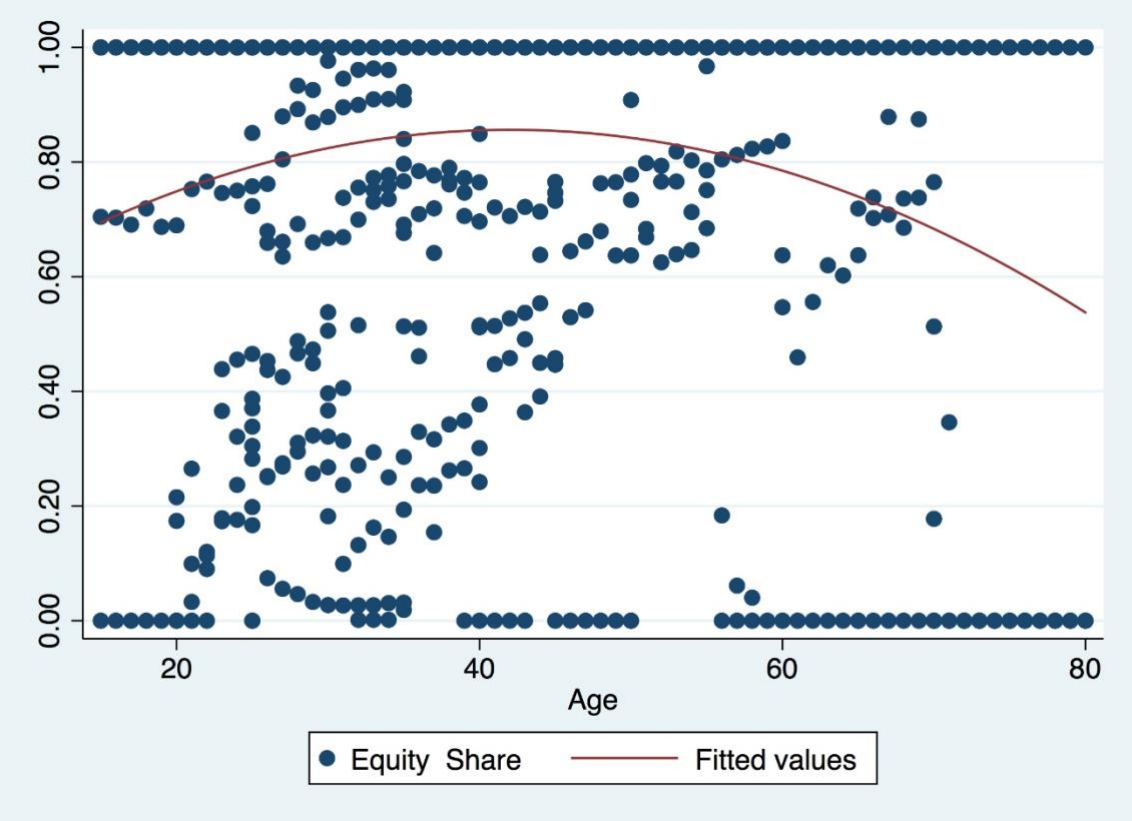


**Figure 7. Graphical Evidence of a Hump-shaped Pattern in Conditional Equity Shares.** The figure describes the conditional equity shares of the portfolios belonging to the individuals that invested at least once in the equity funds in the 10-year period under analysis. The pattern obtained disregards the panel data structure of the observations.

In order to formalize this result, a new variable, the square of age, was added to specification (2). The same prediction was estimated for the participation rate. The results are presented in Table 4.

**Table 4**
**Quadratic Model Parameters**

The table displays the coefficients obtained for the quadratic logit regression for the equity participation, and for the quadratic panel regression for the conditional equity share. The specification used controls for period effects only. This means that the results may still be influenced by generational effects, which are not included due to the multicollinearity between age, period, and birth year. Since the main interest lies in the coefficients of *Age*, and *Age squared*, the remaining variables were omitted. The standard errors are shown in parentheses.

| | (4) | (4) |
|---|---|---|
| *Variables* | Equity Participation | Conditional Equity Share |
| Age | 0.0348** | 0.00961** |
| | (0.0153) | (0.00488) |
| Age squared | -0.000670*** | -0.000118** |
| $R^2$ | 0.0397 | 0.0365 |

*** p<0.01, ** p<0.05, * p<0.1

The first observation is that, in this model, the coefficient of age is now positive. However, the coefficient of age squared is negative. In particular, in the equity participation specification, per each percent change in age, the probability participating in the equity market will increase by 0.7%. Nonetheless, at a given point in their lifecycle, such likelihood will slowly start to decrease by 0.01 percentage points with marginal changes in age, *ceteris paribus*. Both coefficients are statistically significant: age at a 95% confidence level, and age squared at a 99% confidence level.

**Table 5**
**Logit Quadratic Model Margins**

The table displays by how much the likelihood of investing in the equity funds changes with each percent change in age. The standard errors are presented in parentheses.

| Variables | Margins |
|---|---|
| Age | 0.00732** |
| | (0.00322) |
| Age squared | -0.000141*** |
| | (3.45e-05) |
| Observations | 2,475 |

*** p<0.01, ** p<0.05, * p<0.1

The quadratic model for the equity participation predicts that when individuals are 26 years old, they are the most likely to enter the equity market. In particular, in 2017, the probability of investing in the equity funds for subjects at this point in the lifecycle equals 79%. Interestingly enough, the likelihood of participating in the risky investments is never equal to 100% at any moment in the lifecycle.

The direction of the age effect for the second variable, *conditional equity share*, is identical. Holding every other variable constant, the fraction of the portfolio allocated to equity funds will increase by 0.01, or 1%, per each additional year of age. Yet, the square of age captures the negative effect of ageing, and signals that the share will slowly decrease by 0.2%, per each additional year of age. Both coefficients are significant at a 95% confidence level. According to this specification, the conditional equity share reaches its peak when an individual is 41 years old. In particular, in 2017, it is predicted that for a 41-years-old customer, equity equals 78.4% of his total portfolio. Previous research findings reached similar conclusions. Namely, for a sample of U.S. households it was found that the equity allocation of the portfolio would rapidly increase until 40 years old, reaching its peak, and then it would decrease at a slower rate (Samwick & Poterba, 2008).

In sum, the positive sign of "age" is capturing the increase in both equity participation and portfolio equity shares in one's lifecycle, which, as suggested in Figure 7, occurs in the early life stages. On the other hand, "age squared" is representative of the hump-shaped age pattern, which indicates that at some point in the lifecycle, the negative effect outweighs the positive effect of "age", causing the likelihood of individuals participating in the equity market, as well as the conditional equity share, to decrease.

In order to verify whether such inverted-U shaped lifecycle pattern is significant, the quadratic specifications before were compared to the equivalent linear form presented in the previous section, in model (2). This time, gender, which was found not to be statistically significant with time fixed effects, is omitted. Through a likelihood ratio test, it is possible to identify which of the formulations explains the most variation in the dependent variables. The null hypothesis in model (4) of such tests is that the smaller formulation of the model is the best fit.

For the equity participation, the test statistic equals 16.9 with a p-value for a chi-squared test with one degree of freedom equal to less than 0.0001. Therefore, it is possible to reject the null hypothesis 4 and to conclude that adding the square of age results in a significant improvement of the fit of the model with a 99% confidence interval. For the equity share, the conclusion is very similar. The p-value for a chi-squared of 5.25 with one degree of freedom is 0.022, which indicates that the square of age is improving the goodness of the model fit at a 98% confidence interval.

## 5.5 Discussion

The first issue that should be addressed when discussing the results obtained is the low R squared of the regressions. Effectively, this means that the chosen models capture a weak amount of the variation in the dependent variables. This, however, comes as no surprise since the specifications provided are very simplistic. There are several other variables that have been proven to have an influence in the portfolio risky allocations: marital status, education, employment status, home ownership, health status, financial knowledge, and so on and so forth (Sahm, 2012). The impossibility to control for these variables decreases the explanatory power of the models. Yet, the objective of this study consists in exploring the relation between age and the dependent variables, rather than testing the accuracy of a complete model.

The following section aims to provide explanations for the results found. These explanations are based on historical events and past literature findings. Since it is not possible to test their validity within the dataset used, they are highly speculative and should be interpreted with caution. Special emphasis will be made on the negative linear age coefficient, on the overall insignificance of time effects, on the joint significance of generational effects in equity participation, and finally on the better fit of the quadratic model in relation to the linear form.

Malkiel (1996) was one of the first authors to advocate that the fraction of the portfolio allocated to equities should be decreasing with age, in particular when individuals approach retirement. It seems that as individuals get older, their risk aversion increases (Bakshi & Chen, 1994). These ideas are strongly connected since it is possible to compute a measure of risk tolerance that equals the ratio of risky assets to total portfolio wealth (Wang & Hanna, 1997). Since volatility is a measure of risk, risky assets are the most volatile assets in the portfolio. Therefore, the sum of stocks could be used as a proxy for risky holdings (Baksi & Chen, 1994; Morin & Suarez, 1983). Thus, the ratio between equities and the total portfolio value is effectively a measure of risk tolerance. In this thesis, this ratio is represented by the dependent variable: conditional equity share.

In simple terms, finding that the conditional equity shares are decreasing with age suggests that the relative risk aversion is increasing. In fact, the correlation between the fraction of debt held in the portfolio and age is equal to 16% in 2017. Thus, there is a

positive age effect associated with the share of the portfolio allocated to debt funds, considered safe assets in this analysis. However, it is also possible that individuals decrease their risky holdings with age because they received the advice to do so. At ERGO, approximately 46% of the total number of customers receive advice from asset managers. Yet the dataset does not allow to identify what asset class and what allocation customers were advised to follow, neither whether indeed the subjects followed it.

Another possible justification for the increasing risk aversion is that individuals' likelihood of recovering from a stock market crash or a large loss decreases per each additional year of age (Kurt, 2008). Customers at ERGO seem to be aware of these odds.

Nonetheless, contrary to this idea, the data in this analysis shows that individuals are not particularly moved by market shocks – period effects are jointly not significant. This provides further evidence that the sampled subjects are not adjusting their equity allocations every year. This behavior can be either due to portfolio inertia, or to a certain degree of independence between the investment decisions and market fluctuations. This finding is particularly striking since the period from 2007 until 2017 comprises two crucial moments in financial history: the financial crisis of 2008 and the European sovereign debt crisis in 2011.

Recalling Figure 1, there was a small decrease (approximately 5%) in the number of customers investing in equities after the years 2008 and 2011. The insignificance of joint time effects, however, tells us that the likelihood of a subject investing in equities did not considerably change throughout this time. Interestingly enough, it has been shown that German households do not significantly alter their stock market participation upon an exogenous increase in the risky asset's return (Huck, Schmidt, & Weizsäcker, 2015). This would explain the low impact of the 2008 financial crisis. Furthermore, Germany was one of the European countries that since 2010 managed to establish an even more prosperous economy than its neighbors. By dominating trade within the Eurozone with large exports, the economy was barely affected by the sovereign debt crisis that by 2011 had taken its toll in countries such as Greece, Ireland, Spain, and Portugal (Young & Semmler, 2011). This would explain the low impact of the sovereign debt crisis.

When it comes to the different portfolio holdings between generations, Curcuru et al. (2010) have outlined several explanatory reasons: labor income, restricted pension

investments, and costs of learning about the market. In particular, the stock market behavior and the exposure to intense stock advertising periods during the first years of one's career have been reported as possible drivers of birth cohort differences (Poterba & Samwick, 2009). The purpose of the following analysis consists in understanding whether the major events in the German stock market described in Section 2 match individuals' equity behavior during the early working years of their lives.

Starting with cohort 1942, individuals from this cohort were 65 to 70 years old in the period covered in the analysis. This birth cohort is the only one with a negative significant coefficient in the equity participation in model (2), meaning that customers born in this year are less likely to invest in the equity funds than the remaining ones. Previous authors have shown that risky holdings particularly decrease during the retirement phase (Fagereng et al., 2017). This finding may explain the negative coefficient obtained in the 1942 cohort only, since this is effectively the oldest cohort included in the analysis (Fagereng et al., 2017). Furthermore, when individuals born in this cohort were in the early years of their working lives, around 1972, the stock market in Germany was still rather unpopular. It was only during this cohort's teenager years that the stock exchange in Germany started showing signs of is recovery from the drastic fall in prices following the war (Deutsche Börse, n.d.).

Individuals from the cohorts 1952 and 1957 have a positive and significant influence in the likelihood of investing in the equity funds. Subjects belonging to these groups were 30 years old between 1979 and 1989. During these years, the German stock exchange witnessed several changes that may have incentivized individuals to start placing their trust on the stock market. Some of the major events advertising in favor of the exchange include the approval of equity options trading by the Federal Republic of Germany in 1983, the birth of the DAX index composed by 30 blue-chip German companies in 1988, and the arrival of futures contracts in 1990 (Deutsche Börse, n.d.).

The next significant birth cohort is 1972. Subjects born in this year hit their 30s in 2002. Not only did the dotcom bubble burst in 2001, but also the *Neuer Markt* segment was abolished in 2002 (Burghof & Hunger, 2003). These two major events damaged investors' trust in the equity market. Nonetheless, the coefficient associated with this birth cohort, even though it is less than the previous cohorts, is still positive – indicating that

these subjects are still more likely to invest in equities than, for example, individuals born in 1942.

The last significant cohort is given by the individuals born in 1982. These subjects were 30 years old in 2017 and have probably achieved the stability to take the risk of investing in equity funds. It is thus a reasonable result that the coefficient associated with this birth year is positive.

It is possible that the *Riester-Rente* incentives to pursue private savings plans have started to induce behavioral adjustments for the individuals born in 1972 and 1982, leading to the positive coefficient associated with these groups. Interestingly enough, the individuals born in the 1960s, who would be more exposed to the intense stock advertising period during the privatizations of Deutsche Post and Deutsche Telekom, do not appear to be significant for any of the variables of interest.

Lastly, the quadratic specification appears to explain more variation in both conditional equity shares and likelihood of investing in equities. Effectively, middle-aged young adults have accumulated a level of wealth that allows them to allocate a higher portion of their portfolios to stocks and still recover from a possible market drop before their retirement (Guiso et al., 1996*)*.

# 6 Conclusion

With increasingly lower interest rates, an ageing population, and a strong incentive towards privately secured pension plans, understanding individuals' investment preferences becomes an essential point for financial advisors and economists. One crucial aspect consists of knowing how individuals are allocating their portfolios and whether they have been adjusting their risky investments to the changing environment. In Germany, this behavior is particularly interesting due to the traditional low interest in the stock market, and the low returns on large savings portfolios relative to other countries in the Eurozone (Allianz SE, 2016). Recalling the main research question, this thesis was concerned with investigating *how individual's risky portfolio holdings change with age.*

On the one hand, financial advisors have advised their clients to reduce the risky component of their portfolios as they age. This way, customers are protected against unrecoverable losses in retirement. On the other hand, previous authors have built models of optimal portfolio choice that lead to the conclusion that the risky asset holdings should remain constant throughout the lifetime. However, the results begin to differ when the underlying assumptions of these models start being broken apart. The ambiguity in the results is strengthened by the several empirical research studies in which authors have used different methodologies, definitions, and geographies to investigate individuals' risky portfolio assets. In these studies, one major problem is the lack of a dataset that is free of self-reporting biases and that accurately tracks individuals' portfolios throughout an uninterrupted period of time. Another concern is the impossibility to separate age from time and cohort effects, meaning that the reported age patterns usually conceal changes in the economic environment or generational changes.

To answer the research question, this thesis used the portfolios of 225 costumers at ERGO Group AG, a German insurance company, and followed their evolution during the period between 2007 and 2017. This sample size allows to draw conclusions on the number of ERGO customers born between 1997 and 1934 with a 6.51% margin of error. As for the German population, the sample size allows to make inferences on the population born between 1997 and 1934 with a 6.53% confidence interval. The previous sections present descriptive evidence on the evolution of the probability of owning equities and respective portfolio allocations throughout individuals' life cycles. The objectives of this thesis were first, to investigate whether the age profile observed in the sample matched the theoretical

predictions of well-established lifecycle models. Second, to compare the results obtained in the analysis with the practical insights attained by other authors in distinct geographies. Third, to isolate the time and cohort effects, in order to verify whether there is an age pattern that is common to all the individuals in the sample, and whether this pattern is decreasing as financial advisors propose.

The first conclusion is that the data on risky portfolio holdings seem to vary greatly within the individuals in the sample. The majority does not invest in any equities, while at the same time others invest in equity funds almost exclusively, some even at older ages. Furthermore, the equity participation rate is decreasing. This goes against the belief that German households would increase their engagement with the stock market due to the low interest rate environment. Moreover, although the annual report on household wealth and finances in Germany from Deutsche Bundesbank (2018) suggests an increase in the equity portfolio component, the average conditional equity share of the total sample remains quite stable from 2007 until 2017.

The second conclusion is that the risky share is not stable throughout the lifecycle as initially suggested by the economic models of Merton (1969) and Samuelson (1969). Instead, evidence points to a negative age effect in both participation rates and in the equity portfolio share, indicating that individuals move away from risky assets as they age. Despite being significant, the age coefficients are very close to zero and suggest that the equity behavior does not change considerably per each additional year of age. This is similar to what Guiso et al. (2003) previously reported for a sample of German investors. This finding, however, may also be hiding the impact of the advice provided by financial planners.

The age effect found in the sample is also in accordance with the findings reported for different countries. The analysis of Poterba and Samwick (2001), Coile and Milligan (2009) in the United States, Spicer et al. (2016) in Australia, and Van Ooijen et al. (2015) in the Netherlands also point to decreasing risky investments with age. The results may be anchored in the historical investment context in which subjects made their equity portfolio decisions (Poterba & Samwick, 2001). Furthermore, this effect can also be due to an increasing loss aversion with age (Coile & Milligan, 2009).

Another point addressed throughout this research are cohort and time effects. These effects are linearly connected with age, and may often spoil the predicted lifecycle behavior. Coile and Milligan (2009) excluded time effects. The authors found evidence of significant birth cohort differences in equity ownership but that the negative effect of aging would prevail nonetheless. On the other hand, Poterba and Samwick (2001) also excluded time effects but found no cohort effects in the likelihood of owning equities and neither in the portfolio share allocated to this asset class. Malmendier and Nagel (2011) excluded cohort effects instead, and reported that when subjects went through low periods of stock returns, they held lower stock investments in their portfolios during the lifecycle.

The results presented in this analysis show that the age effects vary considerably when controlling for time effects or cohort effects. The behavior of individuals of a certain birth year is not equivalent to that of other cohorts at the same age. However, this effect is not identical for the two variables of interest. The differences in cohort are associated with the differences in equity participation rates, but not in the fraction of the portfolio allocated to equities.

The key takeaway is that different generations have distinct probabilities of investing in equities. These differences are of such relevance that, when accounted for, the age effect becomes negligible. Nonetheless, once individuals decide to invest in equities, the year in which they were born is no longer important and the age differences explain the variation in the portfolio equity shares.

Time effects, on the other hand, do not seem to be largely significant for any of the variables. This result strengthens the idea that German investors do not guide their investment decisions by the fluctuations in the market economy (Huck et al., 2015). However, it also makes the results less plausible since the sample period includes two of the most crushing financial crises of the last decade: the financial crisis of 2008 and the European sovereign debt crisis.

Further research is needed in order to accurately identify the time trends that have motivated the differences in equity portfolio shares and the cohort differences that are associated with the probability of holding equities. Parameterizing the time and cohort effects with other variables may provide a better solution for the multicollinearity problem between age, time, and birth cohort. For Germany, experimenting alternative

proxies of time effects could provide novel insights into the societal changes that underline the age pattern of this geography as investors do not seem to be moved by changes in the stock market returns.

Moreover, a decrease in the equity fraction of the portfolio has to necessarily lead to an increase in the fraction of another asset class. In particular, the age pattern has been reported to vary for other classes of financial assets, such as tax-exempt bonds (Samwick & Poterba, 2001). Such differences are likely to be related to the underlying risk of the investment. Older households, for instance, seem to have a preference for more liquid assets (Coile & Milligan, 2009; Spicer et al., 2016). Therefore, a future area of research would be to verify whether customers at ERGO do indeed move towards safer, more liquid investment funds as they age.

Lastly, it would further be interesting to examine to what extent the decisions of customers at ERGO are influenced by the financial advice received. It is crucial to understand whether individuals are decreasing their equity shares because they age, or because they have been recommended to do so.

On a final note, the final conclusion extends beyond the negative linear effect of age. This thesis provides evidence that the likelihood of participating in the equity market and the fraction of the portfolio allocated to equities follow an inverted U-shaped age pattern. The quadratic age profile predicts that individuals aged 26 years old are the most likely to enter the equity market, while the portfolio equity share peaks at 41 years, beginning to decrease thereafter.

The main implications of these results are two-folded. First, this research sheds light on the impossibility to draw conclusions on the age profiles without accounting for differences within generations. Such distinction is noteworthy because the equity market will reflect the age profile of the most numerous birth cohort. For an ageing population, this will result in a stronger representation of the behaviors of older generations. Researchers ought to consider these differences in the future. Second, the results obtained have an important managerial implication. Knowing when customers are most likely to invest in equities and when they will allocate the most of their portfolios to this asset class allows financial advisors to market their products at the most relevant stages during the

lifecycle of their clients. All in all, a "100 minus your age"-rule does not seem to capture the complexity behind individuals' risky holdings.

# Reference List

Abel, A. B. (2001). Will bequests attenuate the predicted meltdown in stock prices when Baby Boomers retire? *Review of Economics and Statistics*, *83*(4), 589-595.

Allianz SE. (2016). *Financial assets of private households in Germany*. Retrieved from https://www.allianz.com/v_1411637334000/media/economic_research/research_data/english_documents/wealth_of_private_households_in_germany/FinassphG.pdf

Ameriks, J., & Zeldes, S. P. (2004). How do household portfolio shares vary with age. *Working paper, Columbia University*.

Annuß, C. (2017). German households' portfolio decisions and balance sheet dynamics from a monetary policy perspective. *Deutsche Bundesbank*. Retrieved from https://www.bis.org/ifc/events/ifc_isi_2017/09_annuss_paper.pdf

Apergis, N. (2015). Financial portfolio choice: Do business cycle regimes matter? Panel evidence from international household surveys. *Journal of International Financial Markets, Institutions and Money*, *34*, 14-27.

Bajpai, P. (2016, March 23). World's Top 10 Insurance Companies. Retrieved June 20, 2018, from https://www.investopedia.com/articles/personal-finance/010715/worlds-top-10-insurance-companies.asp

Bakshi, G. S., & Chen, Z. (1994). Baby Boom, population aging, and capital markets. *The Journal of Business*, *67*(2), 163-202.

Bergantino, S. (1998). *Life cycle investment behavior, demographics and asset prices* (Doctoral dissertation). Retrieved from MIT Theses.

Bertocchi, G., Brunetti, M., & Torricelli, C. (2011). Marriage and other risky assets: A portfolio approach. *Journal of Banking and Finance*, *35*(11), 2902-2915.

Borsch-Supan, A., & Brugiavini, A. (2001). Savings: the policy debate in Europe. *Oxford Review of Economic Policy*, *17*(1), 116-143.

Brooks, R. (2004). The equity premium and the baby boom. *Econometric Society 2004 North American Winter Meetings*, *155*.

Burghof, H., & Hunger, A. (2003). Access to stock markets for small and medium-sized growth firms: The temporary success and ultimate failure of Germany's Neuer Markt. *Social Science Research Network Article*. Retrieved from https://ssrn.com/abstract=497404

Börsch-Supan, A. (1996). The impact of population aging on savings, investments and growth in the OECD area. In *Future global capital shortages: Real threat or pure fiction?*(pp. 103-141). Paris: OECD.

Börsch-Supan, A., & Essig, L. (2003). Stockholding in Germany. *Stockholding in Europe*, 110-138.

Börsch-Supan, A., Reil-Held, A., & Schnabel, R. (2002). Chapter 3 - Household saving in Germany. In A. Börsch-Supan (Ed.), *Life-cycle savings and public policy: A cross-national study of six countries* (1st ed., pp. 149-203). Elsevier.

Börsch-Supan, A., & Winter, J. (2001). Population aging, savings behavior, and capital markets. *National Bureau of Economic Research Working Paper*, *8561*.

Campbell, J. Y., & Viceira, L. M. (1999). Consumption and portfolio decisions when expected returns are time varying. *The Quarterly Journal of Economics*, *114*(2), 433-495.

Campbell, J. Y., & Viceira, L. M. (2003). Chapter 7: Investing for retirement. In *Strategic asset allocation: Portfolio choice for long-term investors* (pp. 171-172). Oxford University Press.

Cardak, B. A., & Wilkins, R. (2009). The determinants of household risky asset holdings: Australian evidence on background risk and other factors. *Journal of Banking & Finance*, *33*(5), 850-860.

Chiappori, P., & Paiella, M. (2011). Relative risk aversion is constant: evidence from panel data. *Journal of the European Economic Association*, *9*(6), 1021-1052.

Coile, C., & Milligan, K. (2009). How household portfolios evolve after Retirement: The effect of aging and health shocks. *Review of Income and Wealth*, *55*(2).

Cottrell, C. (2016, February 12). Why are Germans afraid of the stock market? *Deutsche Welle*. Retrieved from https://www.dw.com/en/why-are-germans-afraid-of-the-stock-market/a-19044578

Curcuru, S., Heaton, J., Lucas, D., & Moore, D. (2010). Heterogeneity and portfolio Choice: Theory and evidence. *Handbook of Financial Econometrics: Tools and Techniques*, 337-382.

Dammon, R. M., Spatt, C. S., & Zhang, H. H. (2004). Optimal asset location and allocation with taxable and tax-deferred investing. *The Journal of Finance*, *59*(3), 999-1037.

Deutsche Bundesbank. (2015). *German households' saving and investment behaviour in light of the low-interest-rate environment* (13). Retrieved from

https://www.bundesbank.de/Redaktion/EN/Downloads/Publications/Monthly_Report_Articles/2015/2015_10_households.pdf?__blob=publicationFile

Deutsche Bundesbank. (2018). *Annual Report 2017*. Retrieved from https://www.bundesbank.de/Redaktion/EN/Downloads/Publications/Annual_Report/2017_annual_report.pdf?__blob=publicationFile

Deutsche Börse AG. (n.d.). *Deutsche Börse celebrates an anniversary: A chronology of efficient markets*. Retrieved from http://deutsche-boerse.com/blob/2532458/42eaf74d142137134dac3985bfb4b6f0/data/jubilaeum425-1585_en.pdf

Deutsches Aktieninstitute. (2018). *Aktionärszahlen des Deutschen Aktieninstituts*. Retrieved from https://www.dai.de/files/dai_usercontent/dokumente/studien/2018-02-19%20Aktieninstitut%20Aktionaerszahlen%202017%20Web.pdf

Eisenhauer, J. G., & Ventura, L. (2003). Survey measures of risk aversion and prudence. *Applied Economics*, *35*(13), 1477-1484.

ERGO Group AG. (2018, August 20). Investmentfonds ERGO. Retrieved June 20, 2018, from https://www.ergo.de/de/Produkte/Investmentprodukte

Eymann, A., & Börsch-Supan, A. (2002). Household portfolios in Germany. In H. Michael, L. Guiso, & T. Jappelli (Eds.), *Household Portfolios* (pp. 291-340). Cambridge, Massachusetts: The MIT Press.

Fagereng, A., Gottlieb, C., & Guiso, L. (2017). Asset Market Participation and Portfolio Choice over the Life-Cycle. *The Journal of Finance*, *72*(2), 705-750.

Guiso, L., Haliassos, M., & Jappelli, T. (2003). Household stockholding in Europe: where do we stand and where do we go? *Economic Policy*, *18*(36), 123-170.

Guiso, L., Jappelli, T., & Terlizzese, D. (1996). Income risk, borrowing constraints, and portfolio choice. *American Economic Review*, *86*(1), 158-72.

Guiso, L., & Paiella, M. (2008). Risk aversion, wealth, and background risk. *Journal of the European Economic Association*, *6*(6), 1109-1150.

Halek, M., & Eisenhauer, J. G. (2001). Demography of risk aversion. *The Journal of Risk and Insurance*, *68*(1).

Halko, M., Kaustia, M., & Alanko, E. (2012). The gender effect in risky asset holdings. *Journal of Economic Behavior & Organization*, *83*(1), 66-81.

Heaton, J., & Lucas, D. (2000). Portfolio choice and asset prices: The importance of entrepreneurial risk. *The Journal of Finance*, *55*(3), 1163-1198.

Huck, S., Schmidt, T., & Weizsäcker, G. (2015). The standard portfolio choice problem in germany. *ifo Institute Center for Economic Studies Working Paper Series No. 5441*.

Investing. (2018). Germany 10-Year Bond Yield. Retrieved June 20, 2018, from https://www.investing.com/rates-bonds/germany-10-year-bond-yield

Kiss, I., & Stehle, R. (2002). Underpricing and long-term performance of initial public offerings at Germany's Neuer Markt, 1997-2001. *Working Paper, Humboldt Universität zu Berlin*.

Kohler, M., Connolly, E., & Smith, K. (2004). *The composition and distribution of household assets and liabilities: Evidence from the 2002 HILDA Survey* (Bulletin 2004). Retrieved from Reserve Bank of Australia website: https://www.rba.gov.au/publications/bulletin/2004/apr/1.html

Kurt, D. (2018, April 23). Is '100 Minus Your Age' Outdated? Retrieved June 20, 2018, from https://www.investopedia.com/articles/investing/062714/100-minus-your-age-outdated.asp

Malkiel, B. G. (1996). *A random walk down Wall Street*. New York: W. W. Norton & Co.

Malmendier, U., & Nagel, S. (2011). Depression Babies: Do Macroeconomic Experiences Affect Risk Taking? *The Quarterly Journal of Economics*, *126*(1), 373-416.

Merton, R. C. (1969). Lifetime portfolio selection under uncertainty: The continuous-time case. *The Review of Economics and Statistics*, *51*(3), 247.

Merton, R. C. (1971). Optimum consumption and portfolio rules in a continuous-time model. *Journal of Economic Theory*, *3*(4), 373-413.

Metzger, C. (2017). Who is saving privately for retirement and how much? New evidence for Germany. *International Review of Applied Economics*, *31*(6), 811-831.

Meyer, J. (2014). The theory of risk and risk aversion. *Handbook of the Economics of Risk and Uncertainty*, *1*, 99-133.

Morin, R., & Suarez, A. F. (1983). Risk Aversion Revisited. *The Journal of Finance*, *38*(4), 1201-1216.

Mossin, J. (1968). Aspects of rational insurance purchasing. *Journal of Political Economy*, *76*(4), 553-568.

Newport, F. (2018, May). Snapshot: Average American predicts retirement age of 66. *Gallup*. Retrieved from https://news.gallup.com/poll/234302/snapshot-americans-project-average-retirement-age.aspx

OECD. (2018). Household accounts - Household financial assets - OECD Data. Retrieved June 25, 2018, from https://data.oecd.org/hha/household-financial-assets.htm

Peytchev, A., & Peytcheva, E. (2007). Relationship between measurement error and unit nonresponse in household surveys: An approach in the absence of validation data. *Proceedings of the Section on Survey Research Methods of the American Statistical Association*, 3864-3860.

Poterba, J. M. (2001). Demographic structure and asset returns. *Review of Economics and Statistics*, *83*(4), 565-584.

Poterba, J. M., & Samwick, A. (2001). Household Portfolio Allocation over the Life Cycle. In S. Ogura, T. Tachibanaki, & D. A. Wise (Eds.), *Aging issues in the United States and Japan* (pp. 65-104). Retrieved from http://www.nber.org/chapters/c10285.pdf

Sahm, C. R. (2012). How Much Does Risk Tolerance Change? *Quarterly Journal of Finance*, *02*(04).

Samuelson, P. A. (1969). Lifetime portfolio selection by dynamic stochastic programming. *The Review of Economics and Statistics*, *51*(3), 239.

Scharnagl, M., & Ramb, F. (2011). Households' portfolio structure in Germany - Analysis of financial accounts data 1959-2009. *European Central Bank Working Paper Series*, *1355*. Retrieved from https://www.ecb.europa.eu/pub/pdf/scpwps/ecbwp1355.pdf?b4728d4b2e7c5ba40adc0f25450595d6

Schulhofer-Wohl, S. (2018). The age-time-cohort problem and the identification of structural parameters in life-cycle models. *Quantitative Economics*, *9*(2), 643-658.

Shorrocks, A. F. (1975). The age-wealth relationship: A cross-section and cohort analysis. *The Review of Economics and Statistics*, *57*(2), 155.

Shum, P., & Faig, M. (2006). What explains household stock holdings? *Journal of Banking and Finance*, *30*(9), 2579-2597.

Sommer, M. (2005). Trends in German households portfolio behavior - assessing the importance of age- and cohort-effects. *Munich Center for the Economics of*

*Aging Discussion Paper Series 05082*. Retrieved from https://ub-madoc.bib.uni-mannheim.de/1273/1/082_05.pdf

Spicer, A., Stavrunova, O., & Thorp, S. (2016). How portfolios evolve after retirement: Evidence from Australia. *Economic Society of Australia*, *92*(297), 241-267.

United States. Central Intelligence Agency. (2018). *The CIA world factbook 2017*. Retrieved from https://www.cia.gov/library/publications/the-world-factbook/

Van Ooijen, R., Alessie, R., & Kalwij, A. (2015). Saving Behavior and Portfolio Choice After Retirement. *De Economist, 163*(3), 353-404. Retrieved from https://link.springer.com/article/10.1007/s10645-015-9254-z

Vanguard. (n.d.). Vanguard Mutual Fund Profile. Retrieved June 21, 2018, from https://investor.vanguard.com/mutual-funds/profile/VTHRX

Veld-Merkoulova, Y. V. (2011). Investment horizon and portfolio choice of private investors. *International Review of Financial Analysis*, *20*(2), 68-75.

Wallick, D., Shanahan, J., & Tasopoulos, C. (2013, October). Baby Boomers and equity returns: Will a boom in retirees lead to a bust in equity returns? Retrieved from https://institutional.vanguard.com/iam/pdf/Baby_boomers_and_equity_returns.pdf

Wang, H. N., & Hanna, S. D. (1997). Does risk tolerance decrease with age? *Financial Counseling and Planning*, *8*(2), 27-31.

Wooldridge, J. (2006). *Introductory Econometrics: A modern approach* (5th ed.). South-Western Cengage Learning.

World Bank. (2018). *Life expectancy at birth*. Retrieved from https://data.worldbank.org/indicator/SP.DYN.LE00.IN?locations=DE

Wu, S., Asher, A., Meyricke, R., & Thorp, S. (2015). Age pensioner profiles: A longitudinal study of income, assets and decumulation. *Working Paper 2015/17 ARC Centre of Excellence in Population Ageing Research*. Retrieved from https://www.cepar.edu.au/publications/working-papers/age-pensioner-profiles-longitudinal-study-income-assets-and-decumulation

Yoo, P. S. (1994). Age Distributions and Returns of Financial Assets. *The Federal Reserve Bank of St. Louis Working Paper Series*, (2).

Young, B., & Semmler, W. (2011). The European sovereign debt crisis: Is Germany to blame? *German Politics and Society*, *29*(1), 1-24.

# Appendixes

## Appendix A. Fund Asset Classes

The table presents all the funds that were used in the analysis, as well as the respective International Securities Identification Number (ISIN). These were all the funds that registered a movement for the sample of customers between 2007 to 2017. The funds under "Equity Funds" consist of the funds that used in the definition of risky assets.

| ***Debt Funds*** | ISIN |
|---|---|
| MEAG EuroFlex | DE0009757484 |
| MEAG EuroRent A | DE0009757443 |
| MEAG RealReturn A | DE000A0HMMW7 |
| MEAG ProRent | DE0009754101 |
| MEAG EuroMediorent | DE00097825755 |
| ***Equity Funds*** | |
| MEAG Nachhaltigkeit A | DE0001619997 |
| MEAG Dividende A | DE000A1W18W8 |
| MEAG EuroInvest A | DE0009754333 |
| MEAG ProInvest | DE0009754119 |
| MEAG GlobalChance DF | DE0009782789 |
| MEAG Osteuropa A | DE000A0JDAY3 |
| MEAG Floor EuroAktien | DE000A0JDAV9 |
| Asia Focus Fund A-Euro | LU0069452877 |
| ***Mixed Funds*** | |
| ERGO Vermögensmanagement Ausgewogen | DE000A2ARYT8 |
| ERGO Vermögensmanagement Flexibel | DE000A2ARYP3 |
| MEAG EuroBalance | DE0009757450 |
| MEAG EuroErtrag A | DE0009782730 |
| MEAG FairReturn A | DE0009A0RFJ25 |
| MEAG EuroKapital | DE0009757468 |
| MEAG GlobalBalance DF | DE0009782763 |
| MEAG VermögensAnlage Komfort A | DE000A1JJJP7 |
| MEAG Vermögensanlage Return A | DE000A1JJJR3 |
| ***Money Funds*** | |
| MEAG ProZins A | DE0009754192 |

## Appendix B. Derivation of Significance of Sample Size

The following diagrams display the level of significance of the sample size chosen for two different populations. The first population consists of the ERGO customers, while the second population refers to the total number of German individuals.

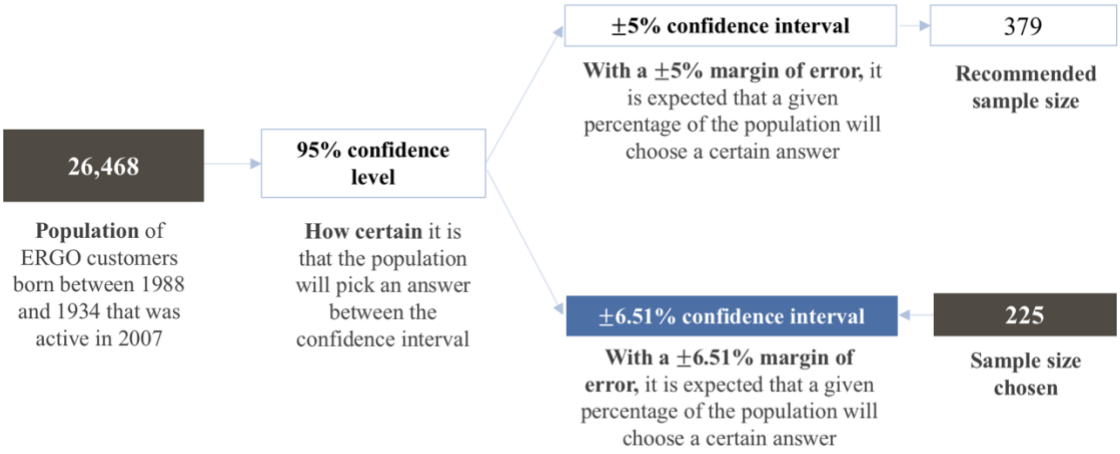


**Figure B1. Significance of Sample Size Taking ERGO Customers as Population.** The diagram is divided in two main branches. On the top branch, the recommended sample size for a standard 5% precision level is calculated. On the bottom branch, the margin of error is calculated for the sample size that was effectively used. These calculations are made taking the population of ERGO customers born between 1997 and 1934, that had open portfolios in 2007.

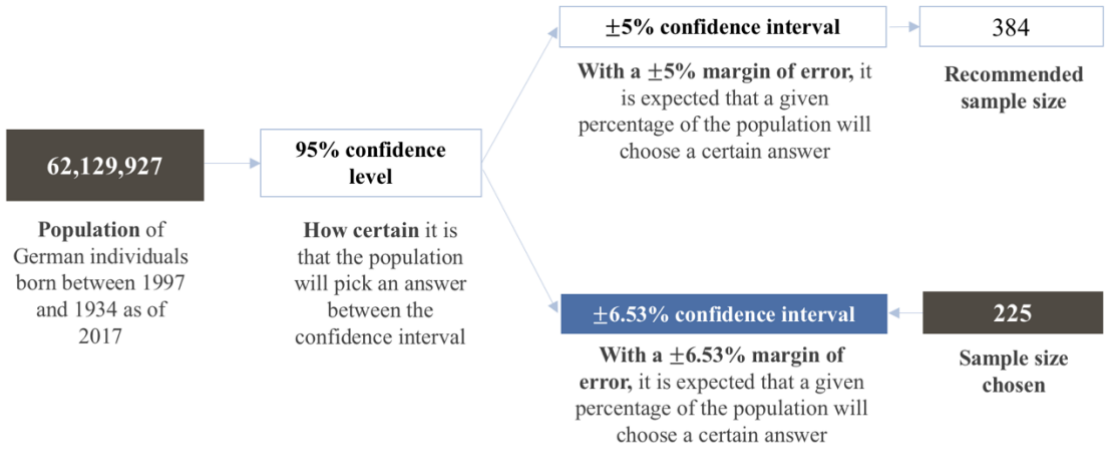


**Figure B2. Significance of Sample Size Taking German Individuals as Population.** The diagram is divided in the same two main branches described before. These calculations are made taking the population of German customers born between 1997 and 1934, as of 2017 (this number was retrieved from the CIA World Factbook 2018).

## Appendix C. Total Period Descriptive Statistics

**Table C1. Descriptive Statistics for the Complete Panel.** The table shows the relevant descriptive statistics for the variables used in the analysis. The values were calculated using all the observations, from every customer, in all 10 years covered in the analysis.

| Variable | Obs | Mean | SD | Min | Max |
|---|---|---|---|---|---|
| Age | 2475 | 46.62 | 17.41 | 15 | 80 |
| Cohort | 2475 | 1965.38 | 17.12 | 1937 | 1992 |
| Equity Share[1] | 2475 | 27.65% | 42.82% | 0% | 100% |
| Equity Participation | 2475 | 0.33 | 0.47 | 0 | 1 |
| Gender | 2475 | 0.41 | 0.49 | 0 | 1 |

[1]The values reported for the *equity share* variable presented are not conditional on participation.

**Table C2. Descriptive Statistics per Sample Year.** The table organizes the statistics per each year of the sample for all 225 customers. It shows the evolution of the equity participation rates, the equity share in percentage of the total portfolio, and the equity share conditional on investing in the equity funds in the given year, over the 10-year period covered in the analysis. Of the 225 customers, only 78 individuals invested in the equity funds. Therefore, the number of observations shown in the bottom panel of the table is lower than the count for the first two variables.

| | Obs | Mean | SD | Min | Median | Max |
|---|---|---|---|---|---|---|
| **Equity Participation:** | | | | | | |
| 2007 | 225 | 0.333 | 0.472 | 0 | 0 | 1 |
| 2008 | 225 | 0.338 | 0.474 | 0 | 0 | 1 |
| 2009 | 225 | 0.333 | 0.472 | 0 | 0 | 1 |
| 2010 | 225 | 0.333 | 0.472 | 0 | 0 | 1 |
| 2011 | 225 | 0.333 | 0.472 | 0 | 0 | 1 |
| 2012 | 225 | 0.329 | 0.471 | 0 | 0 | 1 |
| 2013 | 225 | 0.324 | 0.469 | 0 | 0 | 1 |
| 2014 | 225 | 0.324 | 0.469 | 0 | 0 | 1 |
| 2015 | 225 | 0.329 | 0.471 | 0 | 0 | 1 |
| 2016 | 225 | 0.324 | 0.469 | 0 | 0 | 1 |
| 2017 | 225 | 0.311 | 0.464 | 0 | 0 | 1 |
| Total | 2475 | 0.328 | 0.470 | 0 | 0 | 1 |
| **Equity Share:** | | | | | | |
| 2007 | 225 | 0.283 | 0.430 | 0 | 0 | 1 |
| 2008 | 225 | 0.280 | 0.428 | 0 | 0 | 1 |
| 2009 | 225 | 0.284 | 0.432 | 0 | 0 | 1 |
| 2010 | 225 | 0.288 | 0.434 | 0 | 0 | 1 |
| 2011 | 225 | 0.287 | 0.434 | 0 | 0 | 1 |
| 2012 | 225 | 0.275 | 0.428 | 0 | 0 | 1 |
| 2013 | 225 | 0.271 | 0.428 | 0 | 0 | 1 |
| 2014 | 225 | 0.267 | 0.429 | 0 | 0 | 1 |
| 2015 | 225 | 0.272 | 0.430 | 0 | 0 | 1 |
| 2016 | 225 | 0.274 | 0.429 | 0 | 0 | 1 |
| 2017 | 225 | 0.260 | 0.419 | 0 | 0 | 1 |
| Total | 2475 | 0.276 | 0.428 | 0 | 0 | 1 |
| **Conditional Equity Share:** | | | | | | |
| 2007 | 78 | 0.815 | 0.312 | 0 | 1 | 1 |
| 2008 | 78 | 0.809 | 0.316 | 0 | 1 | 1 |
| 2009 | 78 | 0.820 | 0.313 | 0 | 1 | 1 |
| 2010 | 78 | 0.830 | 0.302 | 0 | 1 | 1 |
| 2011 | 78 | 0.828 | 0.308 | 0 | 1 | 1 |
| 2012 | 78 | 0.793 | 0.340 | 0 | 1 | 1 |
| 2013 | 78 | 0.781 | 0.358 | 0 | 1 | 1 |
| 2014 | 78 | 0.770 | 0.377 | 0 | 1 | 1 |
| 2015 | 78 | 0.785 | 0.360 | 0 | 1 | 1 |
| 2016 | 78 | 0.792 | 0.346 | 0 | 1 | 1 |
| 2017 | 78 | 0.750 | 0.372 | 0 | 1 | 1 |
| Total | 858 | 0.797 | 0.337 | 0 | 1 | 1 |

**Appendix D. Total Portfolio Amount and Equity Allocation Distribution**

The table crosses the total portfolio values, and the amount of equity holdings in Euros. It is shown that the individuals with the lowest amount of equity holdings also have the lowest portfolio value.

| Total portfolio | Amount of Equity Holdings | | |
|---|---|---|---|
| *in EUR* | 0-1000 | >1000 | Total |
| 0-7000 | **46%** | 13% | 59% |
| 7000-15000 | 14% | 8% | 22% |
| 15000+ | 13% | 6% | 19% |
| Total | 73% | 27% | 100% |

**Appendix E. Relation between DAX Returns and Equity Participation Rates**

The table reports the change in the participation rates and the annual returns of the German stock market index from 2008 to 2017. The first observation in the table under "One-year lagged DAX Returns" corresponds to the return of this index in 2007. The aim of this table is to show that there is no strong correlation between the changes of the two variables throughout time. The correlation is effectively equal to -12%.

| | Percent Change in Participation Rate | One-year lagged DAX Returns |
|---|---|---|
| 2008 | 1% | 1% |
| 2009 | -1% | -37% |
| 2010 | 0% | 29% |
| 2011 | 0% | 26% |
| 2012 | -1% | -9% |
| 2013 | -1% | 20% |
| 2014 | 0% | 20% |
| 2015 | 1% | 15% |
| 2016 | -1% | -8% |
| 2017 | -4% | 18% |

*Source: Returns retrieved from Yahoo Finance, 14/08/2018*

## Appendix F. Descriptive Statistics for 2017

**Table F$_1$. Descriptive Statistics of Categorical Variables in 2017.** The table shows the fraction of the total sample that invested in the equity funds, as well as the gender breakdown. It is shown that a large portion of the sample do not participate in the equity funds in 2017 and that there are more men investing in these funds than women.

| | Observations | Fraction of total sample |
|---|---|---|
| **Equity Participation:** | | |
| *Yes* | 70 | 31.1% |
| *No* | 155 | 68.9% |
| Total | 225 | 100.0% |
| **Gender:** | | |
| Female Equity Participants | 31 | 33.3% |
| Female Equity Non-participants | 62 | 66.7% |
| Total Female | 93 | 41.3% |
| Male Equity Participants | 39 | 29.5% |
| Male Equity Non-participants | 93 | 70.5% |
| Total Male | 132 | 58.7% |

**Table F2. Descriptive Statistics of Portfolio Composition in 2017.** The table is divided in different sections. The top panel presents descriptive statistics for the age of the total sample, as well as for the female and male subjects. The second and the third panels below provide statistics for each of the asset classes for all the individuals: debt, mixed, and equity. The money funds are not displayed in the table because they represent less than 4% of the average portfolio allocation. The last two sections of the table restrict the statistics to the subjects that had a positive amount invested in the corresponding fund as of 2017. At last, the conditional equity share is broken into gender.

| | Observations | Mean | Standard Deviation | Median |
|---|---|---|---|---|
| **Demographics:** | | | | |
| Age Female | 70 | 50.3 | 16.7 | 50.0 |
| Age Male | 155 | 52.2 | 17.2 | 50.0 |
| Age | 225 | 51.6 | 17.2 | 50.0 |
| **Fund holdings in EUR for all subjects:** | | | | |
| Total Portfolio | 225 | 8 846.6 | 11 156.9 | 4 795.4 |
| Debt Funds | 225 | 3 341.7 | 7 917.7 | 0.0 |
| Mixed Funds | 225 | 3 221.4 | 7 702.6 | 0.0 |
| Equity Funds | 225 | 2 283.6 | 5 722.7 | 0.0 |
| **Portfolio share in % for all subjects:** | | | | |
| Debt Funds | 225 | 29.0% | 44.5% | 0.00% |
| Mixed Funds | 225 | 40.1% | 47.5% | 0.00% |
| Equity Funds | 225 | 26.0% | 41.9% | 0.00% |
| **Fund holdings in EUR for asset class participants:** | | | | |
| Debt Funds | 75 | 10,024.1 | 11,039.8 | 5,976.6 |
| Mixed Funds | 102 | 7,105.8 | 10,183.6 | 3,129.3 |
| Equity Funds | 70 | 7,340.1 | 8,286.3 | 4,534.5 |
| **Portfolio share in % for asset class participants:** | | | | |
| Debt Funds | 75 | 87.3% | 29.3% | 100.0% |
| Mixed Funds | 102 | 88.4% | 26.0% | 100.0% |
| Equity Funds | 70 | 86.0% | 25.0% | 100.0% |
| *Within genders* | | | | |
| Conditional Equity share held by women | 31 | 79.1% | 29.5% | 100.0% |
| Conditional Equity share held by men | 39 | 80.6% | 28.9% | 100.0% |

## Appendix G. Development of Equity Participation and Conditional Equity Shares per Age and per Year

**Table G1. Mean Equity Participation per Age and per Sample Year.** The table displays the age evolution of the fraction of the sample (%) that invested in the equity funds in each year of the analysis.

| Age | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 20-24 | 0.30 | 0.35 | 0.35 | 0.35 | 0.35 | 0.47 | 0.47 | 0.47 | 0.53 | 0.53 | 0.42 |
| 25-29 | 0.55 | 0.55 | 0.55 | 0.55 | 0.55 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 |
| 30-34 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.55 | 0.55 | 0.55 | 0.55 | 0.55 | 0.55 |
| 35-39 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.30 | 0.30 | 0.30 | 0.30 | 0.25 | 0.25 |
| 40-44 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 |
| 45-49 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 |
| 50-54 | 0.50 | 0.56 | 0.56 | 0.56 | 0.56 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 |
| 55-59 | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 | 0.56 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 |
| 60-64 | 0.23 | 0.24 | 0.24 | 0.24 | 0.24 | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 | 0.28 |
| 65-69 | 0.05 | 0.06 | 0.06 | 0.06 | 0.06 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 |
| 70-74 | 0.23 | 0.18 | 0.12 | 0.12 | 0.12 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 |
| 75-79 | | | | | | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 |

**Table G2. Mean Conditional Equity Share per Age and per Sample Year.** The table displays the age evolution of the portfolio equity share for the individuals that invested in the equity funds in each year of the analysis.

| Age | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 20-24 | 0.74 | 0.73 | 0.75 | 0.79 | 0.79 | 0.79 | 0.80 | 0.79 | 0.84 | 0.84 | 0.60 |
| 25-29 | 0.75 | 0.72 | 0.76 | 0.76 | 0.74 | 0.80 | 0.81 | 0.81 | 0.83 | 0.83 | 0.84 |
| 30-34 | 0.65 | 0.62 | 0.65 | 0.70 | 0.69 | 0.76 | 0.78 | 0.76 | 0.76 | 0.77 | 0.76 |
| 35-39 | 0.89 | 0.88 | 0.89 | 0.91 | 0.93 | 0.69 | 0.67 | 0.62 | 0.77 | 0.56 | 0.59 |
| 40-44 | 0.86 | 0.85 | 0.86 | 0.86 | 0.86 | 0.84 | 0.84 | 0.84 | 0.76 | 0.84 | 0.87 |
| 45-49 | 0.94 | 0.91 | 0.92 | 0.92 | 0.91 | 0.78 | 0.79 | 0.79 | 0.82 | 0.82 | 0.82 |
| 50-54 | 0.87 | 0.95 | 0.96 | 0.96 | 0.95 | 0.91 | 0.92 | 0.91 | 0.91 | 0.91 | 0.95 |
| 55-59 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.94 | 0.80 | 0.79 | 0.79 | 0.88 | 0.85 |
| 60-64 | 0.64 | 0.61 | 0.64 | 0.65 | 0.65 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.83 |
| 65-69 | 0.72 | 0.74 | 0.88 | 0.69 | 0.87 | 0.66 | 0.68 | 0.68 | 0.68 | 0.68 | 0.69 |
| 70-74 | 0.67 | 0.59 | 0.50 | 0.50 | 0.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 75-79 | | | | | | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 |

## Appendix H. P-values for Hypotheses Tested

**Table $H_1$. P-values for T-test for Significance of Age Coefficient.** The table displays the p-values obtained for the significance tests ran for the coefficient of Age in the linear regressions, for both dependent variables. For the hypothesis in this thesis, the most relevant result lies on the line where Age < 0. The one sided formulation tests the significance of a decreasing age effect in the equity participation and on the conditional equity share. The p-values were evaluated against standard alpha levels, 0.10, 0.05, and 0.01. The significant results are highlighted in bold.

| | Equity Participation | | | Conditional Equity Share | | |
|---|---|---|---|---|---|---|
| *Hypothesis* | (1) Linear Age | (2) Fixed Time Effects | (3) Fixed Cohort Effects | (1) Linear Age | (2) Fixed Time Effects | (3) Fixed Cohort Effects |
| *Age = 0* | < **0.001** | < **0.001** | 0.512 | 0.002 | 0.612 | < **0.001** |
| *Age < 0* | < **0.001** | < **0.001** | 0.256 | **0.001** | 0.306 | < **0.001** |
| *Age > 0* | > 0.999 | > 0.999 | 0.744 | 0.999 | 0.694 | > 0.999 |

**Table $H_2$. P-values for Test of Joint Significance.** The table displays the p-values obtained for the significance tests ran for the join significance of the *time dummies* and the *cohort dummies* in the linear regressions, for both dependent variables. The test analyses whether there are considerable differences in the decision to invest in equities, or in the conditional equity share held, between the years from 2007 to 2017, and between the different generations. The p-values were evaluated against standard alpha levels, 0.10, 0.05, and 0.01. The significant results are highlighted in bold.

| | Equity Participation | Conditional Equity Share |
|---|---|---|
| *Time dummies in* (2) | 0.9981 | 0.3546 |
| *Cohort dummies in* (3) | < **0.001** | 0.1729 |

**Table $H_3$. P-values for Test of Goodness of Model Fit.** The table displays the p-values obtained for the significance tests ran for the join significance of the *time dummies* and the *cohort dummies* in the linear regressions, for both dependent variables. The test analyses whether including these variables provides a better fit of the model as opposed to not including them. The p-values were evaluated against standard alpha levels, 0.10, 0.05, and 0.01. The significant results are highlighted in bold.

| | Equity Participation | Conditional Equity Share |
|---|---|---|
| *Quadratic form in (4)* | < **0.001** | < **0.001** |

## Appendix I. The Equity Share of Households in the G7 Countries

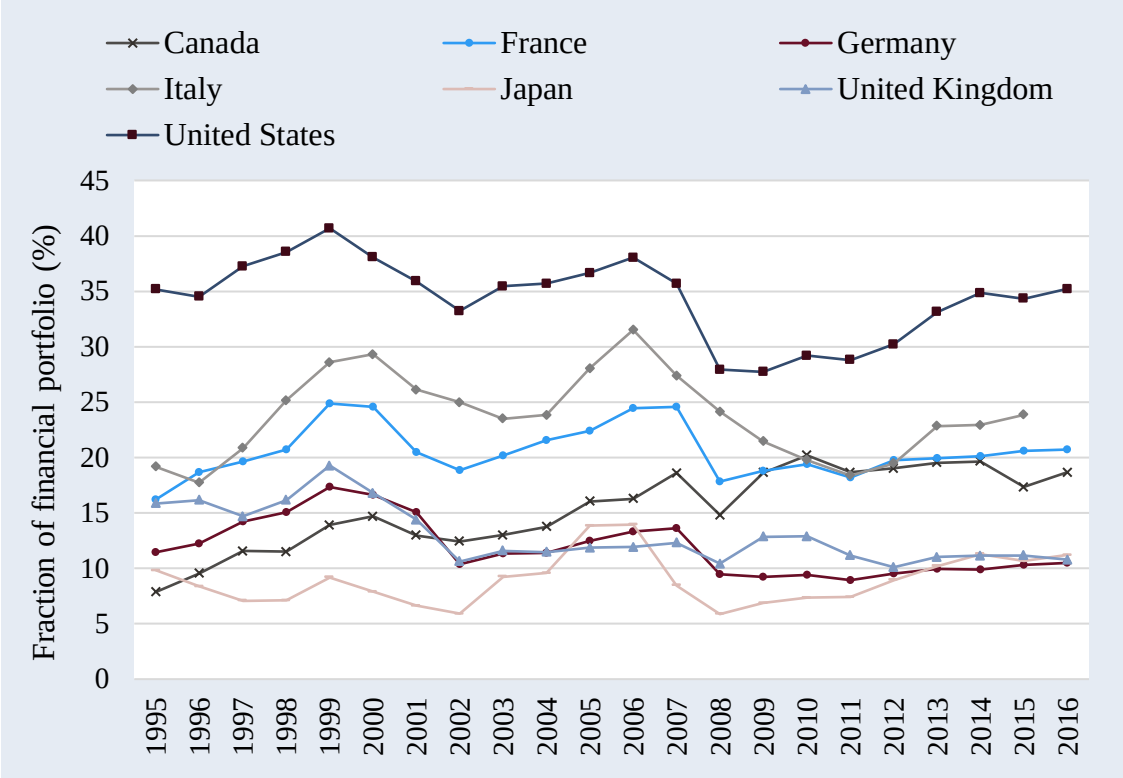


**Figure I. The Equity Share of Households in the G7 Countries.** The figure shows the fraction of the portfolio that was allocated to equities from 1995 until 2016 for the households living in the G7 countries. Germany is one of the countries with the lowest equity shares, followed by Japan. It is evident that since 2008, German households kept a rather constant fraction of their portfolios allocated to this asset class. Adapted from households' portfolio data provided by the Organisation for Economic Cooperation and Development, as of 2018[1].

[1] For more details on the portfolio composition of other countries, please visit https://data.oecd.org/hha/household-financial-assets.htm

## Appendix J. Sample Distribution per Sample Year

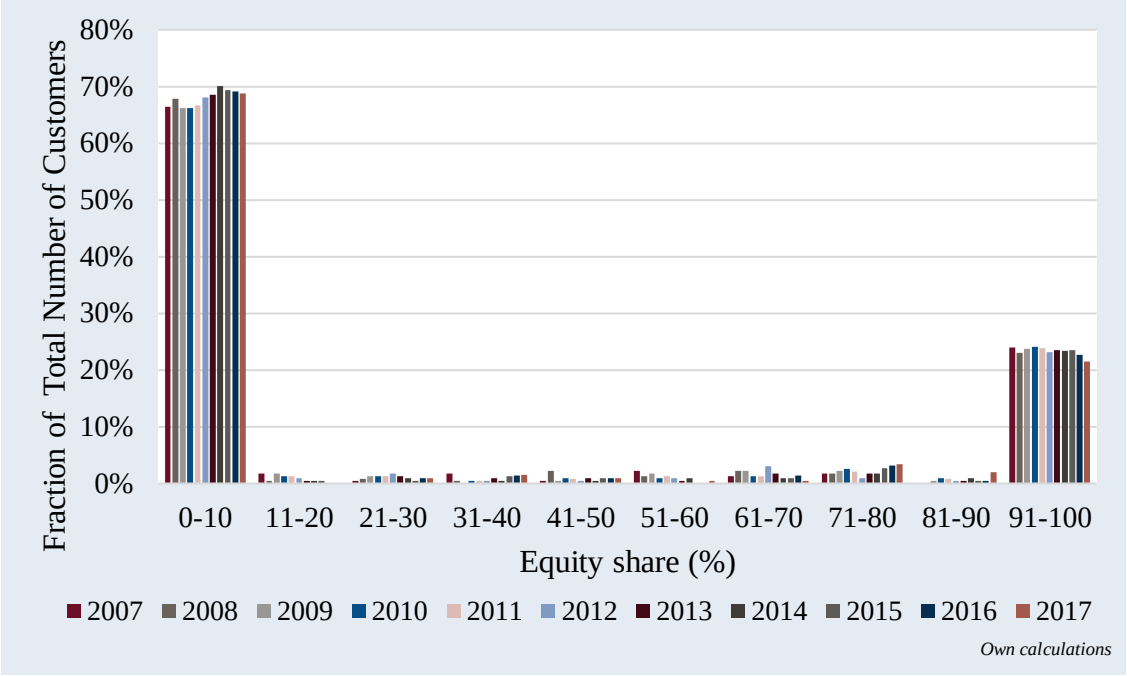


**Figure J₁. Distribution of the Share of Total Portfolio Allocated to Equity Funds.** The figure shows the distribution of the equity shares per each year of the sample of all the customers included in the sample. This figure also includes the customers that had no investments in the equity funds. It is shown that there is a large amount of portfolios that contain a fraction of only 0% to 10% equity.

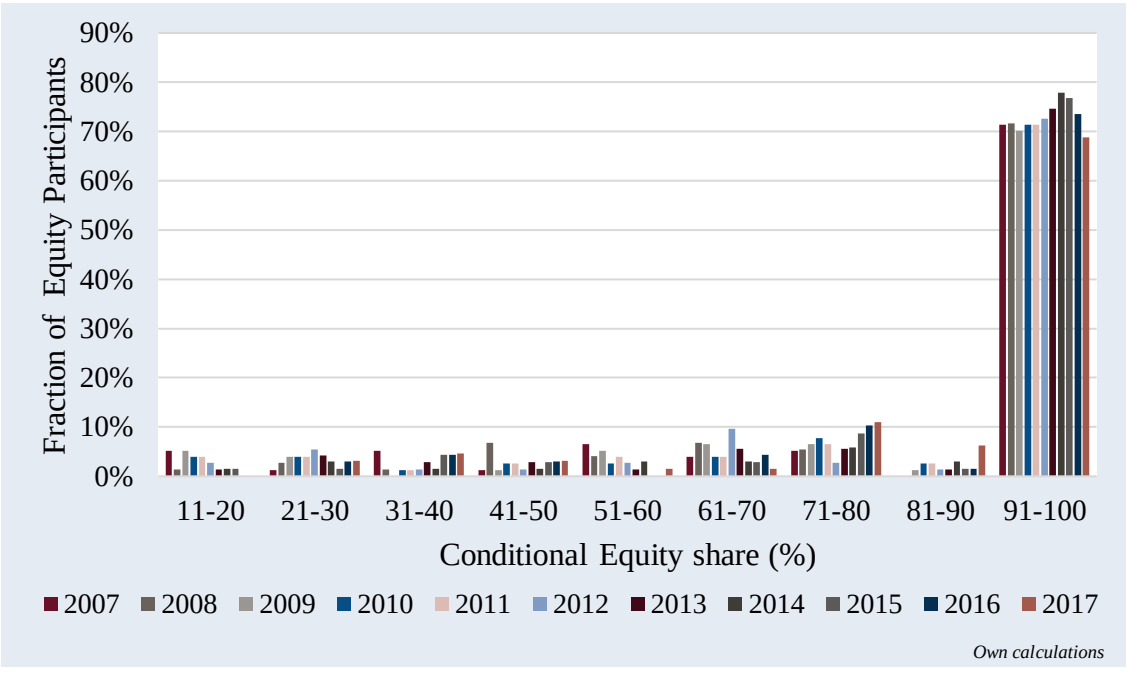


**Figure J₂. Distribution of the Conditional Share of Total Portfolio Allocated to Equity Funds.** The figure shows the distribution of the equity shares per each year of the sample of all the customers included in the sample. This figure also includes the customers that had no investments in the equity funds. It is shown that there is a large amount of portfolios that contain a fraction of only 0% to 10% equity.

## Appendix K. Macroeconomic Indicators

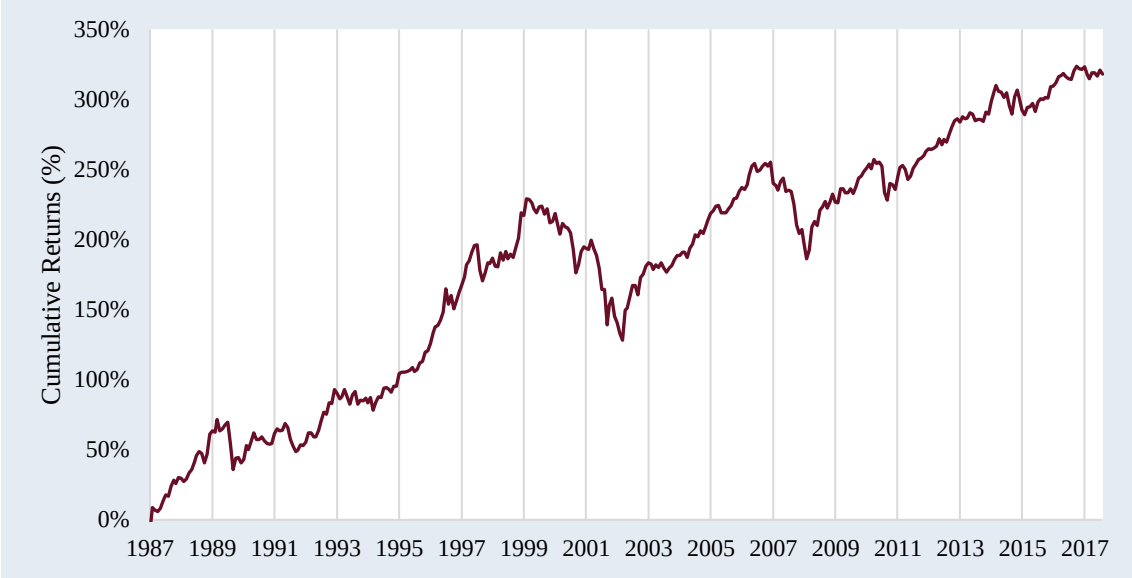


**Figure K1. DAX Index Historical Returns.** The figure shows the development of the returns of German stock market index since it was created in 1987 until 2017. The largest falls this index has suffered occurred when at the financial crises of 2001 and 2008. Adapted from historical prices retrieved from Yahoo Finance, on 16/08/2018.

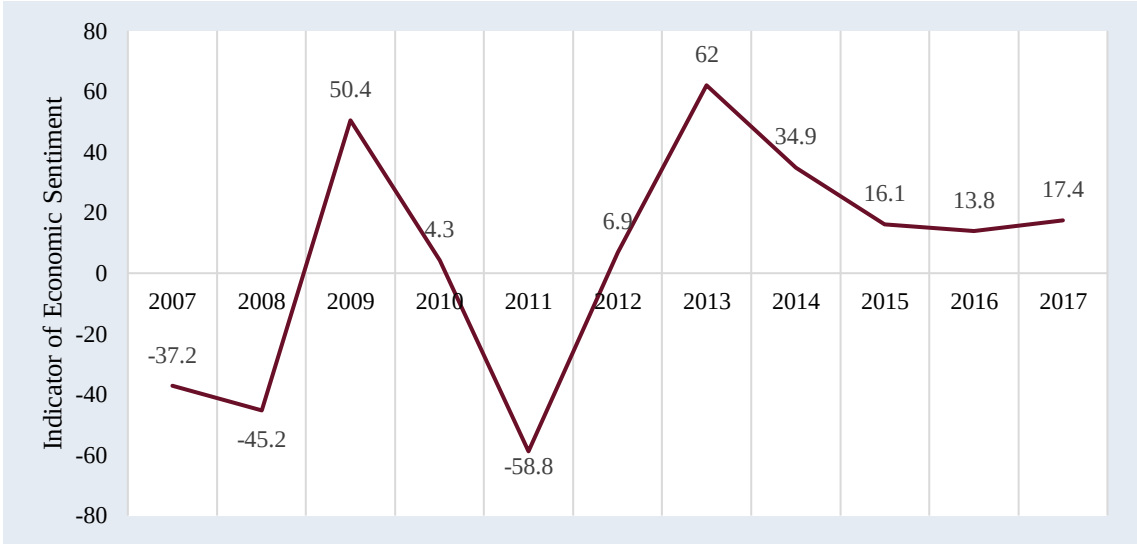


**Figure K2. ZEW Indicator of Economic Sentiment for Germany.** The figure shows the development of the indicator from 2007 to 2017 for every December month – point in which the fund prices were calculated. This indicator is equal to the difference between the percentage share of the survey respondents that are optimistic and those that are pessimistic regarding the economic outlook for Germany in the next six months. Therefore, a positive number means that the share of optimists is higher than the share of pessimists[2]. Adapted from the reports provided by The Centre for European Economic Research.

[2] For more details, please visit https://www.zew.de/en/publikationen/zew-gutachten-und-forschungsberichte/forschungsberichte/konjunktur/zew-finanzmarktreport/

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I certify that:

(a) the thesis being submitted for examination is my own account of my own research

(b) my research has been conducted ethically

(c) the data and results presented are the genuine data and results actually obtained by me during the conduct of the research

(d) where I have drawn on the work, ideas and results of others this has been appropriately acknowledged in the thesis

(e) where any collaboration has taken place with other researchers, I have clearly stated in the thesis my own personal share in the investigation

(f) the thesis has not been presented to any other examination committee before

(g) the thesis has not been published before.

Oestrich-Winkel, 10 / 09 / 2018 (date: day/month/year)

Catarina Maria Vieira Dias Pereira (signature)

CATARINA (first name in BLOCK LETTERS)

PEREIRA (last name in BLOCK LETTERS)