STOCKHOLM SCHOOL OF ECONOMICS
MASTER'S THESIS IN FINANCE

Cognitive Ability and Portfolio Composition

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ABSTRACT

In this paper we match data on retirement investments from the Swedish Premium Pension Authority to conscription data from the Swedish military and examine the association between cognitive ability and portfolio investment decisions. Consistent with much laboratory evidence, we find that cognitive ability is associated with greater financial risk-taking. The magnitude of the reported association is weak. We also report some evidence suggesting that people with higher cognitive ability are more likely to make active financial choices. These results are considered in relation to current debates in finance about the causes and consequences of individual heterogeneity in portfolio composition.

Key words: Cognitive Ability; Portfolio Composition; Risk Preferences; Risk; Pension

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I. Introduction

Standard models of portfolio choice (e.g. Markowitz, 1952) require a level of analytic sophistication that is likely to be beyond the ability of most people. This observation raises the possibility that the well-known heterogeneity in portfolio choice (Guiso, Haliassos and Jappelli, 2002; Curcuru et al. 2009) may reflect not only differences across individuals in wealth holdings, income, demographic factors and risk preference parameters, but also the ability to acquire and process information. Heterogeneity in asset allocation decision-making remains one of the least understood areas of finance (Riley Jr. and Chow, 1992), as theories of portfolio allocation often provide a poor fit to the data, leaving most of the individual level variance unexplained. In this thesis, we ask if differences in cognitive ability explain heterogeneity in portfolio composition.

A number of papers have examined how gender, wealth, age and a host of other demographic factors are associated with investment behavior (Guiso, Haliassos and Jappelli, 2002). Understanding the causes of individual differences in financial investment behavior is important for any effort to help people make better financial decisions. This is especially important in the context of Swedish retirement accounts, where investment decisions made by young people can have quite significant consequences for wealth levels at retirement (Gordon, Mitchell and Twinney, 1997). Historically, the difference between investing in relatively risk-free assets compared to investing in risky assets has been staggering. Because of the power of compounding, small differences in average returns of retirement savings can have large consequences for post-retirement wealth. For example, Siegel and Thaler (2009) point out that an individual who invested $1,000 in 1925 in Treasury bills would find his initial investment to be worth $12,720 seven decades later. By comparison, the portfolio would have been worth $842,000 had the initial endowment been invested in stocks.

This paper uses a unique dataset of Swedish twins to investigate how cognitive ability (IQ) is associated with portfolio investment decisions made in the year 2000, when the majority of the Swedish adult population had to simultaneously make an investment decision affecting post retirement wealth. From a menu of several hundred funds with varying risk profile, individuals had to compose an investment portfolio. Those individuals who did not make an active decision had their money invested in a default fund. In this paper we ask how, if at all, cognitive ability is related to two important aspects of portfolio composition; portfolio risk and active participation. A virtue of having a sample of twins is that we can examine if the associations hold both within and between families.

The paper builds on a growing literature in behavioral economics which has used laboratory experiments to show that "preference" anomalies and behavioral biases are more common in samples with low cognitive ability. For example, Benjamin, Brown and Shapiro (2006) find that subjects with low cognitive ability are more likely to exhibit small-stakes risk aversion (a violation of expected utility theory, see Rabin 2000) and more likely to discount the short run at a higher rate. Cognitive ability has also been associated with dominance violations in economic games (Burnham et al., 2009), anchoring (Bergman et al., 2009) and social awareness (Burks et al., 2009). Outside the laboratory, labor economists have known for quite some time that cognitive ability is a modest predictor of wages, employment, teenage pregnancies, incarceration and other important outcomes (Heckman et al. 2006).

Perhaps of greatest relevance to this paper is the recent work by Dohmen et al. (2008). Dohmen et al. (2008) found that in a representative sample of German adults, laboratory measures of patience and risk-aversion were related to cognitive ability. Specifically, people with higher cognitive ability are less likely to exhibit risk aversion over small stakes and discount the future at a higher rate. These results are consistent with those reported in Benjamin, Brown and Shapiro (2006). Despite this convergence of evidence from the laboratory, little is known about how cognitive ability is associated with portfolio investments. An important exception is Korniotis and Kumar (2009), who find in two separate datasets that investors classified as "smart" (high cognitive ability), enjoy substantially higher risk-adjusted returns than so-called ”dumb” (low cognitive ability) investors. An advantage of our dataset is that it contains information on cognitive ability taken from conscription data, and hence we do not need to impute cognitive ability from observable characteristics.

In addition to studying the relationship between risk and cognitive ability we also examine a related hypothesis, namely whether or not cognitive ability predicts if an individual makes an active investment or not. There is a vast amount of literature on financial participation which tries to uncover why individuals differ in their likelihood of participating in financial markets (Haliassos and Bertaut, 1995). There is also related literature examining how financial fluency affects investment decisions and participation. Our data allows us to examine directly whether or not cognitive ability, a reasonable proxy for an individual's ability to process information, predicts active investment decisions. If making active investment decisions requires the mobilization of cognitive resources, and if people differ in their endowment of such resources, then we would expect to observe a relationship between participation and cognitive ability. Broadly speaking, this theory is in line with the behavioral view of investors, which emphasizes cognitive biases and irrationality in decision-making.

To preview our findings, we find that higher cognitive ability is associated with greater portfolio risk. The estimated coefficients are similar both within and between families, though precision is weaker in the within family estimates. Moreover, the coefficient on cognitive ability declines significantly when level of education is included as a control. Since the tests of cognitive ability are taken shortly after high school, a plausible interpretation of this result is that the effect of cognitive ability on risk is mediated by educational attainment. That is to say, the channel through which cognitive ability affects risk-taking is educational attainment. We also find that participation – that is, making an active choice – is associated with cognitive ability within family.

The paper is structured as follows: We begin by describing our sample in Section II. Section III describes our empirical methodology. Section IV describes the results. Section V investigates the robustness of our results. Finally, a discussion with regards to our findings, with special reference to current efforts in finance to understand heterogeneity in financial market participation and portfolio composition, is found in Section VI.

II. Data

This paper uses a dataset which has previously been described in detail by Cesarini et al. (2009). The data was initially assembled to estimate the heritability of financial risk-taking and is constructed by merging information from four separate sources; the Premium Pension Agency (Premiepensionsmyndigheten), The Swedish Twin Registry (Svenska tvillinginstitutet), Statistics Sweden (Statistiska centralbyrån) and the National Service Administration (Pliktverket). We begin by giving a brief historical narrative of the Swedish Pension reform, before then describing the four data sources.

Historical Narrative

Prior to the pension reform in the late 1990s, the Swedish pension system was a 'pay-as-you-go' system called the ATP (Allmän tilläggspension). The ATP system had been in place since the 1960s. Under the ATP, a full earnings-related benefit could be obtained after 30 years of covered earnings at age 65, based on an average of the best 15 years. Largely due to the changing demographic environment in Sweden an increasingly widespread belief that the system was underfunded emerged and that it could not meet its promises in the future. As the trust for the previous pension system was eroding, it soon became clear to politicians and experts that the Swedish pension system had to be reformed (Palmer, 2000).

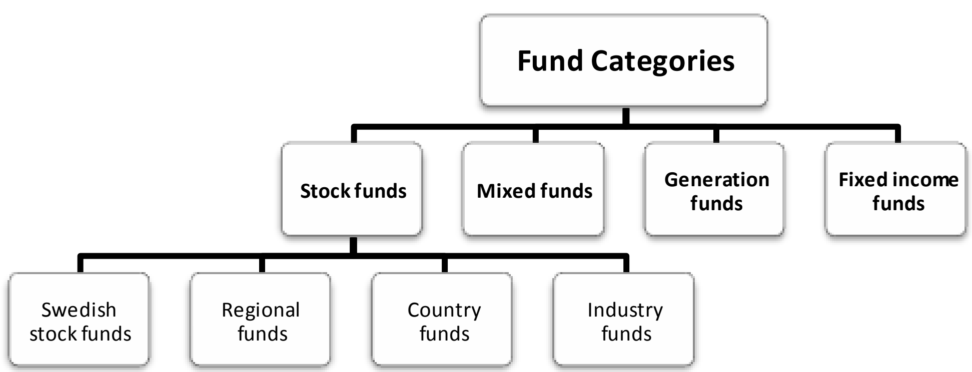
In 1994 the Swedish parliament made the official decision to reform the system. The new system implies a contribution rate of 18.5 percent on monthly earnings, out of which 2.5 percentage units are placed in the mandatory premium pension. The novelty of the premium pension is one of the new system's key advantages and is the part of an individual's pension that is placed in self-directed accounts. All individuals can actively choose how to manage their premium pension savings from over 500 different funds. Those individuals who do not wish to make an active choice will have their premium pension savings placed into a "default fund" named the Premium Savings Fund (Premiesparfonden), managed by the government entity Seventh Swedish Pension Fund (Sjunde AP-fonden). The default fund is a mixed fund with the aim to give those investors who did not actively chose funds at least as good a return as everyone else.

The pension reform was gradually introduced in the late 1990s. In the fall and winter of 2000, all eligible participants[3] of the new pension system simultaneously had to decide how to allocate their premium pension savings. Prior to this event, all participants were sent a catalogue with information about all the funds available. Each individual could compose a portfolio of up to five different funds and the justification for this policy was that all individuals should be able to pick a portfolio that best suited their preferences. Approximately 70 percent of the participants made an "active choice" while the remaining contributions were invested into the government run default fund. (Palme et al., 2007).

Premium Pension Fund

The pension system is administered by the government authority PPM. In the catalogue sent out by the Swedish Pension Authority to all participants in the pension system, all of the approximately 500 funds were presented according to the categories in Diagram 1.

Diagram 1. Fund categories and their definitions.



[3] In order to be eligible to select funds your monthly income had to exceed SEK 36,000 in 1995, SEK 36,800 in 1996, SEK 37,000 in 1997 and SEK 37,100 in 1998.

Table 1. Fund Category and Description

Fund Category	Definition
Stock funds	At least 75% of the fund value is invested in stocks or instruments that are related to stocks. Each stock fund normally invests in 20-30 different stocks
Mixed funds	Invests in both stocks and fixed income and consequently the risk level lies between stock funds and fixed income funds
Generation funds	Initially a large proportion is invested in stocks. As retirement approaches for the investor the assets are gradually reallocated into fixed income
Fixed Income funds	Invests in fixed income securities such as bonds and T-notes with different maturities

All funds in the catalogue were presented with a short description including; fund number, fund name, the size of the fund, management fee and historical return and risk (for the 400 funds that had a historical record)[4]. The risk was presented as a number showing the variation in return over the last three years (standard deviation of the return expressed as percentage per year). The risk level was presented according to a color scheme that spanned from red (high risk) to green (low risk). Table 2 illustrates the scale used to deviate between the different levels of risk. A.1 in the appendix also shows an example of the information from the guide.

Table 2. Risk levels

Interval	Risk level	Color
0 – 2	Very Low Risk	Green
3 – 7	Low Risk	Light Green
8 – 17	Medium Risk	Yellow
18 – 24	High Risk	Orange
25 +	Very High Risk	Red

Generally, stock funds had the highest risk while fixed income funds had the lowest risk. Mixed funds and Generation funds have their assets invested in both stocks and fixed income assets; hence the risk of these funds lies somewhere in between stock funds and fixed income

[4] Additional information could also be found on PPM's homepage, www.ppm.nu.

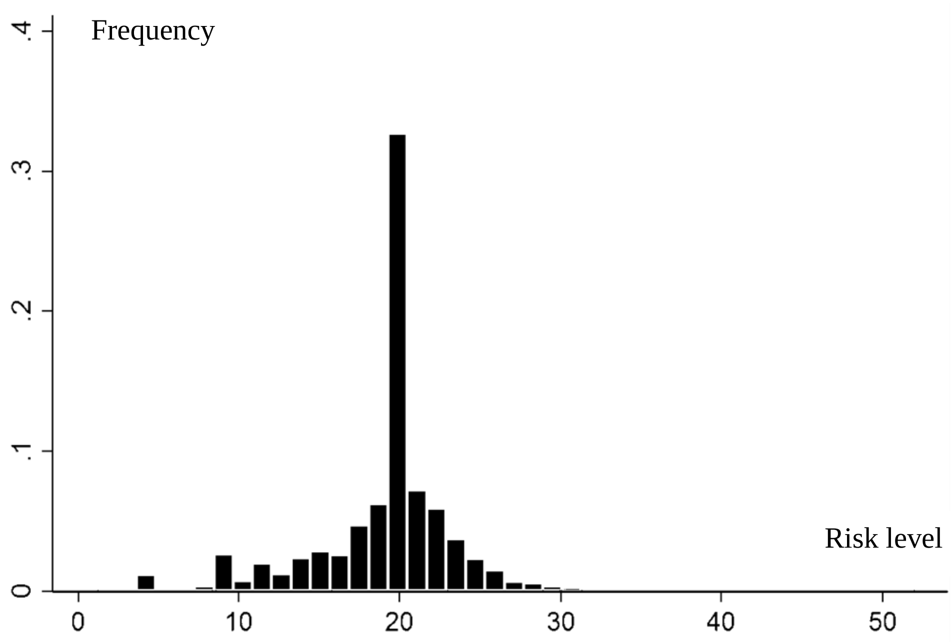
funds. The individuals who had their contributions invested into the default fund had a risk that was designed to represent the preferences of an average investor. The imputed risk of the default fund was approximately 20.0.

The Risk Measure

We use a similar measure of portfolio risk as Cesarini et al. (2009). It is the average risk level of the funds invested in by the individual, with the risk of each fund measured as the (annualized) standard deviation of the monthly rate of return over the previous three years (A.2 in the appendix describes the calculations in more detail). The information on the annualized standard deviation of the monthly return was provided in the catalogue. The measure we use is also similar to that employed in Säve-Söderbergh (2006) and Palme et al. (2007), with the one exception that we also include individuals whose money was invested in the default fund.

The distribution of the portfolio risk of all individuals in the sample is concentrated around 20, primarily because a large number of people chose the default fund. The individuals that chose relatively risk free or relatively risky funds are few in numbers. Diagram 2 shows the density function over the distribution of the individuals' risk preferences.

Diagram 2. Distribution of portfolio risk



The Swedish Twin Registry

The Swedish Twin Registry is the largest twin registry in the world and contains information on the majority of twins born after 1886 (Lichtenstein et al., 2006). The data we use consists of individuals who have participated in one or more of the Twin Registry's surveys. The first survey was SALT (Screening Across the Lifespan Twin study), and was distributed to Swedish twins born between 1926 and 1958. The SALT survey had a response rate of approximately 74%. As a complement to the SALT study an additional survey was later sent to the same cohort. The final survey was STAGE (the Study of Twin Adults: Genes and Environment) which was a web-based survey. It was administered between November 2005 and March 2006 to Swedish twins born between 1959 and 1985 and had a response rate of roughly 61%. Even though the response rates for the SALT and STAGE surveys are fairly high we acknowledge that the information relating to twins is not completely representative for the entire population of twins.

National Service Administration

Around the age of 18, all Swedish men are bound by law to participate in the military conscription test and before 1999 only a few exemptions were made. Drafting of recruits can take days. During this time candidates are exposed to several tests, one of which tests cognitive ability. The conscription test for cognitive ability in Sweden was developed in 1943, and it has since then been revised and reconstructed several times. Carlstedt (2000) discusses the history of intelligence tests in Sweden and provides arguments as to why the measure of cognitive ability is a reliable estimate of an individual's general intelligence (Spearman, 1904). The individual's that we have data on in this paper took four sequential tests (verbal, spatial, technical and logical), all of which were assessed on a scale ranging from 0 to 40. These scores were then converted to a Standard Nine (Stanine) scale that takes the values from 1 to 9. Besides the four tests, the military conscription also involves meeting a psychologist for an assessment of social and leadership skills.

Due to the fact that the Swedish military's cognitive ability test has been changed on numerous occasions, we make a few adjustments in the cognitive ability variable. Following the same method as Lindqvist and Westman (2009), we first percentile rank transform the IQ variable by birth-year. Then, we convert this variable to a standard normal by taking the inverse of the standard normal distribution of the percentile transformed variable. This ensures that differences in the tests by birth-year do not affect the measure. It also ensures that cognitive ability is uncorrelated with age (a mathematical approach to this is found in appendix A.3). The National Service Administration has digitalized the archives for all conscripts who enlisted in 1969 and later. Therefore conscription data is available for most men born after 1951. For the twin sample, a research assistant recovered the IQ data from military archives, and thus IQ scores are available for a large sample of male twins born 1938 and onward.

Statistics Sweden

The income, education and marital status information is compiled by Statistics Sweden. The income measure used (sammanräknad förvärvsinkomst) is defined as the income earned from labor work, own business, pension and unemployment compensation. No individuals have been selectively omitted from the sample and capital income is not included. To account for annual fluctuations in income an average income between 1996 and 2000 is used. Needless to say, the income will only be an imperfect proxy of actual income since only information on taxable income is available.

Marital status is a binary variable taking a value of 1 if an individual is married in the 2000 and 0 if an individual is not married. A similar dummy variable is used to describe an individual’s level of education. An individual’s highest attained level of education is converted to years of studying using the same population averages established by Isacsson (2004). As the information on income, marital status and education is taken from an administrative source it can be considered highly reliable.

Final Sample

Restricting the sample to male twins with conscription data and pension investment data gives a total of 11,268 individuals. The reason why all female individuals were removed from the sample is because there were extremely few females and by excluding the females we directly eliminate all possible gender effects that can be a result of gender differences in risk preferences. A summary of the descriptive statistics can be found in Table 3.

The average risk is 19.76 with a standard deviation of 6.05. A little over 69% of the sample decided to actively choose their own funds, 54% are married and the average age is 52 years.

Table 3. Descriptive Statistics

			Sweden Sample		
	Observations	**Min**	**Max**	**Mean**	**Std.Dev.**
IQ	11 268	-3.19	3.13	0	1
Age	12 601	25.09	68.08	52.21	10.10
Education	12 601	7.69	19.27	11.72	2.73
Income	12 601	0	9.97	0.25	0.17
Marital Status	12 601	0	1	0.54	0.50
Risk	12 601	0	53	19.76	6.05
Active Participation	12 601	0	1	0.69	0.46

Note: IQ refers to the results from the Swedish Army Enlistment Test. The scores have been adjusted to have a mean of zero and the standard deviation is one for the entire sample. Age is the individuals' age in year 2000. Education is a dummy variable that represents the highest degree attained by an individual, converted to years of studying using the same population averages established by Isacsson (2004). The income measure used is a log-average of income earned between 1995 and 2000 for an individual. Marital status is a dummy variable taking the value 1 if the individual is married and 0 if the individual is not married. The risk measure was calculated using the weighted average risk in an individual's portfolio in accordance with Cesarini et al., (2009). Active participation is a dummy variable taking the value 1 if the individual is active and 0 otherwise.

III. Empirical Framework

Model for Risk-taking

Our basic empirical strategy is to estimate ordinary least squares (OLS) regressions of the form,

$$Risk_i = \alpha_1 + \alpha_2 IQ_i + \alpha_3 \mathbb{X}_i + \varepsilon_i$$

Where, $Risk_i$ is the portfolio risk of individual i, IQ_i is cognitive ability (standardized to have mean zero and standard deviation one) for individual i, $\mathbb{X}_i$ is a vector of control variables for individual i and ε_i is the error term. We report results with two different covariate sets. The first, narrow, covariate set only includes age. Since the IQ variable is orthogonal to age by construction, the only effect of including the age variables is to reduce residual variance and produce slightly tighter standard errors than we would get with age excluded.

A second specification, with a broad covariate set, adds years of education, marital status and income. All demographic and control variables are measured in the year 2000 and the test of cognitive ability is taken around the age of eighteen. Since the measure of cognitive ability is taken shortly after the completion of high school, the inclusion of additional covariates such as education level, marital status and income will help determine whether the effect of cognitive ability is mediated by these variables. We refer to the coefficient on IQ in the regression with only age controls as the unconditional effect, and the coefficient with the broader set of controls as the conditional effect.

We also report estimates of the same specifications with family fixed effects included in the regression. This method ensures that unobserved determinants of portfolio risk that twins share, including age, are eliminated as confounds. Griliches (1979) is a classical reference on the merits and pitfalls of within family estimation. For example, shared aspects of the rearing environment that affect portfolio risk-taking and are correlated with IQ would bias the coefficients in the cross-sectional regression, but not in the fixed effects within family regressions. However, whether or not within family estimation is an improvement over cross-sectional regressions depends on what the sources of variation within family are (Griliches, 1979). The estimating equation is therefore,

$$\Delta Risk_{ij} = \alpha_1 + \alpha_2 \Delta IQ_{ij} + \alpha_3 \Delta \mathbb{X}_{ij} + \varepsilon_{ij}$$

Where, $\Delta Risk_{ij}$ is the difference in the portfolio risk of individual *i* in the twin pair *j*. ΔIQ_{ij} is the difference in IQ of individual *i* in twin pair *j*, $\Delta\mathbb{X}_{ij}$ is a vector of differences in control variables of individual *i* in twin pair *j* and ε_{ij} is the error term. With the constant omitted, this specification is mathematically equivalent to a specification with family fixed effects.

Model for Active Participation

We also examine the relationship between active participation and cognitive ability using simple linear probability models. That is, we run regressions of the form,

$$Active\ Participation_i = \alpha_1 + \alpha_2 IQ_i + \alpha_3 \mathbb{X}_i + \varepsilon_i$$

Where *Active Participation$_i$* is now a binary variable taking the value 1 if individual *i*'s portfolio is not the default fund. We use the same set of controls as for risk-taking, and report both the cross-sectional regressions and the fixed effects within family regressions.

For the reason that we are using twins in our regression we adjust all tests to account for any unwanted correlation in the error terms in order not to violate the OLS assumptions[5]. This is done by using the General Estimating Equation (GGE) cluster-robust variance-covariance matrix proposed by Liang and Zeger (1986).

[5] A standard OLS regression assumes the following: $\mathrm{Cov}(\varepsilon_i, \varepsilon_j) = 0 \; \forall \; i \neq j$ and is likely not to hold if individual *i* and individual *j* are twins.

IV. Results

Results on the Relationship between Risk-taking and Cognitive Ability

Table 4 reports estimates from the cross-sectional regression of portfolio risk on cognitive ability and age. The coefficient on cognitive ability suggests that holding age constant, a one standard deviation increase in cognitive ability is associated with approximately a quarter of a unit greater portfolio risk. To put this into perspective, the standard deviation of the risk measure is approximately 6. The coefficient on cognitive ability is also highly significant.

Table 4. Portfolio risk on cognitive ability and age

	Coefficient	**Std.Error**	**t-statistic**	**Sig. Level**
Constant	26.12	0.31	82.93	0.00***
Age	-0.12	0.01	-20.16	0.00***
IQ	0.26	0.06	4.40	0.00***
Observations	11 268			
R-squared	0.04			
F-statistics	218.63			

Note: ***/**/* denote statistical significance at 1/5/10 percent significance levels.

Estimates with additional control variables included are reported in Table 5. The coefficient on cognitive ability drops when educational attainment, income and marital status are included in the regressions. With these control variables included, the coefficient on cognitive ability is half of that reported using unconditional effect in Table 4. The conditional effect of cognitive ability is only borderline significant ($p = 0.074$). An additional year of educational attainment is associated with 0.07 unit greater portfolio risk, holding cognitive ability, marital status, income and age constant. Being married is associated with a 0.12 unit greater portfolio risk, holding the remaining covariates constant, although the coefficient is not statistically significant. Papke (1998) also studies marital status and finds no discrepancy between investments in stocks between single and married women. Finally, as the income variable is in logs, an increase in income of 1% will result in an increase of risk of 0.0038 units, holding all other covariates constant.

Table 5. Portfolio risk on cognitive ability, age, education, income and marital status

	Coefficient	**Std.Error**	**t-statistic**	**Sig. Level**
Constant	25.01	0.50	50.01	0.00***
Age	-0.12	0.01	-18.44	0.00***
IQ	0.13	0.07	1.78	0.07*
Education	0.07	0.03	2.78	0.01***
Income	0.38	0.29	1.30	0.19
Marital Status	0.12	0.12	1.01	0.31
Observations	11 268			
R-squared	0.04			
F-statistics	90.90			

Note: ***/**/* denote statistical significance at 1/5/10 percent significance levels.

Table 6 reports the estimates from the fixed effects within family regression of portfolio risk on cognitive ability. The fixed effects regression controls for all variations that are shared between twins, e.g. age, diet, parents, genes, environment. In this model the coefficient on cognitive ability indicates that a difference in cognitive ability between twins of one standard deviation is related to a difference of 0.240 unit of portfolio risk. This point estimate is similar to the cross-sectional estimate, however the coefficient is not statistically different from zero (p = 0.212).

Table 6. Fixed effect regression of risk on cognitive ability

	Coefficient	**Std.Error**	**t-statistic**	**Sig. Level**
Constant	19.64	0.00	-	0.00
IQ	0.23	0.19	1.17	0.24
Observations	11 268			
R-squared	0.58			
F-statistics	1.36			

Note: ***/**/* denote statistical significance at 1/5/10 percent significance levels.

The results from the fixed effects regressions adding the set of control variables are reported in Table 7. The coefficient on cognitive ability is still around 0.2 and is yet again measured very imprecisely. In fact none of the variables that are tested for are statistically significant at a 10% level. Even education, which was highly significant in the cross-sectional model, is not significant when controlling for fixed effects. In the fixed effects within family regressions we measure 5 844 absorbed clusters.

Table 7. Fixed effect regression of risk on cognitive ability, education, income and marital status

	Coefficient	**Std.Error**	**t-statistic**	**Sig. Level**
Constant	19.05	0.85	22.45	0.00***
IQ	0.19	0.20	0.93	0.36
Education	0.05	0.07	0.64	0.52
Income	-0.08	0.70	-0.11	0.91
Marital Status	0.11	0.27	0.43	0.67
Observations	11 268			
R-squared	0.58			
F-statistics	0.49			

Note: ***/**/* denote statistical significance at 1/5/10 percent significance levels.

Results on the Relationship between Active Participation and Cognitive Ability

The results from the unconditional cross sectional regression of active participation on cognitive ability are provided in Table 8. These results suggest that there is a positive relationship between cognitive ability and active participation. The coefficient on IQ is approximately 0.02, implying that if cognitive ability increases by one standard deviation the probability of being active is increased by approximately 2 percentage units, holding age constant. Moreover, the coefficient is significant at all reasonable significance levels (p = 0.001).

Table 8. Active participation on cognitive ability and age

	Coefficient	Std.Error	t-statistic	Sig. Level
Constant	0.87	0.03	31.50	0.00***
Age	-0.03^{O}	0.01^{O}	-6.64	0.00***
IQ	0.02	0.05^{O}	4.28	0.00***
Observations	11 268			
R-squared	0.01			
F-statistics	29.88			

Note: ***/**/* denote statistical significance at 1/5/10 percent significance levels. ^{O} indicates values that have been multiplied by 10.

With the wider set of controls, cognitive ability is no longer a statistically significant predictor of active participation (p = 0.54). Notice also that according to the results presented in Table 9 the sign of the coefficient on cognitive ability is negative. Looking at the other variables one can see that one year of additional education is associated with one percentage unit higher likelihood of being active, holding age, cognitive ability, income and marital status constant. Furthermore, a one percent increase in disposable income of an individual leads to a 0.02 percentage unit greater chance of being active holding the other covariates constant. If an individual is married, keeping the other covariates constant, the person is 10 percentage units more inclined to actively decide funds in the premium pension.

Table 9. Active participation on cognitive ability, age, education, income and marital status

	Coefficient	Std.Error	t-statistic	Sig. Level
Constant	0.79	0.04	18.99	0.00***
Age	-0.01	0.01^{O}	-9.00	0.00***
IQ	-0.03^{O}	0.01	-0.61	0.54
Education	0.01	0.02^{O}	2.32	0.02**
Income	0.20	0.06	3.41	0.00***
Marital Status	0.10	0.01	10.69	0.00***
Observations	11 268			
R-squared	0.03			
F-statistics	45.67			

Note: ***/**/* denote statistical significance at 1/5/10 percent significance levels. ^{O} indicates values that have been multiplied by 10.

Within family, the coefficient on cognitive ability is also highly significant (p = 0.004) in the model without control variables. The estimated coefficient suggests that within families, a one standard deviation increase in cognitive ability is associated with a 4 percentage unit higher probability of making an active choice.

Table 10. Fixed effect regression of active participation on cognitive ability

	Coefficient	**Std.Error**	**t-statistic**	**Sig. Level**
Constant	0.69	0.00	-	0.00
IQ	0.04	0.14	2.90	0.00***
Observations	11 268			
R-squared	0.61			
F-statistics	8.43			

Note: ***/**/* denote statistical significance at 1/5/10 percent significance levels.

With the broader control set, the coefficient is only marginally significant (p = 0.089) and the lower point estimate, approximately 2.55%, suggests that the effect of cognitive ability may be mediated by the association with marital status, income and, particularly, education.

Table 11. Fixed effect regression of cognitive ability, education, income and marital status on active participation

	Coefficient	**Std.Error**	**t-statistic**	**Sig. Level**
Constant	0.50	0.06	8.13	0.00***
IQ	0.03	0.02	1.70	0.09*
Education	0.01	0.01	1.73	0.08*
Income	0.16	0.10	1.58	0.11
Marital Status	0.08	0.02	3.88	0.00***
Observations	11 268			
R-squared	0.62			
F-statistics	8.38			

Note: ***/**/* denote statistical significance at 1/5/10 percent significance levels.

V. Sensitivity Analysis

In this section we examine the robustness of the basic results to some alternative specifications and sample selection criteria.

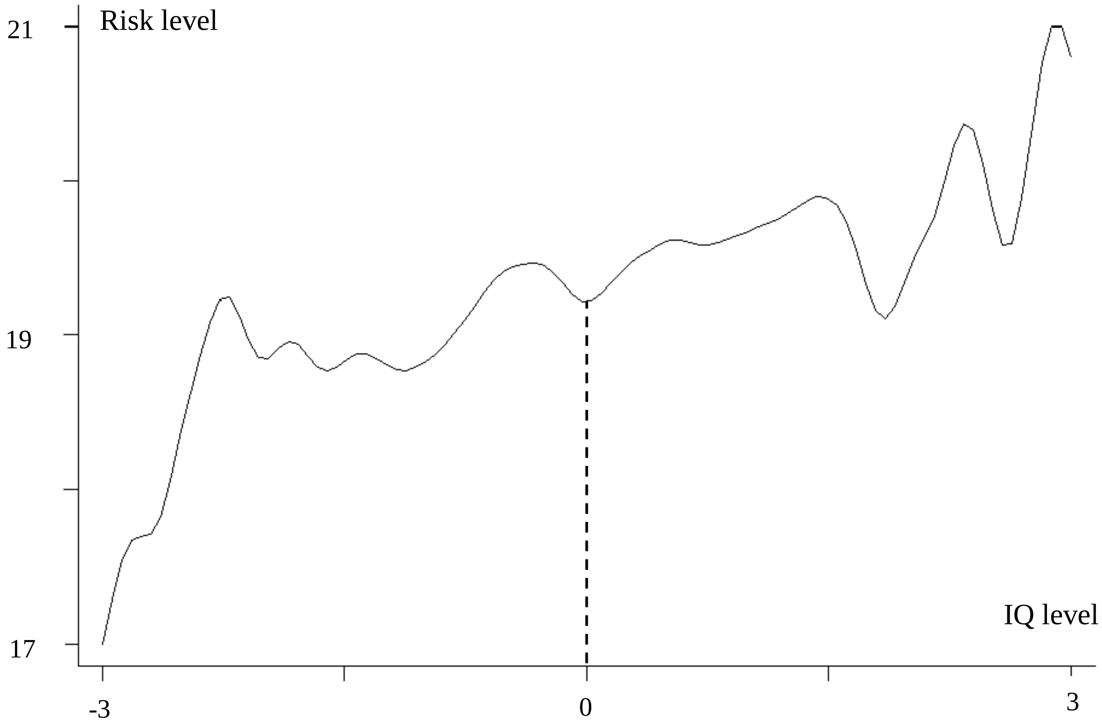
Sample Selection

First we investigate how the results are affected by excluding those individuals who did not make an active choice. Obviously, restricting the sample so that it only includes active participants amounts to selection on the dependent variable. This selection bias could potentially be corrected by using Heckman's two step selection model (Heckman, 1979). However, we were not able to identify a variable that affects active participation in the first step equation without affecting active participation in the second step equation. Hence, we did not pursue this possibility and view the results for the restricted sample as a crude robustness check. In Appendix A.4., we report the baseline regressions using only subjects who made an active investment decision. The results are qualitatively similar to those reported for the whole sample. The coefficient on cognitive ability is uniformly higher in all regressions.

Linearity

The regression models are based on an assumption of a linear relationship between the dependent and independent variables, a reasonable yet untested assumption. In order to explore whether risk-taking actually increases linearly with cognitive ability, we estimate a Nadaraya-Watson nonparametric regression with cognitive ability as the independent variable (Nadaraya, 1964). We use a Gaussian kernel with 100 grid points and the results are given in Diagram 3. There are signs that the relationship is steeper for lower levels of cognitive ability, implying that the relationship between cognitive ability and risk-taking is of greatest importance for these levels, this is also in line with what Benjamin, Brown and Shapiro (2006) reported. However, overall the relationship looks approximately linear.

Diagram 3. Nonparametric regression of risk-taking on cognitive ability.



Note: The curve is based on a Gaussian kernel with 100 grid points. The mean IQ of 0 is indicated with a dotted line.

VI. Discussion

The main finding that emerges from the analysis is that there is a statistically significant bivariate relationship between cognitive ability and risk-taking in the cross sectional data. However, it is important to emphasize that the estimated coefficient is quite low, implying that a one standard deviation increase in cognitive ability is associated with 0.25 more units of portfolio risk, or approximately 4% of a standard deviation in the dependent variable. The estimated coefficient from the cross-section is very similar to the within family coefficient, but the latter is estimated with considerably less precision. Since cognitive ability is measured with error, the coefficient estimates are probably plagued by some attenuation bias. Under a reasonable, but only ballpark, estimate of a reliability ratio of 0.9 for the IQ test, this would imply that the coefficients would need to be adjusted upward by approximately ten percent.

Taken together, the data on risk-taking is supportive of the conclusions derived from experimental studies (Frederick, 2006; Benjamin, Brown and Shapiro, 2006; Dohmen et al., 2008), namely that cognitive ability is associated with greater financial risk-taking. An important question to resolve in future work is whether or not one should think of the greater degree of risk-aversion as reflecting a cognitive bias. Korniotos and Kumar (2008) provide some evidence suggesting that people with higher cognitive ability enjoy higher risk-adjusted returns and propose that the mechanism is superior informational acquisition. Those findings are consistent with a behavioral explanation of the relationship between risk and cognitive ability. An advantage of our paper is that we do not impute cognitive abilities from demographic characteristics, but instead directly measure cognitive abilities. We note that much of the evidence on the relationship between cognitive ability and preference anomalies have been documented in the laboratory. List and Levitt (2007) have argued, however, that the external validity of laboratory experiments is more limited than most experimental economists are willing to acknowledge. It is reassuring therefore that qualitatively, the same patterns that have been reported in the laboratory data seem to hold in field data studied here.

Our finding that the unconditional effect of cognitive ability is considerably higher than the conditional effect with education included is consistent with the hypothesis that differences in the costs of information acquisition explains some of the portfolio choice differences between people of low and high cognitive ability. The estimated coefficient on cognitive ability falls by approximately 50% in the cross-sectional regressions and by 75% in the within-family regressions. Since the test of cognitive ability is taken in adolescence, this renders it unlikely that education is causing cognitive ability, and suggests that part of the effect of cognitive ability on portfolio investment operates through the effect of cognitive ability on educational attainment. The same also holds for marital status. Marriage is positively correlated with cognitive ability and is associated with greater risk-taking. The coefficient on marital status could be interpreted as evidence of information dissemination within the marriage, or risk-pooling within the marriage. Consistent with much empirical research on portfolio research, the share of variation explained by our covariates is fairly small, as indicated by the coefficient of determination of 4%.

It is well-known that there is ample heterogeneity in financial decision making (Guiso, Haliassos and Jappelli (2002); Curcuru et al. 2009), but these differences are not fully understood. One particularly pressing problem has been to understand why so many households do not participate in financial markets at all, despite the normative prescription that emerges from most models that they should hold at least some fraction of their wealth in stocks. One solution to this, which some have claimed may be relevant in understanding the equity premium puzzle (Mehra and Prescott, 1985), is to assume that there are some fixed costs of participation. The nature of the fixed costs is rarely specified. The results reported here – along with those in Korniotos and Kumar (2008) – suggest that differences in the costs of acquiring and processing information may be one channel. Cognitive ability may serve as useful proxy for ability to acquire information, and including cognitive ability as a covariate in models of portfolio choice can therefore lead to a richer understanding of investment heterogeneity.

The results reported here for active participation are broadly consistent with this hypothesis. We found a relationship between cognitive ability and participation for the unconditional cross-sectional data, but not for the conditional data. We also found a significantly positive relationship within family. Holding family background, and other influences that twin siblings share, constant, higher cognitive ability is associated with participation. The point estimates suggest that a one standard deviation higher cognitive ability within family is associated with a 4% greater likelihood of making an active choice. Including the additional controls, marital status, income and level of education reduces the estimated coefficient to 2.6%. If our interpretation of these findings is correct, this would provide further evidence in favor of the hypothesis that heterogeneity in cognitive skills is relevant for efforts to understand heterogeneity in portfolio choice.

Finally, we note that our results are also broadly consistent with a behavioral view of financial investment behavior. Standard models of portfolio investment do not explicitly incorporate cognitive constraints into the decision problem of the individual. A fundamental tenet of behavioral finance, however, is that people have limited cognitive resources and that tapping into these resources can be costly. The within family estimates of the effect of cognitive ability on participation suggest that the differences between more and less able people can be quite large. In the context of the particular retirement investment studied here, it probably did not matter too much that some people failed to make an active choice, as the default fund is widely agreed to be very well managed and at a low fee (Cronquist and Thaler, 2004). This suggests that people with higher cognitive ability may even be more likely to choose the default fund, in which case it is not clear whether or not one should expect a positive association between participation and cognitive ability. It is easy to imagine, however, that with a poorly designed default option, the costs of non-participation might have been large. This underlines the importance of designing policies taking people's cognitive constraints into consideration.

VII. Conclusion

In this paper we have examined the association between cognitive ability, on the one hand, and portfolio risk and financial market participation on the other hand. Using conscription data on over eleven thousand twin individuals, we find some evidence of a positive relationship between cognitive ability and financial risk-taking. The coefficients are quite imprecisely estimated. Yet, we view these results as a good complement to investigations based on laboratory data. A major advantage of our results is that that they are based on a reliable measure of cognitive ability and not from imputed measurements. We find some evidence that the relationship between cognitive ability and risk-taking is mediated by educational attainment. We also find that active participation is associated with cognitive ability. This is broadly consistent with a behavioral view of investors, in which cognitive and computational constraints affect investment behavior.

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IX. Appendix

A.1. Sample from the Guide

AKTIEFONDER 18

All information i tabellerna grundas på information från fondförvaltarna.

Låg risk — Hög risk

REGIONALA FONDER

Fond-nummer	Fondnamn / Fondförvaltare	Information om fonderna	Fondförmögenhet Mkr 99-12-31	Fond-avgift %	Värdeutveckling i % 99-12-31 (efter fondavgifter) respektive år 95	96	97	98	99	senaste 5 åren	Total risk (senaste 3 åren)	Egna note-ringar
	NORDEN											
348 987	**Carnegie Fund Nordic Markets subfund** Carnegie Fund Management Co S A	Nordenfond med en koncentrerad aktieportfölj, vanligtvis 25 till 30 bolag.	248	1.30	–	–	38	40	55	–	20	
134 007	**Industrifinans Aksje Norden** Industrifinans Fondsforvaltning AS	Nordiska börsnoterade aktier, cirka 50% svenska aktier.	267	1.23	–	–	–	20	64	–		Ny
539 056	**Nordic Equity Fund** Trevise Unibank Investment Management (Unibank A/S)	Genom en tematisk investeringsprocess investerar fonden i nordiska aktier.	257	1.04	–	–	–	–	–	–		Ny
595 546	**Parvest Scandinavia** Paribas Luxembourg	Aktier med maximiränta noterade i medelstora till stora nordiska bolag.	1 180	1.32	–	–	30	29	113	–	28	
498 386	**Placeringsfonden Evli Nordic Smaller Companies** Evli Fondbolag Ab	Fonden placerar i börsnoterade, nordiska småbolag.	417	1.30	–	–	–	-14	82	–		Ny
892 513	**Roburs Miljöfond** FöreningsSparbanken Fonder AB	Placerar i företag med verksamhet som bedrivs med aktivt miljötänkande.	727	1.17	–	–	28	-2	48	–	19	
820 852	**Roburs Nordenfond** FöreningsSparbanken Fonder AB	Placerar i olika branscher i Norden.	6 431	1.17	9	45	31	27	59	320.0	22	
860 932	**Roburs Småbolagsfond Norden** Robur Fonder AB	Placerar i mindre nordiska börsnoterade företag.	3 668	1.16	14	59	24	-1	37	203.8	18	
857 276	**SalusAnsvar Öhman Resurs och Miljöfond** SalusAnsvar E. Öhman Fonder AB	Placerar i nordiska företag som är resurseffektiva och tar miljöhänsyn.	50	1.38	–	–	–	–	42	–		Ny
897 355	**Storebrand Norden** Storebrand Fondene AS	Brett urval av större, finansiellt attraktiva företag i Norden.	207	1.41	–	–	–	–	70	–		Ny

Note: The rows represents the different funds, and the columns show the management fee, size and risk of the funds.

A.2. Risk Measure Calculations

The risk measure of an individual's pension portfolio is the weighted average of the risk of each fund in the portfolio. Unfortunately all funds did not have a risk level, since some funds did not have any historical data. Therefore the risk level of these funds had to be imputed using the average risk of similar funds:

$$\overline{Risk}_{klm} = \frac{1}{n_{klm}} \sum_{i=1}^{n_{klm}} Risk_{iklm}$$

Where *i* is the individual fund, *k* is the type of fund, i.e. equity fund, mixed fund, generation fund or interest fund, *l* is the region of the fund, and *m* is the business sector of the fund. n_{klm} is the number of funds of type *k*, region *l* and business sector *m*. This means that two new funds of the same type, from the same region and in the same business sector were assigned the same risk.

The total risk is then the weighted average of the funds that had risk measures in the information catalogue and the funds that had imputed risk:

$$\overline{Risk}_j^p = \sum_{i,k,l,m} \omega_{jiklm}\, Risk_{iklm} + \sum_{k,l,m} \bar{\omega}_{jklm}\, \overline{Risk}_{klm}$$

where,

$$\sum_{i,k,l,m} \omega_{jiklm} + \sum_{k,l,m} \bar{\omega}_{jklm} = 1$$

and, ω_{jiklm} is the proportion of the contribution from portfolio *j* invested into fund *i* of type *k*, from region *l* and business sector *m*, with the risk stated in the guide. $Risk_{iklm}$ is the risk data for that particular fund. $\overline{\omega}_{jklm}$ is the proportion of the contribution from portfolio *j* invested in funds of type *k*, from region *l* and business section *m* with an imputed risk as above.

Note that when calculating the portfolio risk no consideration was made to possible covariance between the different funds, as this information was not provided in the guide. This means the portfolio risk should be viewed as the indicated risk given by the guide and not the actual risk level.

A.3. Relationship between Cognitive Ability and Age

The relationship between the IQ measure that we use and an individual's age can be described by the following model:

$$y = \beta_1 x_{1i} + \beta_2 x_{2i} + \varepsilon_i$$

Where x_{1i} is the normalized IQ level of individual i, x_{2i} is the age of individual i and ε_i is the error term. Since the IQ measure is created to be orthogonal to age we have:

$$Cov(\beta_1 x_{1i}, \beta_2 x_{2i}) = 0$$

If we define variable ε_{1i}, such that:

$$\varepsilon_{1i} = \beta_2 x_{2i} + \varepsilon_i$$

The following holds:

$$Cov(\beta_1 x_{1i}, \varepsilon_{1i}) = Cov(\beta_1 x_{1i}, \beta_2 x_{2i} + \varepsilon_i) = Cov(\beta_1 x_{1i}, \varepsilon_i) + Cov(\beta_1 x_{1i}, \beta_2 x_{2i}) = Cov(\beta_1 x_{1i}, \varepsilon_i)$$

This implies that regressing y on x_{1i} and x_{2i} gives the same estimate of β_1 as regressing y on x_{1i}.

A.4. Risk on IQ for Active Participants

The results from restricting the sample to individuals that made an active choice are given in the following tables.

Table A3.1. OLS Regression of IQ and Age on Risk

	Coefficient	**Std.Error**	**t-statistic**	**Sig. Level**
Constant	29.01	0.45	64.65	0.00***
Age	-0.18	0.01	-20.79	0.00***
IQ	0.46	0.09	5.37	0.00***
Observations	7 763			
R-squared	0.06			
F-statistics	228.82			

Note: ***/**/* denote statistical significance at 1/5/10 percent significance levels.

A3.2. Portfolio risk on cognitive ability, age, education, income and marital status

	Coefficient	Std.Error	t-statistic	Sig. Level
Constant	27.35	0.72	37.94	0.00***
Age	-0.18	0.01	-19.14	0.00***
IQ	0.23	0.10	2.17	0.03**
Education	0.12	0.04	3.11	0.00***
Income	0.63	0.33	1.88	0.06*
Marital Status	0.38	0.18	2.16	0.03**
Observations	7 763			
R-squared	0.06			
F-statistics	95.75			

Note: ***/**/* denote statistical significance at 1/5/10 percent significance levels.

Table A3.3. Fixed effect regression of risk on cognitive ability

	Coefficient	**Std.Error**	**t-statistic**	**Sig. Level**
Constant	19.45	0.01	1751.82	0.00***
IQ	0.59	0.39	1.53	0.13
Observations	7 763			
R-squared	0.71			
F-statistics	2.34			

Note: ***/**/* denote statistical significance at 1/5/10 percent significance levels.

Table A3.4. Fixed effect regression of risk on cognitive ability, education, income and marital status

	Coefficient	**Std.Error**	**t-statistic**	**Sig. Level**
Constant	18.62	1.69	11.03	0.00***
IQ	0.53	0.40	1.31	0.19
Education	0.05	0.14	0.38	0.70
Income	0.07	1.01	0.07	0.94
Marital Status	0.32	0.52	0.61	0.54
Observations	7 763			
R-squared	0.71			
F-statistics	0.71			

Note: ***/**/* denote statistical significance at 1/5/10 percent significance levels.