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The Private Equity Premium Puzzle Revisited –

New Evidence on the Role of Heterogeneous Risk Attitudes

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Abstract:

The empirical finding that entrepreneurs tend to invest a large share of their wealth in their own firms despite comparably low returns and high risk has become known as the private equity premium puzzle. This paper provides evidence supporting the hypothesis that lower risk aversion of entrepreneurs, and not necessarily credit constraints, may explain this puzzle. The analysis is based on a large, representative panel data set for Germany, which provides information on asset portfolios and experimentally validated risk attitudes. The results show that both the ownership probability and the conditional portfolio share of private business equity significantly increase with higher risk tolerance.

JEL classification: G11, G32, L26, J23, D81

Keywords: Entrepreneurship, Private Equity, Investment, Risk Aversion

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1 Introduction

Why do entrepreneurs invest a large share of their wealth in their own firms, despite the high risk associated with such an undiversified portfolio? The entrepreneurial risk-taking is not compensated by a premium on expected returns, as documented by Moskowitz and Vissing-Jorgensen (2002), and thus represents, in their wording, a 'private equity premium puzzle'.[2] One possible explanation for the puzzle may be that external financing may be costly in imperfect financial markets due to asymmetric information (Gentry and Hubbard, 2004, page 21). In other words, entrepreneurs would like to diversify, but face credit constraints. Hintermaier and Steinberger (2005) present a theoretical model of occupational choice over the life cycle under borrowing constraints and imperfect information about the profitability of potential businesses, which is able to generate the empirical finding. An alternative explanation may be lower risk aversion of entrepreneurs (Moskowitz and Vissing-Jorgensen, 2002, page 772; Gentry and Hubbard, 2004, page 21f). In this case, entrepreneurs' portfolios may result from unconstrained individual optimization, and the private equity premium puzzle does not necessarily indicate frictions in the capital market.

This paper provides the first empirical investigation of the heterogeneous risk tolerance explanation by analyzing the relationship between risk attitudes and entrepreneurial investment. The results confirm the hypothesis that higher individual risk tolerance increases both the probability of holding private business equity, and its share in the asset portfolio conditional on ownership. The most risk tolerant individuals have an 8 times higher probability of owning private business equity than the most risk averse individuals, and the portfolio share of the most risk tolerant entrepreneurs is 31.5 % higher than that of the most risk averse entrepreneurs.

[2] In contrast, the classical public equity premium puzzle (Mehra and Prescott, 1985) is concerned with the much *higher* returns to public equity stocks in comparison to safe government bonds.

Recent literature has provided evidence that lower risk aversion increases the probability of being or becoming an entrepreneur (van Praag and Cramer, 2001; Cramer *et al.*, 2002; Caliendo, Fossen, and Kritikos, 2008). Consistently with that, the self-employed are found to be less risk averse than employees (Hartog *et al.*, 2002; Barsky *et al.*, 1997). As this literature already shows that low risk aversion is an important characteristic of entrepreneurship, it is straightforward to proceed further and investigate the relationship with entrepreneurial investment.[3] In contrast to the existing literature, this analysis addresses potential endogeneity of the risk attitude.

The new evidence on risk aversion and entrepreneurial investment is based on the German Socio-Economic Panel, a large, representative panel survey of the German population. Besides a rich variety of socio-economic background variables, it provides information on personal wealth, asset portfolios, and measures of individual risk attitudes. The behavioral relevance of the survey measures of risk attitudes has been validated in a field experiment by Dohmen *et al.* (2005). Section 2 describes the data in more detail. The empirical methodology in this paper, as discussed in section 3, takes into account both observed and unobserved heterogeneity and potential endogeneity of the risk attitude. Section 4 presents the estimation results, and section 5 concludes with policy implications.

2 Data on Private Equity and Risk Attitudes

The German Socio-Economic Panel (SOEP), which is provided by the German Institute of Economic Research (DIW Berlin), is a representative yearly panel survey covering about 22,000 individuals living in 12,000 households in Germany. Wagner *et al*. (2007) provide a detailed description of the data. The waves of 2002 and 2007 included a special module collecting information about private wealth. The interviewers asked for the market value of

[3] Uncertainty is increasing in the level of entrepreneurial investment in the model of Fraser and Greene (2006), for example. In a related study, Barasinska, Schäfer, and Stephan (2008) analyzed the relationship between risk aversion and the number and combination of different asset classes held by private households.

personally owned real estate (owner-occupied housing, other property, mortgage debt), financial assets, tangible assets, private life and pension insurance, consumer credits, and, most importantly for this analysis, private business equity (net market value; own share in case of a business partnership). The wording of the question for private equity is reported in Appendix B. In contrast to a similar wealth module in the SOEP questionnaire of 1988, which collected wealth information at the household level, in 2002 and 2007 the information was elicited at the individual level (for a discussion see Frick *et al.*, 2007). This allows connecting personal wealth to individual risk attitudes. Since 2002, the SOEP has been enriched with a sample of high-income households (in 2002, this subsample comprised 2,671 individuals in 1,224 households with monthly net income above 3,835 euro). The oversampling of these households ensures that this analysis takes into account entrepreneurial investment by the rich, who hold an important share of aggregate private business equity.

The dependent variable s_{it} in this analysis is defined as the share of private business equity in gross wealth:

$$s_{it} = \frac{private\ business\ equity_{it}}{gross\ wealth_{it}}. \tag{1}$$

The variable $gross\ wealth_{it}$ is obtained by adding up the personal shares[4] of all the items in the wealth questionnaires:

$$gross\ wealth_{it} = owner\text{-}occupied\ housing_{it} + other\ property_{it} + financial\ assets_{it} + tangible\ assets_{it} + private\ life\ and\ pension\ insurance_{it} + private\ equity_{it}. \tag{2}$$

Thus, gross wealth is defined as wealth which is convertible into cash on the market and does not include human capital or statutory pension insurance entitlements. Mortgage debt on owner-occupied housing and other property and consumer credits are not deducted (this

[4] With regard to owner-occupied housing, other property, and financial assets, respondents are asked to state the total value and the share they personally own. The variables used in equation (2) and reported in Table 1 refer to the values of the personal shares, i.e. the total values multiplied with the personal shares. For the other asset classes including private business equity, the interviewers directly asked for the values of the personally owned shares.

would yield net worth), as the portfolio split, rather than the leverage decision, is the focus of this paper. This definition ensures that s_{it} always lies in the interval from 0 to 1.

New measures of individual risk attitudes were included in the SOEP waves of 2004 and 2006. Respondents were asked to indicate their willingness to take risks on an 11-point scale ranging from 0 (complete unwillingness) to 10 (complete willingness); the exact wording is provided in Appendix B. In a field experiment with real money at stake, based on a representative sample of 450 subjects, Dohmen *et al.* (2005) found that these survey measures of risk attitude are good predictors of actual risk-taking behavior.[5]

The panel estimations in this paper are based on the waves of 2002 and 2007, which provide the wealth information. The individual risk attitude of the same respondent in 2004 is used as a proxy for the risk attitude in 2002, and the risk attitude in 2006 as a proxy for 2007. The correlation coefficient between the risk attitudes reported in 2004 and in 2006 by the people in the 2007 sample is 0.48. The mean (standard deviation) changed from 4.89 (2.14) in 2004 to 5.14 (2.08) in 2006. The data thus suggests that risk attitudes are not entirely stable over time. In this case the risk attitude in 2004 may be influenced by the personal situation in 2002. This paper follows two different approaches to deal with this potential endogeneity: First, instrumental variables estimation, and second, using the wave of 2007 only, with the risk attitude in 2006 as explanatory variable for the outcome in 2007 (see section 3). The sample is restricted to individuals at working age (between 18 and 65 years) and excludes farmers, who presumably have different determinants of investment because of the dominating role of agricultural subsidies in Germany.[6] This leaves 10,368 observations without missing values in the variables used in this analysis.[7]

[5] The wave 2004 additionally included a measure of risk attitudes using lottery choices, and questions for the willingness to take risks in specific domains. In this paper only the question about the general willingness to take risks is used, as this is the only risk question repeated in 2006. Furthermore, the experiment by Dohmen *et al.* (2005) showed that this measure performs better than the lottery measure in predicting behavior.

[6] The results remain largely the same if farmers are included, although some of the standard errors increase.

[7] The results are robust with respect to observations with missing values, see footnote 10.

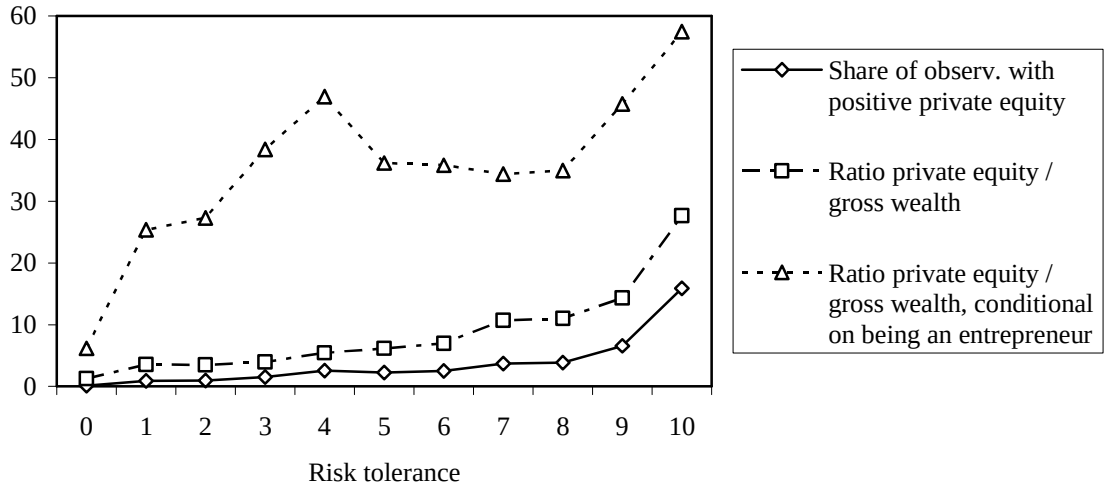
Table 1 shows the weighted mean values of the different asset and dept categories given in the German data in euro, separately for entrepreneurs and nonentrepreneurs and for the years 2002 and 2007. Entrepreneurs are defined here as individuals with a positive amount of private business equity.[8] All asset values and incomes are deflated to prices of 2002 using the consumer price index provided by the Federal Statistical Office throughout the analysis. Note that this comparison of assets exaggerates the wealth difference between entrepreneurs and the remaining population as it does not consider the statutory pension insurance entitlements of the dependently employed in Germany. The high portfolio share of private business equity, which gives rise to the private equity premium puzzle, becomes immediately evident: entrepreneurs invested 48 % of their gross wealth in their own business in 2002 and 43 % in 2007. This is consistent with the literature analyzing the portfolio composition of entrepreneurs in the U.S.A. (Moskowitz and Vissing-Jorgensen, 2002; Gentry and Hubbard, 2004; Heaton and Lucas, 2000).

As Figure 1 shows, the data clearly suggest a positive relationship between risk attitudes and entrepreneurial investment. With increasing risk tolerance, the share of observations with a positive amount of private business equity (entrepreneurs) increases, as well as the unconditional portfolio share of private business equity, and the portfolio share conditional on being an entrepreneur. The bumps in the conditional portfolio share which deviate from a monotonically increasing function could easily be explained by sampling error, as the sample only includes 726 observations with positive business value. In the following, econometric techniques will be used to control for observed and unobserved factors in order to ensure that this is not a spurious relationship. Table A 1 in Appendix A gives the weighted means of the variables used in this analysis, including the risk attitudes. Entrepreneurs are more willing to take risks than the remainder of the population. On the 11-point scale, their average is 5.53 in 2002 (6.18 in 2007), in comparison to the average 4.81 (5.03) of nonentrepreneurs. The

[8] Three quarters of the entrepreneurs defined in this way also report self-employment as their primary activity.

histograms in Figure A 1 illustrate the distribution of risk tolerance among entrepreneurs and nonentrepreneurs based on their answers in 2004 and 2006. Table A 2 provides descriptions of all the variables used in this analysis.

Figure 1: Risk Attitudes and Private Business Equity (SOEP 2002/2007)



3 Empirical Methodology

To estimate the effect of individual risk attitudes on entrepreneurial investment, the share of private business equity in the asset portfolio of person *i* at time *t* is modeled as a stochastic function of a measure of risk tolerance $risk_{it}$ and a vector of control variables x_{it}. Most people do not hold any private business equity in their portfolio. Only 7.05 % (6.95 %) of the people in the sample from 2002 (2007) reported positive values. The observed portfolio share of private business equity s_{it} is thus censored at 0. Additionally it is censored at 1, which is reached if somebody invests her entire portfolio in her private business, although this case is far less relevant in the data (32 observations in the pooled sample). Let the latent variable s_{it}^* denote the notional desired share of private business equity in person *i*'s portfolio at time *t*:

$$s_{it}^* = \gamma risk_{it} + x_{it}'\beta + \nu_i + \varepsilon_{it}, \qquad (3)$$

where ν_i is an unobserved random effect, and ε_{it} is the error term. The observed portfolio share s_{it} is expressed as

$s_{it} = s_{it}^*$ if $s_{it}^* \in (0..1)$

$s_{it} = 0$ if $s_{it}^* \leq 0$

$s_{it} = 1$ if $s_{it}^* \geq 1$.

Under the assumptions that ν_i is i.i.d., N(0, σ_ν^2), and ε_{it} is i.i.d., N(0, σ_ε^2), independently of ν_i, the model is specified as a random effects two-limit tobit model (cf. Wooldridge, 2002).

The vector x_{it} controls for factors which may influence entrepreneurial investment and which may be correlated with risk aversion. The personal financial situation is accounted for by the variables net worth (gross wealth minus mortgage and other debt, in €100,000) and its square, gross labor income (in €1,000), and the individual average income tax rate (ATR). The ATR is calculated as

$$ATR_{it} = 1 - \frac{net\ (after\ tax)\ income_{it}}{gross\ (before\ tax)\ income_{it}}. \quad (4)$$

As both income concepts are asked for in the SOEP questionnaire at the household level, this approach takes into account that married couples are taxed jointly with full income splitting in Germany. To control for the life cycle and experience, x_{it} includes age (in years), prior work experience (in decades) and prior unemployment experience (in years) and the corresponding square terms. Prior work and unemployment experience are calculated using the full panel, which started in 1984 and was extended several times thereafter, and retrospective biography information informing about the time before people entered the panel. The employment status in the year of observation is excluded from this calculation to avoid endogeneity. Furthermore, dummy variables indicating educational attainment, gender, region, disability, German nationality, a self-employed father,[9] and marital status are included, plus the number

[9] In Germany, self-employed mothers were rare in the generation of most respondents' parents, and information on the mother's job position is often missing in the data, so only self-employed fathers are used.

of children under 17 in the household, 11 industry dummies, and a constant. A time dummy for 2007 accounts for potential business cycle effects.

The following will discuss the model assumptions of this baseline specification which may be critical for the results. Alternative econometric models will be employed additionally to assess the sensitivity of the results with respect to these assumptions.

First, the risk attitude measured on the scale from 0 to 10 may have a nonlinear effect on entrepreneurial investment. Thus, the risk measure $risk_{it}$ will be replaced by a vector of 11 dummy variables in an alternative specification, allowing for maximal flexibility.

Second, if individual risk attitudes are not constant (as commonly assumed), but change over time – to a certain degree the data actually suggest this, as mentioned in section 2 –, they may be endogenous with entrepreneurial investment. Endogeneity may arise if important life events such as the failure of a proprietary business have an impact on risk attitudes. The first approach to deal with this potential problem is to use the body height and the mother's secondary schooling level as instrumental variables (IV) for the risk attitude. The mother's schooling level is measured by a dummy indicating if she obtained the higher secondary school degree *Abitur*, which qualifies for university admission in Germany. Dohmen *et al.* (2005) found a strong positive partial correlation between these two variables and the risk attitude even after controlling for other characteristics. The education level of the father had a much weaker influence. These correlations are confirmed on the sample used here. As children and the elderly are excluded from the sample, body height is clearly exogenous, and should not have a direct influence on entrepreneurial investment. The mother's secondary schooling level is also fixed over the observation time and should not directly influence the adult offspring's portfolio allocation decision (the test of oberidentifying restrictions is passed, see below). The second approach to solve the potential endogeneity problem is to use the risk attitude observed in 2006 to explain private business equity observed in 2007 only, not using the wave 2002. This of course rules out panel estimators, as this leaves only a single

observation of the asset portfolio per person in the cross section of 2007. An additional IV tobit estimation addresses the possibility that the risk attitude may still be endogenous with the private equity portfolio share due to events in the further past or unobserved factors influencing both variables, such as entrepreneurial ability.

Third, the control variables net worth, labor income, and ATR, may be problematic. Measurement error in the value of private equity would change both s_{it} on the left hand side and net worth on the right hand side of equation (3) in the same direction, as private equity is used to calculate both quantities. Thus, such measurement error would bias the coefficient of *net worth* upward, in contrast to the usual downward attenuation bias introduced by measurement error. Labor income may be endogenous, as a higher portfolio share of private business equity may generate higher income from self-employment, although the portfolio share not only depends on the amount invested in the business, but also on the leverage decision. Given the focus of this paper, the potential endogeneity of these control variables would be relevant if they introduced bias in the coefficient of the variable measuring the risk attitude $risk_{it}$. The model will thus be re-estimated omitting net worth, labor income, and the individual ATR (because of its correlation with labor income) to see if this changes the coefficients of $risk_{it}$.

Fourth, the tobit model is potentially sensitive to the assumption of homogeneity of the error term ε_{it}. This assumption is relaxed in an alternative tobit model with heteroskedastic errors. Here, the variance is specified flexibly as

$$\sigma^2_{\varepsilon,it} = \sigma^2_{\varepsilon} \exp(x^h_{it}\acute{}\alpha), \tag{5}$$

where x^h_{it} equals x_{it} excluding the constant.

Fifth, the tobit specification implies that the ownership and portfolio decisions are determined by the same parameters. Intuitively it seams reasonable that personal factors which increase the probability of a positive amount of private equity also increase its expected conditional portfolio share. Poterba and Samwick (2002) used the tobit specification to

estimate a portfolio choice model of various financial assets (not including private business equity). They tested and did not reject the tobit specification; the same result applies to this application (see below). A more general alternative to the tobit model is a model with selection, which allows the determinants of ownership to differ from the determinants of the conditional portfolio share. This approach was taken by King and Leape (1998), who estimated the asset portfolio composition of US households (again excluding private business equity because of data limitations). The decision to hold private business equity, or of being an entrepreneur in this sense, is modeled in a selection equation

$$z_{it}^* = \kappa risk_{it} + x_{it}'\delta + u_{it}. \quad (6)$$

The latent variable model of the portfolio share of private business equity is now specified as

$$s_{it}^* = \theta\ risk_{it} + x^p{}_{it}'\pi + w_{it}, \quad (7)$$

and the observed portfolio share is

$$s_{it} = s_{it}^* \quad \text{if } z_{it}^* > 0$$

$$s_{it} = 0 \quad \text{if } z_{it}^* \leq 0.$$

The error terms w_{it} and u_{it} are assumed to have a bivariate normal distribution with zero means and correlation ρ. This model with selection (Heckman, 1979) is estimated using the FIML estimator. Censoring at 1, which occurs very seldom as mentioned above, is neglected in this specification. For better identification of the selection effect, the dummy variable indicating a self-employed father is used as an exclusion restriction not entering $x^p{}_{it}$ in the portfolio equation (7), which is otherwise equal to x_{it}. A self-employed father is likely to influence the probability of being an entrepreneur (Dunn and Holtz-Eakin, 2000), but is not expected to have a direct impact on the leverage and portfolio allocation decisions after controlling for the other factors.

In comparison to the tobit specification, this model with selection has the advantage of being more general. The disadvantage is that the number of parameters to be estimated almost doubles, so they cannot be estimated as precisely. Again, the model will additionally be

estimated using the two instrumental variables for the risk attitude in equation (7). Moreover, in this model equation (7) can be estimated with fixed effects. This is an alternative method of controlling for unobserved time-invariant individual characteristics which may both be correlated with the risk attitude and entrepreneurial investment, such as entrepreneurial ability. The fixed effects estimation does not require the assumption that the unobserved individual effects are uncorrelated with the explanatory variables, which is necessary for the random effects estimation of equation (3), and may thus be regarded more robust. The estimation results based on the models with selection will be presented as a robustness check in section 4.3. Table 2 summarizes all the alternative specifications employed.

4 Estimation Results

4.1 Results from the Tobit Models

Table 3 shows the estimated tobit coefficients for equation (3), using both data waves of 2002 and 2007, under five alternative specifications discussed in section 3. The positive and significant coefficients of the risk attitude variables indicate that a higher risk tolerance increases the portfolio share of private business equity in the personal asset portfolio. In four specifications, the risk attitude $risk_{it}$ enters the equation linearly (variable *risk tolerance*). The estimation result of $\hat{\gamma}$ = 0.0502 from the baseline specification, RE Tobit (1), falls into the 95-% confidence intervals of the estimated coefficients in models RE Tobit (2) and Heter. Tobit (5). Excluding net worth, gross labor income and the ATR from model RE Tobit (2) somewhat increases the point estimate for the coefficient of *risk tolerance*.[10] In the model with multiplicative heteroscedasticity, Heter. Tobit (5), all explanatory variables in x_{it} were

[10] The estimated coefficient of the risk attitude also remains similar if net worth is represented by 6 interval dummies instead of the level and the square. The variables net worth, gross income, and the ATR, are the ones which most often suffer from item non-response. Excluding these variables, it was possible to additionally estimate model RE Tobit (2) on a larger sample of 14,834 observations. The results are very similar, suggesting that the coefficient of *risk tolerance* is not sensitive to selection on missing information. All results not reported in the tables are available from the author upon request.

included to specify the heteroscedasticity, but only the significant variables are shown for brevity. In line with the presence of significant variables in the heteroscedasticity equation, homoscedasticity is rejected by an LM test. The estimated coefficient of risk tolerance changes only slightly in the model allowing for heteroscedasticity, however, so it is robust to the neglect of heteroscedasticity.

In the IV estimation, IV Tobit (4), the coefficient of interest remains positive and significant.[11] The point estimate is almost 10 times larger than in the baseline estimation, and the standard error is even 30 times larger. The higher point estimate in the IV estimation indicates that the coefficient of *risk tolerance* may be biased *downwards* in the baseline estimation. One reason may be that measurement error in the risk attitude leads to downward attenuation bias in the baseline estimation. IV estimation reduces the noise, particularly because body height can be measured with more precision. As the standard error in the IV estimation becomes very large, the coefficient of *risk tolerance* is imprecisely estimated, and the coefficient in the baseline estimation is still included in its 90-% confidence interval. Despite the low precision, the larger point estimate reinforces the finding that risk tolerance has a positive and significant effect on the portfolio share of private business equity. The result alleviates possible concerns that risk attitudes might be positively correlated with unobserved entrepreneurial ability, which in turn might be positively correlated with the portfolio share of private business equity. This would result in a lower point estimate emerging from IV estimation. The instrumental variables *height* and *motherhighersec* are jointly significant at the 1 % level (Wald $\chi_2^2 = 20.46$) in the "first stage" regression of risk tolerance on the instrument set, which additionally includes all explanatory variables in x_{it}. The coefficients of *height* and *motherhighersec* reported in the table are estimated jointly with

[11] 410 observations provide no information about their body height or their mother's education level and have to be excluded from the IV models. The results are similar if the mother's education is not used and the IV estimation relies solely on the body height, although this instrument alone is weaker. In this case, only 7 observations have to be excluded.

the tobit coefficients in the FIML estimation. The test of overidentifying restrictions is not rejected at the 10 % level. A Wald test rejects exogeneity of the risk attitude at the 10 % level, but not at the 5 % level. The fact, that exogeneity is not rejected very strongly, increases confidence in the baseline estimation.

In specification RE Tobit (3), $risk_{it}$ is represented by 10 dummy variables, which allows for arbitrary nonlinear effects. The omitted base category is *risk0*, which indicates the highest risk aversion on the 11-point scale. A slightly higher risk tolerance indicated by *risk1* and *risk2* has a positive influence on the portfolio share in comparison to the base category, but the difference is not yet significant. The point estimates of the coefficients of the dummy variables *risk3* to *risk10* are significant and increase monotonically with higher risk tolerance. This result strongly supports the hypothesized positive relationship between risk tolerance and entrepreneurial investment.

In the three RE tobit models, the point estimates for the standard error of the unobserved random effect σ_v are positive, and $\sigma_v = 0$ is rejected by a likelihood ratio test at the 1 % level. Although the efficiency of the models is improved by controlling for random effects, the coefficient of *risk tolerance* in the baseline model is robust to omitting the random effect, as indicated by the results from model Heter. Tobit (5) without random effects.

The results from estimating the models on the 2007 data only are shown in Table 4. As discussed in section 3, using only the wave of 2007 and the lagged risk attitude reported in 2006 may avoid possible endogeneity. In comparison to the estimations based on both waves of 2002 and 2007, the standard errors increase due to the smaller sample size. In the tobit models (6), which corresponds to the baseline specification, (7) with the reduced set of explanatory variables, and (10) with heteroscedasticity, the point estimates for the coefficient

of *risk tolerance* are larger than in the estimations based on the full sample.[12] The point estimate in the baseline model RE Tobit (1) estimated on the full sample, $\hat{\gamma}$ = 0.0502, is still included in the corresponding 95-% confidence intervals in models (6) and (10), but not in model (7). The higher point estimates may indicate that endogeneity of the risk attitude in the estimations based on the full sample biases the estimated coefficient of risk tolerance *downwards*. This may arise, for example, if a declining market value of a private business increases the risk tolerance of the entrepreneur. In this case, negative shocks in the observed portfolio share of private business equity in 2002 may be associated with positive shocks in the risk tolerance observed in 2004, which would result in a downward bias of the coefficient. This interpretation is in line with prospect theory, which predicts that entrepreneurs who have lost on their business are willing to take high risks in order to get a chance to offset the loss. In any case, the higher point estimates in the models based on the 2007 sample reassure that risk tolerance has a positive influence on entrepreneurial investment, and the lower point estimates in the models based on the full sample are the more conservative estimates.

The results from the specification with dummy variables for the risk attitude, Tobit (8), are similar to the results based on the full sample, although the coefficients are less precisely estimated due to the smaller sample size. The point estimates of the coefficients of *risk9* and *risk10* become larger, in line with the findings reported above, but the point estimates based on the full sample remain within the 95-% confidence intervals.

The coefficient of *risk tolerance* in the IV estimation (9) is estimated to be much larger than in the models without IV, which replicates the findings based on the full sample. The standard error becomes so large due to the small sample size that the coefficient is not even significantly different from 0, however. The coefficients of *height* and *motherhighersec* in a regression of *risk tolerance* on the instrument set are still jointly highly significant (Wald χ_2^2

[12] The heteroscedasticity equation (5) used in model Heter. Tobit (5) was first estimated with all variables in x_{it}. Then the estimation was repeated including only the 4 variables in the heteroscedasticity equation, which turned out to be significant. This reduced the standard errors of the tobit coefficients.

= 12.41). Exogeneity of the risk attitude is not rejected by the Wald test here (*p*-value = 0.352). This supports the idea that limiting the sample to the wave of 2007 and using the lagged risk attitude avoids the endogeneity problem, and confirms the validity of the models without IV in the limited sample.

Many of the control variables, which are reported completely in Table 3 and in part in Table 4, are found to significantly influence the portfolio share of private business equity. Net worth has a positive effect at slightly diminishing rates. This may be interpreted as an indication for the presence of liquidity constraints in the sense of Evans and Jovanovic (1989), and Blanchflower and Oswald (1998), although Hurst and Lusardi (2004) casted doubt on this explanation. The positive effect of net worth on entrepreneurial investment found in this analysis would then suggests that less wealthy people who would like to start up a business face constraints due to imperfect financial markets, and that less wealthy entrepreneurs are similarly constrained if they want to reduce the portfolio share of their business by taking on debt. In this case, capital constraints may be an additional explanation for the private business equity premium puzzle, besides the role played by heterogeneous risk attitudes.

Both gross labor income and the ATR are found to have a positive influence on the portfolio share. The positive effect of the ATR is in line with the theoretical predictions and empirical results of Cullen and Gordon (2007). One mechanism through which higher income taxes may encourage entrepreneurship is the implied sharing of risk with the government (see also Fossen, 2007). Better tax avoidance and evasion opportunities for the self-employed in comparison to the dependently employed may also make entrepreneurship more attractive in the presence of higher taxes, although the empirical evidence is mixed (Parker, 1996 and 2003). In any case, the coefficient of *risk tolerance* is not sensitive to the exclusion of the variables related to net worth and income, as mentioned above. Furthermore, entrepreneurial investment is lower for women and higher for older people, which confirms results from the

literature (Wagner, 2007, investigated the gender effect). As expected, a self-employed father also has a positive influence.

4.2 Effects on the Ownership Probability and Portfolio Share of Private Equity

The effect of risk attitudes on entrepreneurial investment is twofold. First, they influence the probability of owning private business equity, which can be interpreted as the decision to be an entrepreneur. Second, they influence the share of private business equity in the asset portfolio, conditional on owning private equity. The size of both effects can be calculated using the estimated tobit models. The marginal effects of the measure of risk tolerance $risk_{it}$ on the probability of owning private business equity, $\partial \operatorname{Prob}\left(s_{it} > 0 \middle| risk_{it}, x_{it}\right) \big/ \partial risk_{it}$, and the marginal effect on the portfolio share conditional on owning private equity, $\partial \operatorname{E}\left(s_{it} \middle| s_{it} > 0, risk_{it}, x_{it}\right) \big/ \partial risk_{it}$, are evaluated at the mean values of $risk_{it}$ and x_{it}, and given a zero random effect. The standard errors are calculated using the delta method.

Table 5 shows the estimated marginal effects of *risk tolerance* on the probability of ownership and the conditional portfolio share of private equity, which are estimated based on the different specifications and samples. The baseline model RE Tobit (1) yields the smallest and thus most conservative point estimates of both effects, except for a smaller effect on the probability of ownership based on model Heter. Tobit (5). In the baseline model, an increase of the risk tolerance by one point on the 11-point scale increases the probability of holding private business equity by 0.65 percentage points. Given that the expected probability of owning private equity is 4.72 % at the mean values of the explanatory variables, this corresponds to a relative increase of 13.8 %. The portfolio share of private equity, conditional on owning a positive amount, increases by 0.48 percentage points if the risk tolerance grows by one point on the 11-point scale. The expected conditional portfolio share of private business equity is 28.56 %, again evaluated at mean *x*, so the relative increase is 1.68 %. Thus, the estimated *relative* effect of risk attitudes on the decision to be an entrepreneur is

much higher than the relative effect on the conditional portfolio share of private business equity.

The estimated marginal effects based on the different tobit specifications are all significantly positive at the 5 % level, except for the effects estimated using model IV Tobit (9) on the 2007 data. The estimated marginal effects in the baseline estimation RE Tobit (1) reported above lie within the 90-% confidence intervals of the estimated effects in the other models, except for model Tobit (7), which yields larger marginal effects.

Table 6 presents the estimated effects of the dummy variables capturing the risk attitude $risk_{it}$ alternatively to the linear variable. These are the effects of discrete changes of one of the risk dummy variables from 0 to 1, evaluated at a value of 0 for the other risk dummies, and at the mean values of the other explanatory variables. In model RE Tobit (3), the estimated effects, both on the ownership probability and on the conditional portfolio share, grow monotonically with increasing risk tolerance, starting from *risk3*. The effects of the low levels of risk tolerance *risk1* and *risk2* are not significantly different from the effect of the base category *risk0* (highest risk aversion). There are remarkably stronger effects for the most risk tolerant people. Those indicating the highest level of risk tolerance, *risk10*, have an 11.28 percentage-points higher probability of owning private business equity than those in the base category with the lowest level of risk tolerance. Thus, they are 8 times more likely to be entrepreneurs than the most risk averse, whose expected probability is only 1.37 %. The conditional portfolio share of private business equity of the most risk tolerant entrepreneurs is 7.83 percentage points larger than the portfolio share of the most risk-averse entrepreneurs. As the conditional portfolio share of the latter is predicted to be 24.90 %, this corresponds to a relative effect of 31.45 %. In model Tobit (8), which is estimated using the wave of 2007 only, the estimated effects are even stronger. The point estimates from model RE Tobit (3) lie within the 95-% confidence intervals, however.

4.3 Robustness Check: Results from the Selection Models

Table A 3 in Appendix A shows the estimated coefficients for different variants of the portfolio share model with selection, as described by equation (7), based on the full sample of 2002 and 2007. The coefficient of *risk tolerance* is positive in the four models including this variable, indicating that higher risk tolerance increases the portfolio share of private business equity, but it is not statistically significant in these models with selection. Here, the identification of the influence of risk attitudes on the portfolio share must rely solely on those observations with positive holdings of private business equity. As the number of these observations is low, the standard errors are large. It turns out that the correlation between the error terms in the selection equation (6) and the portfolio share equation (7) is not statistically significant. The hypothesis that $\rho = 0$ is not rejected by Wald tests in the FIML models (11), (12), and (13), with *p*-value = 0.71 and larger, and the inverse Mill's ratio is insignificant in the two-step models (14) and (15).

The estimated marginal effects of *risk tolerance* on the conditional portfolio share of private business equity, $\partial \mathrm{E}\left(s_{it} \left| z_{it}^{*} > 0, risk_{it}, x_{it}\right.\right) \big/ \partial risk_{it}$, are reported on the right side of Table 5 and can be compared directly to the conditional marginal effects based on the tobit models.[13] The conditional marginal effects based on the model including the net worth and income related variables (11) and the model excluding these variables (12) are larger than the one based on model RE Tobit (1), although the latter still lies within their 95-% confidence intervals.

In the IV estimation with selection, IV Heckit (14), both the coefficient of *risk tolerance* and its standard error (as well as the conditional marginal effect) become substantially larger, similarly to the findings based on the IV tobit models. The large point estimate of the

[13] The conditional marginal effects in the FIML models (11), (12), and (13), are calculated as in Greene (2008), page 885. In the two-step models (14) and (15), the point estimators of the coefficients are directly taken as estimates for the conditional marginal effects, as the inverse Mill's ratio is insignificant.

coefficient again indicates that the estimations without IV may be downward biased. The large standard error is due to the inefficiency of the IV method.

In the fixed effects estimation with selection, FE Heckit (15), the point estimate for the coefficient of *risk tolerance* is 3.7 times larger than in model Heckit (11) without fixed effects. As the standard error is also larger, the coefficient is still not significantly different from zero. The coefficient is imprecisely estimated, because using the fixed effects method, the coefficient of *risk tolerance* is identified solely based on those individuals whose risk attitude changes between the two observation years, i.e. for individuals who reported a different risk attitude in 2006 than in 2004. The hypothesis that all fixed effects equal 0 is rejected by an *F*-test ($F = 3.59$). The larger point estimate for the coefficient of *risk tolerance* suggests that without controlling for fixed effects, the coefficient may be biased downwards. This is consistent with the results from the IV estimations. If risk tolerance were correlated with time-invariant unobserved characteristics such as entrepreneurial ability, and these characteristics had a positive influence on entrepreneurial investment, the coefficient of risk tolerance would become smaller in the fixed effects model.

Using dummy variables to describe the risk attitude in model Heckit (13), all corresponding coefficients except for *risk1* are positive and significant.[14] The coefficient and also the effect on the conditional portfolio share (reported in Table 6) are largest for the highest level of risk tolerance, *risk10*. The levels of risk tolerance indicated by *risk3* to *risk5* have a larger effect on the conditional portfolio share in this specification than *risk6* to *risk9*. Apart from *risk3* to *risk5*, the effect is still increasing with higher risk tolerance. Given the standard errors, the hypothesis of a monotonically increasing function of the risk tolerance cannot be rejected. At all levels of risk tolerance other than the base category, which indicates

[14] The number of observations in the 11 different risk classes becomes small in the second step of the model with selection, which is based on entrepreneurs only. To increase the number of observations, in model Heckit (13) mean values are imputed for observations which have missing values in gross labor income or the ATR. This is not deemed critical, as the coefficients of these variables are insignificant in all the models reported in Table A 3.

complete unwillingness to take risks, the estimated effect on the conditional portfolio share is higher than in the tobit specifications, which thus remain the more conservative estimates.

Table A 4 presents the estimated coefficients of variants of the probit selection equation (6), which describes the probability of owning private business equity. Here the coefficients of *risk tolerance* are not only positive, but also statistically significant. The coefficients reported under the column title Probit (11) in Table A 4 and under Heckit (11) in Table A 3 are estimated jointly using the FIML estimator. The same applies to Probit (12) and Heckit (12), as well as Probit (13) and Heckit (13). In contrast, the models IV Heckit (14) and FE Heckit (15) are estimated using two-step procedures. The estimated coefficients in the first step probit equation are very similar to those reported under Probit (11) and therefore not shown. The estimated coefficient of the dummy variable indicating a self-employed father, which is excluded from the portfolio equation, is positive and significant at the 1 % level in the selection equations, with *t*-values 2.92 in model (11), 5.89 in (12), 3.79 in (13), and 2.99 in (14).

Additionally, results of a probit estimation with *height* and *motherhighersec* as IVs for *risk tolerance* are presented under IV Probit (16). The IV estimation yields a substantially larger probit coefficient, which remains significant despite its increased standard error. This points to a possible downward bias of the probit coefficients without IV and is consistent with the result from model IV Tobit (4).

The estimated marginal effects of the risk attitude on the probability of ownership of private business equity based on the probit models, $\partial \operatorname{Prob}\left(s_{it} > 0 \middle| risk_{it}, x_{it}\right) \Big/ \partial risk_{it}$, are presented in the first column of Table 5, models (11) to (15). The effects on the ownership probability are positive and significant and larger than the effect obtained from the baseline model RE Tobit (1), although the latter is still included in the 95-% confidence intervals except for model (12). In summary, the results from the models with selection show that the effects of risk tolerance both on the ownership probability and on the conditional portfolio

share of private business equity based on the baseline model RE Tobit (1) are unlikely to be overestimated and may rather be underestimated.[15]

The more general model with selection can be used to assess the validity of the tobit specification. If the tobit specification is correct, the estimated ratio of the tobit coefficients over the standard error of the error term should not be statistically different from the estimated probit coefficients on the same variables. The test is conducted using the estimation results from model Tobit (6), which is based on the wave of 2007. An additional test uses a tobit estimation based on the pooled sample of 2002 and 2007 as in the baseline estimation, model RE Tobit (1), but without the random effects, as the random effects tobit model is not directly comparable to the probit model. It turns out that the ratios based on the tobit models indeed lie within the 95-% confidence intervals of the corresponding coefficients in the probit models for all the explanatory variables except for *net worth* and its square. The coefficients of *net worth* and its square also pass the test based on model Tobit (6) if the confidence intervals for the probit coefficients are calculated using heteroscedasticity robust standard errors. In any case, the signs of these coefficients are the same in the tobit and probit models. As the coefficient of *risk tolerance* is not sensitive to the exclusion of the *net worth* variables (see above), in summary the tobit model seems to be appropriate for the purpose of this study.[16]

A further robustness check was conducted regarding public start-up subsidies for the unemployed. A dummy variable indicating if an entrepreneur started up her business during the previous year with the help of a public subsidy known as "Ich-AG" ("Me-Incorporation") was included in the vector of control variables x^p_{it} in the otherwise identical models with

[15] The estimated effects on the ownership probability based on the dummy variables probit model, which are shown on the left side of Table 6, under the column heading Heckit (13), increase monotonically with increasing risk tolerance and are significant starting from *risk3*. The effects based on model RE Tobit (3) lie within the 95-% confidence intervals except for the medium range of *risk4*-*risk7*, which are estimated smaller using model Heckit (13). Taken together, the results from the dummy variable models suggest that a medium range of risk tolerance has smaller positive effects on the probability of private equity ownership than on the conditional portfolio share, a detail that the tobit models cannot identify by assumption. This finding should not be overemphasized because of the large standard errors involved, however. The results persist if the categories *risk0* and *risk1* are joined together to form a broader base category.

[16] Poterba and Samwick (2002) actually only conduct this test for the coefficient of interest and ignore the other explanatory variables.

selection reported in Table A 3. The program was available from January 2003 to August 2006, so it is only potentially relevant for entrepreneurs observed in 2007 who started their business before August 2006. The coefficient of the subsidy variable turned out to be insignificant in all the models, so it could be dropped from the final specifications. The data give insufficient information about the bridging-allowance (*Überbrückungsgeld*), which was also available till August 2006, and the new start-up subsidy programme which replaced the two programs (*Gründungszuschuss*). As the popular Me-Incorporation program is not found to have a significant impact, it is likely that these programs do not significantly affect the coefficient of interest either. Baumgartner and Caliendo (2008) provide a description and evaluation of the older two German start-up subsidy programs.

5 Conclusion

This paper provides evidence that people with lower levels of risk aversion are more likely to invest in an own entrepreneurial firm, and less risk averse entrepreneurs invest a larger share of their asset portfolio in their own business. This finding is robust to a variety of specifications, which control for observed and unobserved characteristics and potential endogeneity of the risk attitude. The most risk tolerant individuals have an 8 times higher probability of owning private business equity than the most risk averse individuals, and the portfolio share of the most risk tolerant entrepreneurs is 31.5 % larger than that of the most risk averse entrepreneurs.

The results contribute to explaining the private equity premium puzzle. This puzzle arises from the observation that entrepreneurs invest a large share of their wealth in their own firms, despite the high risk associated with such an undiversified portfolio, and without being compensated for by a risk premium that would seem adequate for a population average level of risk aversion. The evidence found in this paper suggests that the observed undiversified portfolio structures of entrepreneurs result at least in part from self-selection of risk tolerant

people into entrepreneurship. While this hypothesis has been stated in the literature, this paper provides the first empirical evidence on the positive relationship between risk tolerance and entrepreneurial investment.

Heterogeneous risk attitudes compete with credit constraints as another possible explanation for the private equity premium puzzle. In the presence of imperfect financial markets, entrepreneurs may want to diversify their portfolio by taking on debt, but external financing may be costly due to asymmetric information. This would call for government intervention in the financial markets, e.g. through subsidized venture capital. In contrast, if heterogeneous risk attitudes explain the observed undiversified portfolio structures of entrepreneurs, they may result from unconstraint individual optimization, and no government intervention is needed. While the results from this paper do not rule out that credit constraints may be at work as well, finding evidence that heterogeneous risk attitudes explain at least an important part of the puzzle certainly puts the case for government intervention into perspective.

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Tables

Table 1: Weighted Mean Asset Holdings and Portfolio Shares

Asset category	Entrepreneurs			
	2002		2007	
	Mean	Share of gross wealth	Mean	Share of gross wealth
Private business equity	274,707	0.480	207,401	0.429
Owner-occupied housing	101,964	0.178	95,222	0.197
Other property	126,121	0.220	109,890	0.227
Financial assets	25,482	0.045	38,572	0.080
Life and private pension insurance	39,658	0.069	31,013	0.064
Tangible assets	4,638	0.008	1,871	0.004
Gross wealth	572,570	1.000	483,970	1.000
Mortgage on owner-occ. housing	25,153	0.044	24,127	0.050
Mortgage on other property	43,948	0.077	35,265	0.073
Other liabilities	17,529	0.031	21,673	0.045
Net worth	485,941	0.849	402,905	0.832
N	371		355	
Asset category	Others			
	2002		2007	
	Mean	Share of gross wealth	Mean	Share of gross wealth
Private business equity	0	0.000	0	0.000
Owner-occupied housing	64,811	0.605	60,961	0.582
Other property	14,976	0.140	19,403	0.185
Financial assets	11,924	0.111	12,633	0.121
Life and private pension insurance	14,305	0.134	11,007	0.105
Tangible assets	1,060	0.010	689	0.007
Gross wealth	107,076	1.000	104,692	1.000
Mortgage on owner-occ. housing	17,221	0.161	16,527	0.158
Mortgage on other property	5,264	0.049	5,960	0.057
Other liabilities	2,692	0.025	2,447	0.023
Net worth	81,900	0.765	79,758	0.762
N	4,888		4,754	

The means are given in euro deflated to prices of 2002. Source: Own calculations based on the SOEP (2002/2007).

Table 2: Short Descriptions of Alternative Empirical Specifications

Spec. Name	Data	Short Description
RE Tobit (1)	02/07	Random effects 2-limit Tobit (*baseline specification*)
RE Tobit (2)	02/07	Random effects 2-limit Tobit, excluding net worth, gross income, and ATR
RE Tobit (3)	02/07	Random effects 2-limit Tobit, risk attitude captured by dummy variables
IV Tobit (4)	02/07	2-limit IV Tobit with height as IV for risk tolerance
Heter. Tobit (5)	02/07	2-limit Tobit with multiplicative heteroscedasticity
Tobit (6)	07	2-limit Tobit
Tobit (7)	07	2-limit Tobit, excluding net worth, gross income, and ATR
Tobit (8)	07	2-limit Tobit, risk attitude captured by dummy variables
IV Tobit (9)	07	2-limit IV Tobit with height as IV for risk tolerance
Heter. Tobit (10)	07	2-limit Tobit with multiplicative heteroscedasticity
Heckit (11)	02/07	Selection model FIML estimator
Heckit (12)	02/07	Selection model FIML estimator, excluding net worth, gross income, and ATR
Heckit (13)	02/07	Selection model FIML estimator, risk attitude captured by dummy variables
IV Heckit (14)	02/07	2-step selection model, 2nd step: IV GMM with height as IV for risk tolerance
FE Heckit (15)	02/07	2-step selection model, 2nd step: Fixed effects estimator

Table 3: Portfolio Share of Private Equity: Estimated Tobit Coefficients (SOEP 2002/2007)

	RE Tobit (1)	RE Tobit (2)	RE Tobit (3)	IV Tobit (4)	Heter. Tobit (5)
risk tolerance	0.0502***	0.0569***		0.4926**	0.0510***
	(0.0075)	(0.0078)		(0.2229)	(0.0070)
risk1			0.2501		
			(0.1995)		
risk2			0.2245		
			(0.1747)		
risk3			0.2962*		
			(0.1694)		
risk4			0.4154**		
			(0.1699)		
risk5			0.4223**		
			(0.1672)		
risk6			0.4253**		
			(0.1686)		
risk7			0.5075***		
			(0.1674)		
risk8			0.5148***		
			(0.1695)		
risk9			0.5913***		
			(0.1813)		
risk10			0.8160***		
			(0.1922)		
networth100k	0.0214***		0.0208***	0.0128*	0.0893***
	(0.0022)		(0.0022)	(0.0076)	(0.0138)
networth100k_sq	-0.0000***		-0.0000***	-0.0000	-0.0012**
	(0.0000)		(0.0000)	(0.0000)	(0.0005)
grossinc1000	0.0154***		0.0157***	0.0066	0.0170***
	(0.0031)		(0.0031)	(0.0095)	(0.0057)
avgtaxrate	0.2980***		0.3038***	0.2049	0.0082
	(0.1093)		(0.1092)	(0.1546)	(0.3804)
d2007	-0.0146	-0.0315	-0.0172	-0.1210*	-0.0053
	(0.0238)	(0.0239)	(0.0238)	(0.0677)	(0.0554)
highschool	0.0776*	0.0868*	0.0773*	0.0513	0.0391
	(0.0461)	(0.0482)	(0.0460)	(0.0501)	(0.1028)
apprenticeship	-0.0942**	-0.1293***	-0.0926**	-0.1234**	-0.1925*
	(0.0464)	(0.0481)	(0.0463)	(0.0515)	(0.1020)
highertechncol	0.0503	0.0331	0.0534	-0.0893	-0.1009
	(0.0480)	(0.0494)	(0.0478)	(0.0670)	(0.0860)
university	-0.0064	0.0486	-0.0041	-0.1266*	-0.0690
	(0.0497)	(0.0511)	(0.0495)	(0.0758)	(0.1196)
female	-0.3154***	-0.3606***	-0.3163***	0.0071	-0.2391**
	(0.0402)	(0.0424)	(0.0400)	(0.1603)	(0.1090)
east	0.0793*	0.0404	0.0767*	0.0720	-0.1196
	(0.0449)	(0.0467)	(0.0448)	(0.0494)	(0.1109)
south	0.0413	0.0479	0.0423	0.0819	-0.0872
	(0.0404)	(0.0419)	(0.0403)	(0.0520)	(0.0762)
north	0.0603	0.0591	0.0592	0.1149*	0.0557
	(0.0544)	(0.0564)	(0.0543)	(0.0667)	(0.1003)
age	0.1032***	0.1118***	0.1030***	0.1693***	0.1162***
	(0.0200)	(0.0207)	(0.0200)	(0.0361)	(0.0248)
age_sq	-0.0010***	-0.0010***	-0.0009***	-0.0016***	-0.0012***
	(0.0002)	(0.0002)	(0.0002)	(0.0004)	(0.0003)
prworkexp10	-0.2265**	-0.1883**	-0.2310**	-0.3826***	-0.1482
	(0.0905)	(0.0937)	(0.0902)	(0.1387)	(0.2099)
prworkexp10_sq	0.0230	0.0172	0.0239	0.0626*	0.0357
	(0.0206)	(0.0212)	(0.0205)	(0.0338)	(0.0428)

Table continued on the following page.

Table 3 continued

	RE Tobit (1)	RE Tobit (2)	RE Tobit (3)	IV Tobit (4)	Heter. Tobit (5)
prunempexp	0.0020	-0.0190	0.0018	-0.0443	-0.1420*
	(0.0285)	(0.0287)	(0.0289)	(0.0345)	(0.0793)
prunempexp_sq	0.0013	0.0027	0.0014	0.0084*	0.0102***
	(0.0037)	(0.0036)	(0.0039)	(0.0047)	(0.0037)
disabled	-0.0803	-0.1111	-0.0783	-0.0631	-0.0666
	(0.0719)	(0.0744)	(0.0717)	(0.0872)	(0.1599)
german	0.0027	0.0308	0.0059	0.0446	0.5994*
	(0.0894)	(0.0937)	(0.0894)	(0.1085)	(0.3125)
nchildren	0.0294	0.0359*	0.0287	0.0363*	0.0484
	(0.0183)	(0.0187)	(0.0183)	(0.0218)	(0.0317)
married	-0.0614	-0.0737*	-0.0625	0.0239	-0.0332
	(0.0381)	(0.0393)	(0.0381)	(0.0643)	(0.0829)
fatherselfempl	0.1985***	0.2879***	0.1961***	0.1010	0.2475***
	(0.0501)	(0.0512)	(0.0500)	(0.0657)	(0.0724)
11 industry dum.	YES	YES	YES	YES	YES
constant	-3.9648***	-4.1487***	-4.1083***	-7.5714***	-4.5745***
	(0.4151)	(0.4349)	(0.4426)	(1.7830)	(0.4207)
σ_ν	0.6669***	0.7168***	0.6641***		
	(0.0275)	(0.0290)	(0.0276)		
σ_ε	0.3436***	0.3369***	0.3428***		
	(0.0187)	(0.0188)	(0.0186)		
”First stage“ equation of risk tolerance					
height				0.0131***	
				(0.0038)	
motherhighersec				0.1488**	
				(0.0676)	
variables in *x*				YES	
Heteroscedasticity equation					
networth100k					0.0222***
					(0.0036)
networth100k_sq					-0.0000***
					(0.0000)
east					0.2267**
					(0.0902)
prunempexp					0.1476***
					(0.0568)
prunempexp_sq					-0.0122***
					(0.0047)
german					-0.5056***
					(0.1701)
fatherselfempl					-0.2142**
					(0.0869)
insign. variables					YES
Wald χ^2				384.216	679.690
LR χ^2	598.039	439.058	606.340		
log likelihood	-2075.427	-2154.918	-2071.277	-23405.050	-2106.970
N	10368	10368	10368	9958	10368

Stars (* / ** / ***) indicate significance at the 10% / 5% / 1% level. In parenthesis: standard errors in RE models, robust standard errors in spec. (4) and (5). Source: Own calculations based on the SOEP 2002/2007.

Table 4: Portfolio Share of Private Equity: Estimated Tobit Coefficients (SOEP 2007)

	Tobit (6)	Tobit (7)	Tobit (8)	IV Tobit (9)	Heter. Tobit (10)
risk tolerance	0.0698***	0.0854***		0.3997	0.0621***
	(0.0117)	(0.0120)		(0.3531)	(0.0113)
risk1			0.1967		
			(0.3354)		
risk2			0.1671		
			(0.2962)		
risk3			0.2760		
			(0.2909)		
risk4			0.3897		
			(0.2929)		
risk5			0.4006		
			(0.2866)		
risk6			0.4086		
			(0.2885)		
risk7			0.5746**		
			(0.2882)		
risk8			0.5199*		
			(0.2905)		
risk9			0.7697**		
			(0.3034)		
risk10			0.9634***		
			(0.3156)		
networth100k	0.0406***		0.0404***	0.0326***	0.0668***
	(0.0087)		(0.0088)	(0.0101)	(0.0111)
networth100k_sq	-0.0001***		-0.0001***	-0.0001***	-0.0002***
	(0.0000)		(0.0000)	(0.0000)	(0.0000)
grossinc1000	0.0340**		0.0337**	0.0077	0.0451***
	(0.0133)		(0.0133)	(0.0342)	(0.0123)
avgtaxrate	0.2670		0.2690	0.2002	0.2023
	(0.1963)		(0.1943)	(0.2120)	(0.1967)
other controls	YES	YES	YES	YES	YES
σ_ε	0.7416***	0.7875***	0.7374***		
	(0.0392)	(0.0388)	(0.0389)		
"First stage" equation of risk tolerance					
height				0.0139**	
				(0.0060)	
motherhighersec				0.1532	
				(0.1172)	
variables in *x*				YES	
Heteroscedasticity equation					
networth100k					0.0278***
					(0.0079)
networth100k_sq					-0.0001**
					(0.0000)
highertechncol					0.1574
					(0.1125)
german					-0.4353***
					(0.0667)
Pseudo R^2	0.175	0.129	0.178		
Wald χ^2				214.755	336.405
log likelihood	-1077.975	-1138.735	-1073.877	-11419.382	-1057.481
N	5109	5109	5109	4900	5109

Stars (* / ** / ***) indicate significance at the 10% / 5% / 1% level. Robust standard errors in parenthesis. Source: Own calculations based on the SOEP 2007.

Table 5: Ownership Probability and Portfolio Share of Private Equity: Estimated Marginal Effects of Risk Tolerance

		Probability of Ownership		Conditional Portfolio Share	
Model	Data	Marginal Effect	Standard Error	Marginal Effect	Standard Error
RE Tobit (1)	02/07	0.0065***	0.0009	0.0048***	0.0007
RE Tobit (2)	02/07	0.0070***	0.0009	0.0051***	0.0007
IV Tobit (4)	02/07	0.0688**	0.0310	0.0277**	0.0125
Heter. Tobit (5)	02/07	0.0054***	0.0009	0.0051***	0.0007
Tobit (6)	07	0.0084***	0.0013	0.0067***	0.0010
Tobit (7)	07	0.0099***	0.0013	0.0077***	0.0010
IV Tobit (9)	07	0.0591	0.0521	0.0282	0.0249
Heter. Tobit (10)	07	0.0076***	0.0013	0.0062***	0.0010
Heckit (11)	02/07	0.0082***	0.0010	0.0058	0.0052
Heckit (12)	02/07	0.0096***	0.0010	0.0084	0.0053
IV Heckit (14)	02/07	0.0081***	0.0009	0.1256	0.1674
FE Heckit (15)	02/07	see above	see above	0.0196	0.0159

Standard errors are heteroscedasticity robust except for the random effects (RE) tobit models. Stars (* / ** / ***) indicate significance at the 10% / 5% / 1% level. Source: Own calculations based on the SOEP 2002/2007.

Table 6: Ownership Probability and Portfolio Share of Private Equity: Estimated Effects of Risk Attitude (Dummy Variables Model)

	Probability of Ownership			Conditional Portfolio Share		
Model	RE Tobit (3)	Tobit (8)	Heckit (13)	RE Tobit (3)	Tobit (8)	Heckit (13)
Data	02/07	07	02/07	02/07	07	02/07
risk1	0.0167	0.0109	0.0047	0.0214	0.0165	0.1057
	(0.0128)	(0.0176)	(0.0079)	(0.0168)	(0.0277)	(0.0841)
risk2	0.0144	0.0089	0.0055	0.0191	0.0139	0.1482**
	(0.0092)	(0.0131)	(0.0063)	(0.0143)	(0.0240)	(0.0718)
risk3	0.0211**	0.0173	0.0103*	0.0256*	0.0236	0.2111***
	(0.0088)	(0.0132)	(0.0063)	(0.0139)	(0.0235)	(0.0707)
risk4	0.0349***	0.0289**	0.0138**	0.0368***	0.0341	0.2564***
	(0.0096)	(0.0142)	(0.0064)	(0.0139)	(0.0237)	(0.0720)
risk5	0.0358***	0.0302**	0.0191***	0.0374***	0.0352	0.2257***
	(0.0087)	(0.0129)	(0.0061)	(0.0136)	(0.0230)	(0.0648)
risk6	0.0362***	0.0311**	0.0220***	0.0377***	0.0359	0.1697**
	(0.0091)	(0.0134)	(0.0066)	(0.0138)	(0.0232)	(0.0667)
risk7	0.0482***	0.0553***	0.0346***	0.0458***	0.0524**	0.1839***
	(0.0092)	(0.0142)	(0.0069)	(0.0137)	(0.0231)	(0.0665)
risk8	0.0494***	0.0464***	0.0360***	0.0465***	0.0468**	0.1858***
	(0.0101)	(0.0149)	(0.0076)	(0.0139)	(0.0234)	(0.0667)
risk9	0.0626***	0.0951***	0.0577***	0.0543***	0.0731***	0.1919**
	(0.0160)	(0.0273)	(0.0147)	(0.0154)	(0.0252)	(0.0749)
risk10	0.1128***	0.1479***	0.1338***	0.0783***	0.0951***	0.3603***
	(0.0270)	(0.0426)	(0.0316)	(0.0173)	(0.0273)	(0.0791)

Effects of a discrete change of the dummy variables from 0 to 1. Stars (* / ** / ***) indicate significance at the 10% / 5% / 1% level. In parenthesis: standard errors in the RE tobit model (3), robust standard errors otherwise. Source: Own calculations based on the SOEP 2002/2007.

Appendix A: Supplementary Tables and Figure

Table A 1: Weighted Means of Variables

	2002 (risk attitude reported in 2004)		2007 (risk attitude reported in 2006)	
Variable (unit)	Entrepreneurs	Others	Entrepreneurs	Others
risk tolerance	5.533	4.806	6.176	5.034
risk0	0.013	0.031	0.004	0.017
risk1	0.012	0.034	0.022	0.019
risk2	0.096	0.093	0.019	0.086
risk3	0.061	0.135	0.087	0.129
risk4	0.092	0.111	0.070	0.127
risk5	0.222	0.220	0.144	0.215
risk6	0.127	0.126	0.114	0.151
risk7	0.162	0.147	0.297	0.129
risk8	0.178	0.080	0.141	0.099
risk9	0.013	0.017	0.057	0.016
risk10	0.024	0.006	0.045	0.012
networth (€100,000)	4.859	0.819	4.029	0.798
grossinc (€1,000)	4.811	2.519	4.332	2.433
avgtaxrate	0.351	0.324	0.359	0.315
highschool	0.447	0.328	0.472	0.368
apprenticeship	0.319	0.456	0.378	0.431
highertechncol	0.316	0.262	0.281	0.281
university	0.378	0.263	0.435	0.282
female	0.217	0.439	0.246	0.479
east	0.142	0.192	0.183	0.190
south	0.301	0.292	0.329	0.303
north	0.168	0.128	0.095	0.131
age (years)	45.23	43.08	46.33	43.25
prworkexp (10 yrs)	1.887	1.785	1.913	1.741
prunempexp (years)	0.416	0.393	0.465	0.405
disabled	0.058	0.070	0.069	0.069
german	0.982	0.966	0.981	0.963
children (number)	0.557	0.569	0.739	0.530
married	0.591	0.608	0.604	0.578
fatherselfempl	0.143	0.088	0.133	0.083
height (cm)	176.51	173.32	176.45	173.52
motherhighersec	0.084	0.057	0.108	0.073
N	371	4888	355	4754

Source: Own calculations based on the SOEP (2002/2007).

Table A 2: Definitions of Variables

Variable	Definition
dependent variable	Share of private business equity in the personal asset portfolio
risk tolerance	Willingness to take risks on a scale from 0 (risk averse) to 10 (fully prepared to take risks)
risk0 to risk10	Willingness to take risks: Dummies indicating a point on the 11-point scale
networth100k	Net worth in €100,000 in prices of 2002
grossinc	Gross labor income per year (in €1,000) in prices of 2002
avgtaxrate	Personal average income tax rate = 1 – (net income / gross income)
d2007	Dummy indicating the year 2007
highschool	Dummy indicating a high school degree ("Fachhochschulreife" or "Abitur")
apprenticeship	Dummy for having finished an apprenticeship
highertechnical	Dummy for having finished a higher technical college or similar
university	Dummy indicating a university degree
female	Dummy for women
east	Dummy indicating residence in one of the 5 new eastern federal states or East Berlin
south	Dummy indicating residence in one of the southern federal states (Baden-Wuerttemberg or Bavaria)
north	Dummy indicating residence in one of the northern federal states (Schleswig Holstein, Lower Saxony, Hamburg, or Bremen)
age	Age in years
prworkexp10	Prior work experience (until *t*-1) in 10 years
prunemexpexp	Prior unemployment experience (until *t*-1) in years
disabled	Dummy for handicapped / physically challenged individuals
german	Dummy indicating German nationality
nchildren	Number of children under 17 in the household
married	Dummy for married individuals
fatherselfempl	Dummy for individuals with a self-employed father
height	Body height in cm
motherhighersec	Dummy indicating that the mother obtained a higher secondary school degree ("Abitur")

The square of variable *x* is indicated by *x_sq*. Dummy variables are equal to one if the condition holds and zero otherwise.

Figure A 1: Histograms of Risk Tolerance (SOEP)

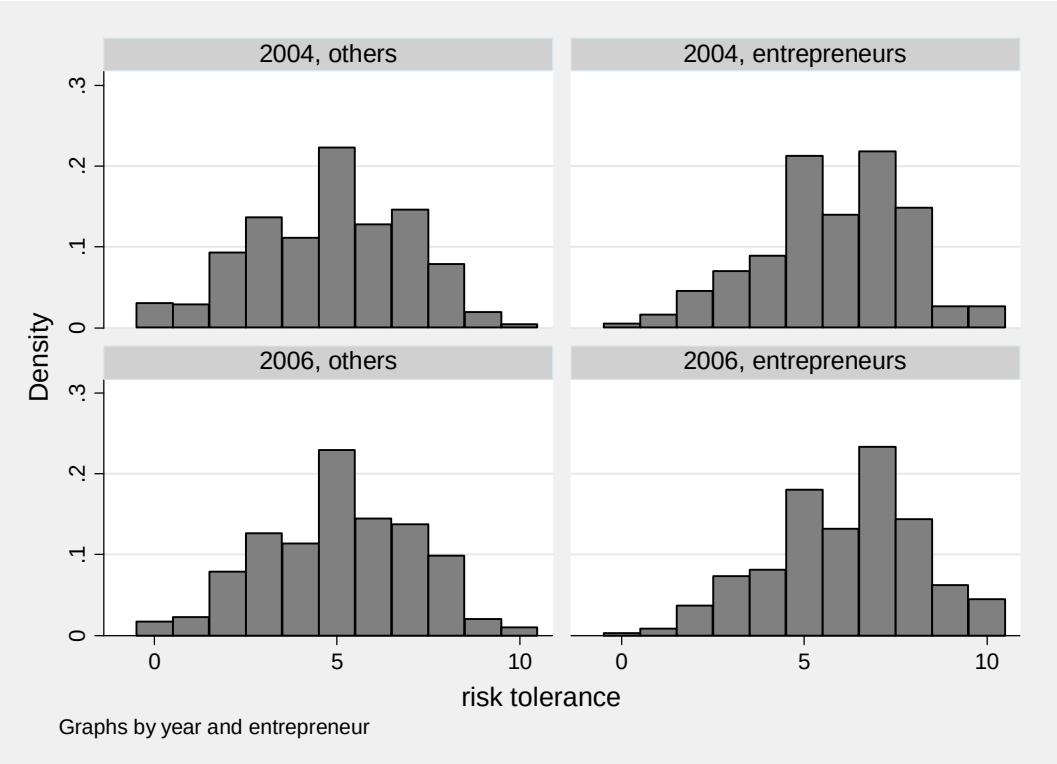

Table A 3: Portfolio Share of Private Equity: Heckit Estimation Results (SOEP 2002/2007)

	Heckit (11)	Heckit (12)	Heckit (13)	IV Heckit (14)	FE Heckit (15)
risk tolerance	0.0053	0.0064		0.1256	0.0196
	(0.0056)	(0.0071)		(0.1674)	(0.0159)
risk1			0.1055		
			(0.0841)		
risk2			0.1480**		
			(0.0717)		
risk3			0.2107***		
			(0.0708)		
risk4			0.2560***		
			(0.0725)		
risk5			0.2252***		
			(0.0654)		
risk6			0.1691**		
			(0.0678)		
risk7			0.1831***		
			(0.0675)		
risk8			0.1850***		
			(0.0684)		
risk9			0.1909**		
			(0.0761)		
risk10			0.3587***		
			(0.0827)		
networth100k	0.0030***		0.0029***	0.0061	0.0012
	(0.0007)		(0.0007)	(0.0047)	(0.0045)
networth100k_sq	-0.0000***		-0.0000***	-0.0000	-0.0000
	(0.0000)		(0.0000)	(0.0000)	(0.0000)
grossinc1000	0.0002		0.0000	0.0045	0.0033
	(0.0011)		(0.0000)	(0.0064)	(0.0071)
avgtaxrate	0.0251		0.0000	0.1846	-0.1417
	(0.0766)		(0.0000)	(0.2249)	(0.1699)
other controls	YES	YES	YES	YES	YES
inv. Mills Ratio				0.2726	0.0200
				(0.3784)	(0.0931)
ρ	-0.0255	-0.0803	-0.0056		
	(0.0960)	(0.2149)	(0.0977)		
σ_ε	0.2755***	0.2799***	0.2829***		
	(0.0066)	(0.0077)	(0.0058)		
Wald χ^2	372.476	186.302	450.585	130.960	
log likelihood	-2175.915	-2393.679	-2726.190		1028.891
N	10368	10368	14724	697	697

Stars (* / ** / ***) indicate significance at the 10% / 5% / 1% level. Robust standard errors in parenthesis. Source: Own calculations based on the SOEP 2002/2007.

Table A 4: Ownership of Private Equity: Estimated Probit Coefficients (SOEP 2002/2007)

	Probit (11)	Probit (12)	Probit (13)	IV Probit (16)
risk tolerance	0.0897***	0.0896***		0.4288***
	(0.0105)	(0.0092)		(0.0816)
risk1			0.1262	
			(0.2137)	
risk2			0.1443	
			(0.1819)	
risk3			0.2429	
			(0.1751)	
risk4			0.3027*	
			(0.1743)	
risk5			0.3844**	
			(0.1697)	
risk6			0.4225**	
			(0.1715)	
risk7			0.5681***	
			(0.1695)	
risk8			0.5819***	
			(0.1723)	
risk9			0.7671***	
			(0.1922)	
risk10			1.1892***	
			(0.2122)	
networth100k	372.476		0.1162***	0.0651*
	-2175.915		(0.0233)	(0.0391)
networth100k_sq	10368		-0.0002***	-0.0001
	372.476		(0.0000)	(0.0001)
grossinc1000	-2175.915		0.0000***	0.0106
	10368		(0.0000)	(0.0153)
avgtaxrate	372.476		-0.0000	0.1860
	-2175.915		(0.0000)	(0.1748)
fatherselfempl	0.2080***	0.3522***	0.2039***	0.0863
	(0.0713)	(0.0598)	(0.0712)	(0.0895)
other controls	YES	YES	YES	YES
Wald χ^2				2153.329
log likelihood		see Table A 3		-23251.277
N				9958

Stars (* / ** / ***) indicate significance at the 10% / 5% / 1% level. Robust standard errors in parenthesis. Source: Own calculations based on the SOEP 2002/2007.

Appendix B: Questionnaire Wording

Questions for private business equity in the SOEP waves 2002 and 2007

The questions for private business equity in the SOEP waves 2002 and 2007 were posed as follows: 1. “Are you the owner of a commercial enterprise, i.e. a company, a shop, an office, a practice or an agricultural enterprise, or are you involved in an enterprise such as the aforementioned?”. If this was answered in the affirmative, two additional questions were asked: 2. “Are you the sole owner or co-owner of this enterprise, e.g. GBR, GmbH or KG?” (the abbreviations are common examples for legal forms in Germany). 3. ”How high do you estimate the current value of your enterprise or of your share to be? This is the price before tax, which you would receive at the sale of your enterprise or your share, taking into account any remaining financial burdens.” The answer was given as euro amount. The questions for the other asset categories are similar and explicitly ask for the personal share of assets owned jointly, e.g. by a married couple.

Question for risk attitude in the SOEP waves 2004 and 2006

The SOEP waves 2004 and 2006 asked the following question about the individual risk attitude: “How do you see yourself: Are you generally a person who is fully prepared to take risks or do you try to avoid taking risks? Please tick a box on the scale, where the value 0 means: 'risk averse' and the value 10 means: 'fully prepared to take risks'. You can use the values in between to make your estimate.”