Preferred Risk Habitat of Individual Investors*

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Abstract

The preferred risk habitat hypothesis, introduced here, is that individual investors select stocks whose volatilities are commensurate with their risk aversion. The data, 1995-2000 holdings of over 20,000 clients at a large German broker, are consistent with the predictions of the hypothesis: the returns of stocks within each portfolio have remarkably similar volatilities, when stocks are sold they are replaced by stocks of similar volatilities, and the more risk averse customers indeed hold less volatile stocks. Greater volatility specialization is associated with lower Sharpe ratios, primarily because more specialized investors hold fewer stocks and thereby expose themselves to more unsystematic risk.

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I Introduction

Portfolio theory suggests that individual investors should buy and hold diversified portfolios. Polkovnichenko (2005), however, using recent waves of the US Survey of Consumer Finances, reports that many US households who participate in the stock market hold only a handful of names even though mutual funds offer cheap diversification and are widely available.

The basic premise of this paper is that a substantial number of investors forego a holistic portfolio optimization approach along the lines advocated by Markowitz (1952) and Markowitz (1959), and rather, select stocks sequentially. These are people who, exhibiting narrow framing, evaluate one stock at a time, or perhaps compare the relative merits of one stock versus another.

Assessing each stock's own merits, an individual tends to follow, evaluate, and select stocks with the risk characteristics that suit his attitude towards risk. This is the hypothesis of stock selection guided by a preferred risk-habitat – in short, the preferred risk habitat hypothesis.

This paper examines the preferred risk habitat hypothesis using trading records between 1995 and 2000 of over twenty thousand customers of a German discount brokerage. Studying the same trading records, Dorn and Huberman (2005) document that these customers' behavior indeed deviates considerably from the standard theory's recommendation to buy and hold a diversified portfolio: even when accounting for the investors' mutual fund holdings, the typical portfolio consists of little more than three stocks.

In the mean-variance framework of portfolio theory, the portfolio's aggregate volatility is the only measure of risk an investor should be concerned with. The preferred risk habitat hypothesis leads to a focus on a different measure: the portfolio's average component volatility, or ACV, which is the value-weighted average of the return volatilities of the portfolio components. For investors who essentially disregard the risk-reducing effects of holding more positions and positions with lower return correlations, ACV is more appropriate than overall portfolio volatility. Kroll et al. (1988), Lipe (1998), and Siebenmorgen and Weber (2003), among others, report that people fail to properly account for return correlations when making investment decisions in experimental and survey settings. (In an asset allocation experiment similar to that in Kroll et al. (1988), Kroll and Levy (1992) report that finance MBA students make investment choices that are more in line with portfolio theory.)

As in much of portfolio theory, the empirical implications of the preferred risk habitat hypothesis rely on variation in investors' attitudes toward risk. Classical portfolio theory predicts that variation in attitude towards risk will affect variation in the relative weights of the safe and risky portions of investors' portfolios. If investors followed the prescriptions of classical portfolio theory, the risky portion of their portfolios should be the same; moreover, there should be no systematic relation between the volatilities of the components of these portfolios and their holders' attitudes to risk. In contrast, the preferred risk habitat hypothesis predicts that the more risk averse investors will have portfolios with lower ACV.

Usually variation in attitude towards risk is not directly observable, and a frequent handicap of studies of portfolio theory is the absence of even a proxy for risk attitude. One advantage of the sample studied here is that it does offer a survey-based proxy for risk attitude for a sub-sample of clients who participate in a survey administered after the end of the sample period. Survey respondents indicate their risk aversion on a four-point scale from "not at all willing to bear high risk in exchange for high expected returns" to "very willing to bear high risk in exchange for high expected returns." (Participants in the U.S. Survey of Consumer Finances answer a similar question.) The portfolio fractions invested in equity mutual funds offer evidence supporting the validity of the questionnaire-based measure of risk aversion: those who say they are more risk averse tend to allocate a larger fraction of their holdings to mutual funds.

The preferred risk habitat hypothesis generates two additional, novel predictions about portfolio choices that are testable without information on risk attitudes. First, if each investor focuses on stocks with similar volatilities, the volatilities of the stocks in his portfolio should be more concentrated than the volatilities of a similarly-weighted portfolio consisting of random stocks – even if these random stocks deliver the same portfolio volatility or ACV as the stocks actually held. Second, when a stock in a portfolio is replaced by other stocks, the purchased stocks should have similar volatilities to the sold stock. The data are consistent with these predictions. In particular, the observed volatility specialization does not appear to be merely a by-product of investors specializing in other stock characteristics that may be related to volatility such as country of issue, industry, size, dividend yield, nominal share price, or realized returns.

The main finding of this paper is not that individual investors tend to hold poorly diversified portfolios (as, for example, reported in Goetzmann and Kumar (2008)) or that they, in aggregate, display a preference for certain stocks (such as high-dividend stocks as reported in Graham and Kumar (2006)), or that an investor's risk posture varies with certain demographic or socio-economic characteristics (for example, male investors holding more volatile stocks than female investors as reported in Barber and Odean (2001)). Moreover, the paper's findings are not implied by studies such as Barber and Odean (2001) and Dorn and Huberman (2005) that cross-sectionally relate the volatility of stocks held to investor characteristics. Rather, the paper documents that individual investors specialize in the volatility of the stocks they hold.

A stylized example helps to illustrate this. Suppose the universe of stocks consists of eight stocks with return volatilities of 20%, 30%, ..., 90%. Further suppose that a male investor wants to split his money equally between two stocks so as to hold a portfolio with an average component volatility (ACV) of 60%. Similarly, a female investor wants to split her money equally between two stocks so as to hold a portfolio with an ACV of 50%. Thus, the male investor can have one of three equally weighted portfolios (of two stocks each) which deliver an ACV of 60%: A portfolio of the stocks with volatilities 50%, 70%, another of the stocks with volatilities 40%, 80% and another of the stocks with the volatilities 30%, 90%. Similarly, the female investor can choose between a portfolio of the stocks with volatilities 40%, 60%, another of the stocks with volatilities 30%, 70%, and another of the stocks with volatilities 20%, 80%. Any of these portfolio choices would be consistent with the previously reported relation between gender and volatility of stocks held (or portfolio volatility).

The preferred risk habitat hypothesis predicts that the male investor is more likely to have the portfolio with the stocks with volatilities 50%, 70% ; thus, he will be specializing in the volatility of the stocks in the portfolio. (Similarly, the female investor will likely have stocks with volatilities 40% and 60% rather than the two other possibilities.)

Moreover, according to the preferred risk habitat hypothesis, risk aversion drives the observed volatility specialization. This interpretation is possible because subjective risk attitudes, available for a sub-sample of investors in the study, can be contrasted with the investors' actual portfolio choices. The questionnaire-based measure of risk aversion explains a far bigger portion of the variation in ACV than the demographic and socio-economic attributes used in previous studies.

Portfolio theory is unlikely to explain the paper's findings. Most investors in the sample appear to only hold a handful of stocks even considering indirect equity holdings via mutual funds. Survey responses identify investors for whom the account is likely important either because it is their only brokerage account or because the account represents a large fraction of their wealth. Even these investors are poorly diversified, thereby violating the basic tenet of portfolio theory.

Greater volatility specialization is not associated with better portfolio performance. In fact, more specialized investors hold portfolios whose Sharpe ratios are systematically lower than those of their peers. This underperformance is mostly due to more specialized investors taking on more unsystematic risk by holding fewer stocks.

Although volatility specialization is widespread, it is especially pronounced among investors with less experience and more concentrated portfolios which points to a behavioral explanation for such specialization.

The preferred risk habitat hypothesis is reminiscent of Shefrin and Statman (2000) and Canner et al. (1997). Shefrin and Statman (2000) contemplate portfolio choices of people who overlook return correlations between entire asset classes. Canner et al. (1997) report that the asset allocation advice of popular financial advisors violates the

CAPM's two fund separation theorem. In contrast to these papers, whose focus is on portfolio allocation across broad asset classes, the present paper is about the individual stocks that investors choose to hold and trade.

The next section motivates the preferred risk habitat hypothesis and lays out its predictions. Section III introduces the data and some of the statistics used in this study. Section IV documents volatility specialization, Section V documents the relation between risk postures and risk aversion, and Section VI evaluates alternative explanations for the observed volatility specialization. Section VII concludes the paper.

II Hypothesis Development

An important ingredient of financial economics' normative approach to portfolio construction, pioneered by Markowitz (1952), is that attributes of individual stocks are relevant only to the extent that they affect attributes of the portfolios. Underlying this approach is the assumption that savings and investment are intended to support future consumption and therefore total portfolio wealth is the relevant object to consider, not the return on one or another component of the portfolio.

This normative approach – sometimes referred to as the rational benchmark – suggests that individuals buy and hold well diversified portfolios; under fairly general conditions these portfolios boil down to the market portfolio. The investors studied here trade rather than buy and hold. Moreover, they typically own a handful of stocks. In this respect the rational benchmark is rejected effortlessly.

One can, however, contemplate extensions of the rational benchmark that allow for investors to have merely a handful of stocks and perhaps even trade them. One possibility is that investors have the ability to predict future returns of a small subset of stocks and guided by these predictions they trade these very few stocks.

The basic premise of this paper is that a substantial number of investors engage in narrow framing, that is, they forego a holistic portfolio optimization approach and rather, select stocks sequentially. The prototypical investors hypothesized here do not view portfolio risk as the relevant unit to be evaluated, nor do they seriously consider all the stocks in the market for their portfolios. They evaluate one stock at a time, or perhaps compare the relative merits of one stock versus another. Both when selecting the stocks under consideration and when selecting among them into their portfolios, these investors focus on attributes of the stocks in which they choose to specialize. Their total portfolio considerations are limited to awareness of the number of stocks they hold and their weights.

Such behavior is likely driven by what Read et al. (1999) call cognitive limitations and cognitive inertia. Cognitive limitations matter simply because portfolio optimization is a computationally difficult task. Cognitive inertia refers to the context in which the decisions are taken. Investment opportunities present themselves to investors one at a time and, hence, investors are predisposed to evaluate them one at a time. In addition, news about a stock that serve as trading signals (for example, earnings announcements or stock recommendations) highlight the stock's individual merits as an investment by itself, perhaps even relative to other stocks in the same industry, but not relative to the portfolio held by the investor.

In the context of the preferred risk habitat hypothesis, narrow framing leads investors to break up the complex decision problem of constructing a portfolio commensurate with their risk attitude into simpler subproblems of finding portfolio components that individually correspond to their risk attitude. Investors solve these subproblems without taking into account the implications of their piecemeal solution for overall portfolio risk. Read et al. (1999) review experiments demonstrating the propensity for narrow framing; Barberis et al. (2001) and Barberis and Huang (2001) explore theoretical asset pricing models based on narrow framing.

This paper argues that investors tend to select stocks with volatilities that match their attitudes to risk, that is, stocks that belong to the investors' preferred risk habitats. Otherwise, attitude to risk plays no role in portfolio construction.

A narrow interpretation of the preferred risk habitat hypothesis predicts that investors specialize in the volatilities of the stocks they hold. These volatilities can be summarized by the portfolio's average component volatility, or ACV, which is the value-weighted average of the return volatilities of the portfolio components. Moreover, ACV should be negatively related to the investors' risk aversion.

A broader interpretation suggests that dimensions of portfolio risk other than ACV are unrelated to the holders' risk aversion. Two such dimensions are considered: portfolio concentration, measured by the portfolio's Herfindahl-Hirschmann Index (HHI), and the average return correlation between the portfolio's components (RHO). Both HHI and RHO are measures of diversification.

The main implications of the preferred risk habitat hypothesis are described below. The first two hypotheses can be explored with data that offers no proxy for risk attitudes.

Since each investor focuses on stocks with similar volatilities,

H1. The volatilities of the stocks in the investor's portfolio are more concentrated than the volatilities of random stocks in a similarly weighted portfolio. (See Section IV, especially the discussion around Table II.)

H2. When an investor replaces stocks in his portfolio by other stocks, the purchased stocks have similar volatilities to the sold stocks. (See Section IV, especially the discussion around Table III.)

The next hypotheses, studied in Section V, require a measure of risk aversion. The data used in this study have such a measure.

H3. The stock portfolios of more risk averse investors will have a lower ACV. (See Section V, especially the discussion around Table IV.)

Total portfolio volatility depends on the portfolio's ACV and on the extent of the portfolio's diversification. The association between attitude to risk and the tendency to diversify has received little attention.

The human propensity to diversify is well known. (For instance, Read and Loewenstein (1995) report on an experiment in which children preferred a diversified bundle of Halloween candy bars although when offered them sequentially, they consistently chose the same bar.) In fact, Rubinstein (2001) offers experimental examples in which subjects diversify although it is best not to do so.

In the context of security selection, diversification is a well known, valid, beneficial risk-reducing measure. The pure form of the rational benchmark asserts that variation in risk aversion should lead to variation in exposure to risk through variation in the relative weight of the safe and risky assets in the investors' portfolios. A broader interpretation of the rational benchmark would predict that variation in risk aversion should lead to variation in the level of diversification of the stocks held by the investors such as HHI and RHO. In contrast, the preferred risk habitat hypothesis predicts that

H4. There is no relation between investors' risk aversion and the HHIs of their stock portfolios. (See Section V, especially the discussion around Table IV and Columns (3) and (4) of Table V.)

H5. There is no relation between investors' risk aversion and the correlations of the returns of the stocks they hold. (See Section V, especially the discussion around Table IV and Columns (5) and (6) of Table V.)

The hypotheses outlined so far have a general, rather than a specific alternative. Even as such, they are testable and suggest patterns in the data that so far have not been known.

A sharper test of the preferred risk habitat hypothesis uses both portfolio volatility and ACV to explain variation in risk aversion. It is natural to expect portfolio volatility and risk aversion to be negatively correlated. In fact, a liberal interpretation of the rational benchmark asserts that among variations in portfolio attributes, only variation in portfolio volatility should explain variation in risk aversion.

According to the preferred risk habitat hypothesis, risk aversion affects ACV and through ACV it affects total portfolio volatility; on the other hand, risk aversion does not affect the other two portfolio risk attributes which affect its volatility. Hence,

H6. Controlling for ACV, total portfolio volatility does not decrease with risk aversion. (See Section V, especially the discussion around Column (9) of Table V as well as Columns (1) and (2) of Table VII.)

H7. Controlling for portfolio volatility, risk aversion declines with ACV. (See Section V, especially the discussion of Columns (1) and (2) of Table VII.)

H8. Controlling for ACV, risk aversion does not decline with RHO or HHI. (See Section V, especially the discussion of Columns (3) and (4) of Table VII.)

Having sketched the implications of the preferred risk habitat hypothesis, it is worthwhile to contrast it further with the rational benchmark. A reconciliation of the data with a straightforward buy-and-hold mean-variance optimization seems impossible, given the high turnover rate and the small number of stocks held in the portfolios. One should then consider broader implications of the rational benchmark.

A liberal interpretation of the rational benchmark suggests that investors could concentrate their stock trading in stocks about which they can relatively easily gather information. Thus, investors will specialize in stocks with particular, investor-dependent attributes such as firm location or industry. Rational investors who specialize give up benefits of diversification. Hence, one should expect their stock picks to outperform other stocks with similar characteristics.

Another suggestion inspired by the rational benchmark is that investors do select mean-variance optimal portfolios, subject to constraints (for example, due to transactions costs). This translates to the question, Could the observed volatility specialization be a by-product of investors trying to construct a portfolio with a particular return volatility?

Section VI considers the data in light of these alternative explanations.

III The Data

The analysis in this paper draws on a complete history of transaction records for a random sample of 21,500 clients at one of Germany's three largest discount brokers during the period January 1995 to May 2000. All sample investors were invited to participate in a survey administered at the end of the sample period. Survey responses are available for a subset of 1,300 respondents.

The opening position as well as complete transaction records from the account opening date until May 31, 2000 or the account closing date – whichever comes first – allows the unambiguous reconstruction of client portfolios at a daily frequency. The typical record consists of an identification number, account number, transaction date, buy/sell indicator, type of asset traded, security identification code, number of shares traded, gross transaction value, and transaction fees.

In principle, brokerage clients can trade all the bonds, stocks, and options listed on

German exchanges, as well as all the mutual funds registered in Germany. Here, the focus is on the investors' individual stock and stock fund holdings and trades for which Datastream provides comprehensive daily asset price coverage: stocks on Datastream's German research stocks list (this includes foreign stocks listed on German exchanges), dead or delisted stocks on Datastream's dead stocks list for Germany (this also includes foreign stocks), and mutual funds registered either in Germany or in Luxembourg. As of May 2000, the lists contain daily prices for 8,213 domestic and foreign stocks and 4,845 mutual funds. These stocks and stock funds represent roughly 90% of the clients' holdings and 80% of the trading volume, with the remainder split between term deposits, bonds, bond and money-market funds, options, as well as stocks and mutual funds for which Datastream does not provide prices or returns. The broker provides a classification of mutual funds that distinguishes between stock funds and other funds such as bond or balanced funds. As of January 1, 2000, the average value of a portfolio considering only holdings of individual stocks is 100,000 Deutsche Mark [DEM] or 50,000 US Dollars [USD] (see Panel A of Table I). The average value of a portfolio considering holdings of both stocks and stock funds is DEM 120,000 (see Panel B of Table I).

The questionnaire elicited information on the investors' investment objectives, risk attitudes and perceptions, investment experience and knowledge, portfolio structure, and demographic and socio-economic status. The time to fill out the questionnaire was estimated to be 20-25 minutes; respondents could elect to be entered into a raffle for a cash prize of roughly USD 3,500 or a trip to New York valued at the cash prize. Dorn and Huberman (2005) describe the survey in detail.

The broker is labeled as a "discount" broker because no investment advice is given. Because of their low fees and breadth of their product offering, German discount brokers attract a large cross-section of clients ranging from day-traders to retirement savers. For example, the selection of mutual funds offered by discount brokers during the sample period was much greater than that offered by full-service brokers (typically divisions of the large German universal banks that were constrained to sell the products of the banks' asset management divisions).

It is likely that the sample is representative of the broader population of discount brokerage clients; at the end of the sample period, the top three German discount brokers commanded more than 80% of the German discount market in terms of accounts and had homogeneous product offerings. Moreover, discount brokerage accounts are an important subset of retail accounts. In June 2000, at the end of the sample period, there were 1.2 million retail accounts at the top three discount brokers (see Van Steenis and Ossig (2000)) – a sizable number, given that the total number of German investors with exposure to individual stocks at the end of 2000 was estimated to be 6.2 million (see Deutsches Aktieninstitut (2003)). Note that all German retail and discount brokerage accounts are taxable accounts as opposed to the US, where tax-deferred accounts, often with a restricted investment menu such as 401(k) accounts, play an important role.

Portfolio Risk

Portfolio risk is quite an elusive term from the perspective of the individual investor who may lack the statistical and computational tools to estimate a variance-covariance matrix of returns or the historical variance of returns of his portfolio.

In the mean-variance framework of portfolio theory, the portfolio's aggregate volatility is the only measure of risk an investor should be concerned with. The annualized volatility of a given portfolio during a given time period consisting of T trading days is calculated as

$$VOL \equiv \sqrt{\frac{252}{T-1}\sum_{t=1}^{T}(r_t - \bar{r})^2} \tag{1}$$

where r_t is the portfolio's value-weighted return measured from the close of trading day $t-1$ to the close of trading day t, adjusted for stock splits and dividends, and $\bar{r}$ is the simple average across the portfolio returns during the time period. Table I reports summary statistics of portfolio volatility and the additional portfolio risk attributes described below for the period January 1, 2000 to May 31, 2000, assuming that portfolio weights remain constant at their levels of January 1, 2000 throughout the sample period. Panel A of the Table reports the statistics based on holdings of individual stocks only and Panel B reports them based on holdings of individual stocks and stock funds. The assumption of constant portfolio weights is made to make the different portfolio risk measures comparable. The focus on the end of the sample period is due to the number of sample investors increasing over time and to the survey responses being elicited after the end of the sample period. The average volatility of a portfolio considering only individual stocks is 52% (see Panel A of Table I). The average volatility of a portfolio considering both stocks and stock funds is 43% (see Panel B of Table I). By comparison, the Dax 100, a German stock market index consisting of the one hundred largest and most liquid stocks, had an annualized volatility of 28% during the first five months of 2000; the Nemax 50 Index, consisting of the fifty largest and most liquid stocks listed on the Neuer Markt (the Frankfurt Stock Exchange's market segment for growth and technology stocks), had an annualized volatility of 56%.

Three summary statistics are central to the determination of portfolio volatility; the number and weights of the components, value-weighted average component volatility, and a weighted average of the pairwise return correlations.

The Herfindahl-Hirschmann Index (HHI) is another proxy for portfolio risk and a natural measure of portfolio diversification. The HHI captures the number and weights of the portfolio components:

$$HHI \equiv \sum_{i=1}^{N} w_i^2 \tag{2}$$

where N is the number of portfolio positions and w_i is the portfolio weight of position i. The index lies between zero and one; higher values indicate less diversified portfolios. The index value for a portfolio of n equally-weighted stocks is $\frac{1}{n}$. The benefits of diversification provided by a mutual fund are recognized by assuming that each fund holds 100 equally-weighted positions that do not appear in another holding of the investor. For example, an investor whose entire portfolio consists of one mutual fund has an HHI of 0.01; an investor holding two mutual funds has an HHI of 0.005. The calculation of the HHI requires no knowledge of the volatility of the portfolio's return or the return of the components of the portfolio.

The simplicity and accessibility of the HHI are at once its strength and weakness. Strength, because it is salient to the investor. Weakness, because HHI is invariant to the properties of the returns of the stocks to which the weights are assigned. The average HHI of a portfolio considering only individual stocks as of January 1, 2000 is 0.47 – the equivalent of investing equal amounts in two stocks (see Panel A of Table I). The average HHI considering both stocks and stock funds is 0.28 (see Panel B of Table I).

The portfolio-weighted average volatility of the portfolio's components (ACV) is a third, fairly accessible, measure of risk. The ACV for a given time period is calculated as

$$ACV \equiv \sum_{i=1}^{N} w_i \sigma_i \tag{3}$$

where N is the number of portfolio positions and σ_i is the annualized standard deviation of daily returns of security i during the time period. Average component volatility is particularly appealing when investors pick the stocks in their portfolio one at a time, and consider the volatility of each stock separately, regardless of overall portfolio considerations. The average ACV across investors of a portfolio considering only individual stocks for the period January 1, 2000 to May 31, 2000 is 69% (see Panel A of Table I); the average ACV considering both stocks and stock funds is 59% (see Panel B of Table I).

Finally, the volatility of portfolio returns depends on the pairwise correlations of the components' returns. For a portfolio of N stocks with w_i as the weight of stock i, σ_i as the standard deviation of returns of stock i, and $\rho_{i,j}$ the pairwise correlation of i's and j's returns, the variance of portfolio returns is

$$\sigma_p^2 \equiv \sum_{i=1}^{N} w_i^2 \sigma_i^2 + \sum_i \sum_{j \neq i} w_i w_j \sigma_i \sigma_j \rho_{i,j} \tag{4}$$

The weighted average of the pairwise return correlations is then calculated by constraining the correlation coefficients to be equal to a single parameter RHO in Equation 4:

$$RHO \equiv \frac{\sigma_p^2 - \sum_{i=1}^{N} w_i^2 \sigma_i^2}{\sum_i \sum_{j \neq i} w_i w_j \sigma_i \sigma_j} \tag{5}$$

The calculation of RHO requires that the investors hold at least two positions, hence the smaller number of observations relative to the VOL, ACV, and HHI calculations reported in Table I. The average RHO of holdings of individual stocks between January 1, 2000 and May 31, 2000 is 18%; the corresponding statistic for holdings of individual stocks and stock funds is 25%. The higher average RHO for holdings of stocks and funds is due to portfolios containing multiple stock funds (almost three out of four investors who have at least two positions, one of which in a stock fund, hold more than one stock fund). Returns of any two funds tend to be more highly correlated than returns of any two individual stocks, partly because the holdings of the funds may overlap, and partly because the funds' returns are more driven by common exposure to systematic risk than by exposure to idiosyncratic risk (which usually dominates at the individual stock level). Portfolios containing multiple stock funds are also responsible for the lower correlations between RHO and the other portfolio risk measures VOL, ACV, and HHI (comparing Panels A and B of Table I). These portfolios tend to have higher RHOs as argued above, but also lower VOL, ACV, and HHI.

Not surprisingly, all three risk component measures are positively correlated with portfolio volatility. However, not all portfolio risk attributes are positively correlated with each other. For example, less concentrated portfolios consist of positions whose returns tend to be more highly correlated with each other. The logarithm of portfolio value as of January 1, 2000, is negatively correlated with all the risk measures except RHO.

The use of Datastream for stock returns raises a number of methodological concerns (Ince and Porter (2005) elaborate on this point). For example, Datastream sometimes replaces missing values or pads values with the last available value indicating stale price problems or outright data errors. Manually inspecting stock-months with extremely high return volatilities uncovers several data errors – for instance, a 100:1 stock split that wrongly reduces the stock's return index level (Datastream datatype RI) leading to a daily return of -99%. The paper thus excludes the top and bottom 1% of stock-months in terms of volatility – this eliminates all stock-months for which annualized volatility is less than 5% or more than 200%. An additional filter, which addresses the staleness of prices, eliminates observations if Datastream recorded the same price or return index value for an entire month or longer during the sample period. Results based on unfiltered data are qualitatively similar and thus not reported.

IV Investors Specialize in Individual Stock Volatility

This section examines the two hypotheses that can be tested without information about risk aversion. The first subsection explores whether the volatilities of stocks in an investor's portfolio are more concentrated than the volatilities of random stocks in a similarly weighted portfolio. The second subsection explores whether investors replace stocks that they sell with stocks that have similar volatilities to those of the stocks sold.

A Individual Stock Volatilities Cluster Around Average Component Volatility

For the individual investor it is fairly straightforward to assess the volatility of individual stocks. It is perhaps even easier to assess diversification as captured by the portfolio's HHI. In contrast, the assessment of a portfolio's overall volatility is more challenging, especially when the investor is in the process of forming the portfolio rather than during a prolonged period of portfolio ownership. Moreover, narrow framing will lead investors to focus on attributes of individual stocks rather than reflect on the way they aggregate in a portfolio context. In particular, it is possible that an investor's attitude to risk translates into focusing on stocks within a narrow volatility range.

To examine the hypothesis that investors focus on stocks within a narrow volatility range (Hypothesis H1), the dispersion of the volatilities of the stocks in each investor's portfolio is compared with the typical dispersion of the volatilities of similarly-weighted portfolios whose stocks are selected at random.

Given a portfolio consisting of N stocks where w_i is the fraction of the portfolio invested in stock i at the end of a given period, σ_i is the standard deviation of returns of stock i during that period, and ACV is the value weighted average component volatility of the portfolio during that period, volatility dispersion during that period is defined as

$$D = \sum_{i=1}^{N} w_i(\sigma_i - ACV)^2 \tag{6}$$

If investors held homogenous portfolios in terms of stock volatilities, then the observed volatility dispersions should be less than the volatility dispersions of simulated portfolios.

The next step is the random assignment of a matching stock to each stock position established by the investor. At the end of a given month, each stock held at the brokerage is randomly replaced by another stock from the universe of stocks held at the brokerage at the end of that month. The random assignment is such that each stock in the universe serves as a replacement stock exactly once, possibly replacing itself. This assignment avoids cases in which a simulated portfolio consists of multiple positions in the same stock.

Volatility dispersion is bounded below by zero and thus positively correlated with ACV. Investors with a target ACV may reinforce this correlation. Take an investor who holds equal amounts of two stocks with volatilities of 9% and 11% and another investor who holds equal amounts of two stocks with volatilities of 90% and 110%. Both investors hold stocks with the same percentage distance from their ACV, but the dispersion of the higher-ACV investor is greater.

To control for differences in ACV across investors and to assess the statistical significance of the results, each of the roughly 450,000 investor-month combinations with two or more portfolio positions is simulated at least 25 times such that the simulated ACVs are within 10% of the actual ACV (for example, given an actual ACV of 40%, the simulated ACVs are in a range of 36%-44%). This also ensures that the average ACV of the simulated portfolios is virtually identical to the ACV of the actual portfolio.

Moreover, conditioning the simulation on actual ACV addresses the issue that variance in ACV across portfolios mechanically induces some volatility specialization – especially in the highest ACV portfolios which will tend to consist of volatile stocks and the lowest ACV portfolios which will tend to consist of docile stocks.

The standardized dispersion for each investor-month is the difference between the actual dispersion and the average of the simulated dispersions divided by the standard deviation of the simulated dispersions for that investor-month. The resulting variable is comparable across investor-months and has a mean of zero under the null hypothesis; under the alternative hypothesis of preferred risk habitat standardized dispersion is predicted to be negative. To account for the correlation of volatility dispersions over time – a portfolio with a low dispersion in month t is likely to have a low dispersion in month

$t + 1$, especially if the underlying positions are the same – standardized dispersion is averaged for each investor.

Across the roughly 450,000 investor-months in the sample, the median dispersion is 0.014. Loosely speaking, the square root of dispersion can be interpreted as a band in which the volatilities of the portfolio components are likely to lie. In a portfolio with a dispersion of 0.014 and an ACV of 50%, for example, the component volatilities are likely to lie in a band of 24% ($2 * \sqrt{0.014}$), that is, between 38% and 62%. (This interpretation is complicated by variance and standard deviation being non-negative and by portfolio weights not being equal.)

By comparison, a strategy of randomly picking stocks (while matching the HHI and ACV of the actual portfolios) generates dispersions that are almost three times the actual dispersion in the typical investor-month, consistent with Hypothesis H1 (see Column (1) of Table II). In other words, the simulation generates volatility bands that are 70% wider than those actually observed. Assuming that standardized dispersions are independent across investors but not across time yields a t-statistics of -100 – one would not expect the observed homogeneity of portfolio positions in terms of component volatilities if investors picked stocks at random.

The results are weaker, but still highly significant, when attention is only paid to the quartile of investor-months with the largest portfolios (Column (2) of Table II) or with the least concentrated portfolios (Column (3) of Table II). In these cases, simulated dispersions are typically 50% higher than actual dispersions.

A possible dismissal of the documented concentration of component volatility is the argument that investors hold stocks outside their account with the broker studied here. A subset of 450 questionnaire respondents state that they have no other brokerage account. Column (4) of Table II reports the results for them. The numbers and their statistical significance are similar to those in Columns (2) and (3).

The results in Columns (1)-(4) of Table II reflect only stock holdings. Similar results to those reported in Column (1) obtain when the simulations are extended to include stock funds (see Column (5) of Table II). In this extension a matching stock fund is assigned to each stock fund position established by the investor, in addition to matching individual stocks as described above.[1]

B Average Component Volatility Is Stable over Time

The previous subsection provides evidence consistent with the prediction that investors will hold portfolios of homogenous stocks with respect to volatility. A related implication of preferred risk habitats, Hypothesis H2, concerns trading: when investors sell securities in their portfolios, they will replace them with securities of volatilities similar to those of the securities they sell.

To examine this prediction, consider the sub-sample of investor-quarters in which an investor both sells and buys stocks. Round-trip transactions – an investor selling and buying the same stock in a given quarter – are excluded. For a given quarter, compute the ACV of stocks sold and the ACV of stocks bought by the same investor. For each quarter, assign investors to a sell ACV tercile and to a buy ACV tercile according to the rank of the ACV of the stocks they sell and those they buy among all stocks sold and

[1] The broker assigns each fund to one of more than fifty categories. In the simulation, actual funds held are replaced by randomly drawing a fund from the same category, for example, large-cap German stocks.

all stocks bought (respectively) in that quarter. In the absence of a tendency to replace stocks of a certain volatility with stocks of a similar volatility, the two assignments to terciles would be independent.

Panel A of Table III shows that investors who sell low-volatility stocks are more than twice as likely to buy low-volatility stocks than to buy high-volatility stocks, consistent with Hypothesis H2. Similarly, investors who sell high-volatility stocks are much more likely to buy high-volatility stocks than lower-volatility stocks.

Next, consider the stability of the tendency to focus on stocks of particular volatilities by comparing portfolio choices over longer periods of time. Specifically, restrict attention to the 4,000 investors who opened accounts on or before December 31, 1995, kept their accounts open until March 31, 2000, and held stocks both in the first quarter of 1996 and the first quarter of 2000. Investors' portfolios are classified into terciles according to their ACV during both periods. Panel B of Table III shows that investors with low-ACV portfolios during the first period also tend to hold low-ACV portfolios during the second period and investors who hold volatile assets during the first period also do so during the second period. To address the concern that these results may be driven by buy-and-hold types – investors who buy stocks before 1996 and hold them until 2000 – focus on the 1,800 investors who satisfy the above criteria and, in addition, hold completely different portfolios in 1996 and 2000 – that is, none of the stocks held in 1996 appears in the portfolio in 2000. The results, reported in Panel C of Table III, are virtually identical. The transition matrices are similar when both individual stocks and stock funds are considered. The transition matrices are also similar when ACV is calculated using one-quarter-lagged returns instead of contemporaneous returns. These results are therefore not reported.

V Stock Volatility Choices Correspond to Risk Aversion

This section examines the relation between self-reported risk aversion, available for a sub-sample of 1,300 investors, and the portfolio risk attributes (VOL, ACV, HHI, RHO). Like participants in the U.S. Survey of Consumer Finances, the sample investors indicate their risk aversion on a four-point scale: (1) very willing to bear high risk in exchange for high expected returns (lowest risk aversion), (2) willing to bear high risk in exchange for high expected returns, (3) unwilling to bear high risk in exchange for high expected returns, and (4) not at all willing to bear high risk in exchange for high expected returns (highest risk aversion). The preferred risk habitat hypothesis predicts that variation in risk aversion is associated with variation in portfolio volatility, but only through variation in the ACV, not through variation in the HHI or the RHO of stock portfolios. Hypotheses H3 through H8 offer detailed implications of this theme.

A Average Component Volatility Decreases with Risk Aversion

The temporal stability of ACV suggests that the investor's risk posture is the result of a relatively stable personal trait. Risk aversion is a candidate trait. The preferred risk habitat hypothesis predicts that more risk-averse investors will pick docile stocks whereas less risk-averse investors will gravitate towards volatile stocks.

Table IV allows a simple examination of Hypotheses H3, H4 and H5 by offering a holdings-based perspective on the relation between risk attitude and portfolio risk attributes. Panel A of Table IV reports mean VOL, ACV, HHI, RHO, and portfolio value for the period January 2000 to May 2000 based on holdings of individual stocks for the four categories of investors grouped by their self-professed risk attitude. Panel B of Table IV reports the corresponding statistics for holdings of individual stocks and stock funds.

One additional variable is reported in Panel B: the average fraction of the portfolio held in stock funds. It suggests that the more risk averse have a stronger tendency to invest in mutual funds. A similar observation emerges from a comparison of the number of observations in the two panels. A portfolio is represented in Table IV if it contains at least two securities, otherwise RHO cannot be calculated. Panel B includes portfolios not represented in Panel A: those with a single stock and one or more stock funds as well as those with at least two stock funds. From Panel A to Panel B the number of observations across the different risk aversion categories increases at an increasing rate – from 11% (that is, from 155 to 172) to 14%, 19%, and to 31% (that is, from 117 to 153) – suggesting a positive correlation between the tendency to invest in funds and aversion to risk.

Hypothesis H3 is that ACV decreases with risk aversion. Table IV indicates that both ACV and portfolio volatility decrease with self-professed risk aversion. Hypothesis H4 is that HHI should not be sensitive to risk aversion. Focusing on the stock portions of the portfolios (Panel A), HHI appears to decrease in risk aversion, but the mean HHI of a portfolio in the lowest risk aversion group is not significantly different from the mean HHI of a portfolio in the highest risk aversion group. Finally, RHO appears unrelated to risk aversion, which is consistent with Hypothesis H5.

A column-by-column comparison of Panels A and B of Table IV indicates that the inclusion of stock funds in the portfolios leads to lower volatilities, lower ACVs, lower HHIs and higher RHOs (the latter because pairwise correlations of fund returns are higher than those of stock returns). Moreover, since the more risk averse are heavier users of mutual funds, in Panel B HHI decreases with risk aversion whereas RHO seems to increase with risk aversion.

Do the results reported in Table IV reflect the behavior of investors to whom the account studied here is not important? To address this question one can look at two subsets of investors: those who report that they have no other brokerage account and those whose brokerage account represents a substantial fraction of their total wealth. Based on the self-reported net worth, asset allocation, and the account's size at the end of the sample period, the typical investor is estimated to hold half of his financial wealth in the observed account. Separate tabulations for investors without other brokerage accounts and investors who hold an above-median fraction of their financial assets in the observed account (unreported) yield results which are indistinguishable from those reported in Table IV.

Further unreported checks suggest that the results are robust to computing the portfolio risk measures from earlier sample periods and to using weekly returns instead of daily returns. The documented relation between self-reported risk aversion and the portfolio risk measures is thus not an artifact of the turbulent end of the sample period.

For Panel A of Table IV, the statistic RHO is inapplicable to an investor who holds a single stock. The holdings of such investors are not reflected in Panel A of Table IV. Panel C of Table IV summarizes the relation between these investors' attitude to risk and the volatilities of the single stocks they choose to hold. Again, the more risk averse hold less volatile stocks.

A comparison between the ACVs reported in Panel A and the volatilities reported in Panel C suggests that those less diversified in terms of HHI tend to hold more volatile stocks, an observation consistent with the 0.21 correlation between HHI and ACV in Panel A of Table I. Thus, it appears that those who choose more volatile stocks fail to compensate by choosing more stocks, or that those who choose fewer stocks fail to compensate by choosing less volatile stocks.

Tables V and VI report a series of regressions designed to explore the relation between attitude to risk and attributes of portfolio risk. The data underlying Table V are stocks only, whereas the data underlying Table VI are stocks and stock funds. These regressions provide additional examinations of Hypotheses H3-H5, with controls for demographic and socio-economic investor attributes.

First, consider Hypothesis H3. Column (1) of Table V and Column (1) of Table VI report the sensitivities of ACV to various individual attributes, other than attitude to risk. The second columns of the same tables include also the sensitivities to risk aversion. These sensitivities are of the right sign, statistically significant and increase the regressions' R-squared at least threefold. The interpretation of the magnitude of the coefficients of Column (2) of Table V is that, other things being equal, an investor who reports being very unwilling to trade off high risk and high expected returns holds a portfolio with an ACV that is 20% below that of a peer who reports being very willing to make that trade-off (55% as opposed to 75%). Consistent with Hypothesis H3, more risk-averse investors pick less volatile securities (stocks and stock funds), other things being equal.

B Portfolio Diversification Is Unrelated to Risk Aversion

Does risk aversion affect portfolio volatility outside of its impact on ACV? Possibly, and in contrast with Hypotheses H4 and H5, the more risk averse have better diversified portfolios, that is lower HHIs or lower RHOs (lower pairwise return correlations of their portfolio constituents).

Consider Hypothesis H4. Do more risk averse investors have less concentrated portfolios as measured by HHI, controlling for the available demographic and socio-economic attributes? When one focuses exclusively on stock holdings, Columns (3) and (4) of Table V suggest a negative answer, consistent with Hypothesis H4. When one extends the assets considered to include stock funds, the answer is that indeed, the more risk averse tend to be better diversified. (See Columns (3) and (4) of Table VI.) However, a comparison between Columns (2) and (4) of Table VI suggests that the marginal impact of risk aversion on HHI is lower than its marginal impact on ACV: the baseline regressions, reported in Columns (1) and (3), have similar explanatory powers (R-squared), but the explanatory power of the regression reported in Column (2) is much higher than that of the regression reported in Column (4).

Consistent with Hypothesis H5, the statistic summarizing the pairwise correlations of the returns of the portfolios components, RHO, appears unrelated to the portfolio holders' attitudes towards risk. This observation emerges from Columns (5) and (6) of both Table V and Table VI.

Tables V and VI indicate that the more risk averse hold less volatile portfolios. The analysis so far suggests that this is primarily because the more risk averse hold less volatile securities rather than because they hold more securities or because they hold securities whose pairwise correlations are lower. In fact, Hypothesis H6 predicts that variation in portfolio volatility should not be explained by variation in risk aversion after controlling for ACV. The last three regressions reported in Tables V and VI explore this.

First, the regressions reported in Column (7) of each table suggest that variation in the demographic and socio-economic variables used here explains little of the variation in portfolio volatility. Second, the addition of risk aversion as an explanatory variable improves the explanatory power and the coefficients are monotone with the right signs (Column (8)). Finally, the last regressions reported in Column (9) of Tables V and VI support Hypothesis H6: once ACV is used as a regressor, the marginal explanatory power of risk aversion is insignificant or small and with the wrong sign.

This result also casts doubt on the inference that most investors must be at least somewhat aware of the benefits of diversification because many of them do hold a few stocks or even stock funds. An alternative inference, consistent with preferred risk habitats and the results presented above, is that investors think of funds as relatively safe investments: the least risk averse investors hold volatile stocks, investors with intermediate risk aversion hold docile stocks, and the most risk averse investors hold broadly diversified stock funds. Unreported results show that investors typically start out with one equity position and become better diversified over time primarily by investing additional cash. Taken together, these observations are at odds with deliberate portfolio diversification; rather, they suggest that portfolios emerge from a collection of isolated investment decisions guided by a preferred risk habitat for individual positions.

Table VII affords an examination of Hypotheses H6, H7 and H8. It reports the results of ordered probit regressions in which the dependent variable is risk aversion as captured by the responses to the questionnaire. These regressions link variations in portfolio risk attributes to variation in risk aversion. The table has two parts, one in which only the stocks holdings are considered (Columns (1)-(4)) and the other in which both the stock and the fund holdings are considered (Columns (5)-(8)). Consistent with Hypothesis H6, those with higher VOL are not less risk averse when allowing for variation in both VOL and ACV to explain variation in risk aversion (Columns (1), (2), (5), and (6) of Table VII). Consistent with Hypothesis H7, the coefficient on ACV has the correct sign – those with lower ACV are more risk averse, other things being equal.

The correlation between ACV and VOL is 0.9 (see Table I), and the regressions' estimates reflect this collinearity. Nonetheless, standard theory suggests that when both VOL and ACV are the explanatory variables in a regression with risk aversion as the dependent variable, it is the slope coefficient of VOL that should have the negative sign and ACV should have no explanatory power. Thus, these regressions offer a summary of one of the paper's main messages.

A related implication of preferred risk habitats, formalized in Hypothesis H8, is that controlling for ACV, variation in HHI or variation in RHO should not explain variation in risk aversion. These predictions motivate the analysis underlying the other columns in Table VII. Consistent with the prediction, risk aversion loads negatively on ACV, but fails to load on either RHO or HHI when both individual stock and stock fund holdings are considered (see Columns (7) and (8) of Table VII). The results are similar for holdings of individual stocks, with one exception: controlling for ACV and HHI, risk aversion is positively correlated with RHO (see Columns (3) and (4) of Table VII). The sensitivity of risk aversion to RHO suggests that controlling for other variables (mainly ACV), the more risk averse tend to have stocks with more highly correlated returns, that is, more similar stocks along some dimension. Possibly, that dimension is familiarity – the more risk averse are more comfortable investing in more familiar stocks. Huberman (2001) suggests that investors tend to invest in the familiar but does not relate variation in risk aversion to variation in this tendency.

Taken together, the regression results presented above suggest that the investor's risk perception is dominated by the return volatility of the individual portfolio positions.

VI Alternative explanations

The first subsection explores whether the documented volatility specialization is an artifact of clientele effects driven by preferences for nearby stocks, stocks in a certain industry, or dividend-paying stocks, for example. The remaining subsections examine whether volatility specialization is likely a by-product of frictions such as costly borrowing or costly information acquisition in an otherwise rational world.

A Specialization in Other Stock Characteristics Fails to Explain Volatility Specialization

Volatility specialization may be a by-product of investors focusing on a stock characteristic other than volatility. Such a characteristic could be systematically related to volatility or spuriously related to volatility during the sample period.

Examples of stock characteristics that are systematically related to volatility include a firm's location, industry, market capitalization, dividend yield, and nominal share price. A preference for the familiar would explain why people focus their portfolios on nearby stocks or on stocks in the industry in which they are employed. Since investing in a stock requires knowledge of that stock, some people might gravitate towards larger firms which are likely better known and more heavily advertised. Investors with high marginal tax rates may try to avoid stocks with high dividend yields. People with smaller amounts to invest might favor lower-priced stocks.

If the observed volatility choices were a by-product of investors specializing in another characteristic, then volatility specialization should vanish once that characteristic is controlled for. To this end, the simulations presented in Section IV.A are conditioned on additional characteristics of the stocks held.

In the simulation reported in Column (1) of Table VIII, each stock held at the end of a given month is replaced by a random nearby stock. In case of a German stock, nearby is defined as headquartered in the same state (for example, a stock from Bavaria is replaced with another stock from Bavaria). In case of a foreign stock, nearby is defined as headquartered in the same country (for example, a stock from the U.S. is replaced with another stock from the U.S.). Headquarters of the stocks held by the sample investors range across sixteen German states and over 50 countries, yielding 70 geographical categories. This simulation policy thus accurately captures any regional or domestic biases in investors' portfolios. In a typical investor-month, actual volatility dispersion is 41% of simulated dispersion. Although simulated dispersions conditioned on firm location and portfolio HHI and ACV are slightly smaller than dispersions conditioned only on HHI and ACV, cross-sectional variation in regional or home equity biases cannot explain the observed volatility specialization.

Columns (2) through (8) of Table VIII report the relation between actual and simulated dispersions for simulations conditioned on firm industry, dividend yield, nominal share price, past returns, size, and popularity, as well as portfolio HHI, ACV and country of issue (domestic or foreign). Industry definitions are adopted from Datastream, yielding 40 different industries. For each of the remaining characteristics, 50 equally-sized categories are formed and updated each month. This translates into between 5 and 25 replacement candidates for each stock in the sample (the number of sample stocks increases over time as more stocks are covered by Datastream and held by the sample investors). Popularity for a given month is defined as the number of sample investors who hold the stock at the end of the previous month.

None of the combinations of other stock characteristics produces anything close to the observed volatility specialization. Even the most successful combinations of characteristics – matching HHI, ACV, country of issue, and size or popularity – produce only a median ratio of actual to simulated dispersions of around two thirds across all investor-months. Standardized dispersions are significantly different from zero for all simulation policies; the corresponding t-ratios assuming independence across investors, but not across time, range between -40 and -153.

In sum, the volatility specialization observed in this sample does not appear to be a mere by-product of specialization along some other dimension that has been previously documented in the literature. Of course, it is possible that volatility specialization can be "explained" by a combination of enough of the above characteristics or by other characteristics not considered here. Note, however, that such an explanation does not invalidate the conjecture of narrow framing. Moreover, it is unclear how this explanation would account for the relation between risk aversion and ACV.

B Portfolio Constraints Fail to Explain Volatility Specialization

Volatility specialization may also be a by-product of an investor who has a particular portfolio variance objective but faces frictions relative to classical portfolio theory. Given an inability to borrow, or a large disparity between borrowing and lending rates, for example, less risk-averse (rational) investors may gravitate towards more volatile stocks.

One way of checking the merits of this story is to condition the simulations presented in Section IV.A on portfolio variance instead of ACV. If the story were true, one would expect that a strategy of randomly investing in stocks that produce the observed portfolio variance also generates the observed volatility specialization.

To control for differences in portfolio volatility (VOL) across investors and to assess the statistical significance of the results, each of the investor-month combinations with two or more portfolio positions is simulated at least 25 times such that the simulated VOLs are within 10% of the actual VOL during the prior month (for example, given an actual VOL of 20%, the 25 simulated VOLs are in a range of 18%-22%). This also ensures that the average VOL of the simulated portfolios is virtually identical to the VOL of the actual portfolio.

Column (8) of Table VIII shows that conditioning on portfolio volatility fails to produce the observed volatility specialization. In fact, actual dispersion is typically only little more than one fourth of the simulated dispersion.

C Performance Fails to Justify Volatility Specialization

It may be that investors who choose specialized portfolios do so because they have informational advantages. If so, the stock picks of specialized investors should outperform stocks with similar characteristics. In addition to stock picking ability, this subsection examines the association between volatility specialization and the portfolios' Sharpe ratios.

To judge whether average portfolio returns are a function of specialization, the sample investors are first grouped by their tendency to specialize in stock volatility. Specifically, investors are ranked by the time-series average of the log ratio of actual to simulated dispersion, and sorted into five equally sized quintiles ranging from the most specialized quintile (investors with the lowest ratios of actual to simulated dispersion) to the least specialized quintile (investors with the highest ratios of actual to simulated dispersion).

To gauge the stock-picking ability of the different groups, the monthly raw return for a given group is computed in two steps: first, each member's portfolio return is computed and then the equally-weighted group average is taken. To calculate monthly benchmark returns for a given investor's portfolio, a value-weighted benchmark based on the investor's beginning-of-the-month holdings is formed as follows. Each German stock is assigned an equally-weighted portfolio of German stocks with the same Datastream industry designation and in the same market capitalization decile based on the beginning-of-the-month market cap. Each foreign stock is assigned an equally-weighted portfolio of foreign stocks that have the same Datastream industry designation and are in the same market cap decile. Size and industry were chosen because they are available for all stocks in the sample; other characteristics, such as the market-to-book ratio, are only available for a small subset of stocks listed on German stock exchanges. Each mutual fund is assigned an equally-weighted portfolio of mutual funds held at the broker with the same investment objective (for example, a fund that invests in U.S. small-cap stocks is benchmarked against the portfolio of funds investing in U.S. small-cap stocks). The monthly excess return is the difference between the actual portfolio return during the month and the return of the benchmark portfolio assuming that the securities are held throughout the month.

Trading commissions, bid-ask spreads, and price impact affect the investors' net returns. If an investor bought 200 shares of an individual stock at a price of DEM 50 per share (this is the actual transaction price, that is, it reflects the bid-ask spread and any price impact), paid a commission of DEM 90, and the Datastream closing price for the stock on the trading date were 49, then the associated trading costs would be DEM 290 (90+200*(50-49)). Across all transactions, trading costs average 1.2% of transaction value; by themselves, trading commissions average 0.9% of transaction value. Monthly excess returns after trading costs are defined as the difference between gross returns for a given month and the ratio of trading costs accumulated during the month divided by the average actual portfolio value during the month.

Panel A of Table IX reports the five groups' average monthly raw returns, excess returns, and excess returns after fees considering only holdings and trades of individual stocks. All investor groups do well in terms of raw returns – a reflection of the roaring late 1990s. The returns of the least specialized investors appear to lag behind their peers, but the differences are not significant (assuming that returns are independent across time, but not across investors). The excess returns of all investor groups are very close to zero; none of the groups significantly out- or underperforms its benchmark. In particular, there does not appear to exist any differential stock picking ability across investor groups after accounting for size and industry tilts. Excess returns after trading costs are significantly negative for all investor groups. The overall performance of the sample investors before and after trading costs is thus similar to that of the U.S. discount brokerage customers studied by Barber and Odean (2000).

Panel B of Table IX reports the corresponding results when both holdings of individual stocks and stocks funds are considered. The inference is similar.

The investor's Sharpe ratio offers another performance perspective. This perspective is especially meaningful given the low average level of diversification and the large variation of diversification across investors.

Sharpe ratios are estimated based on the investors' end-of-sample holdings (May 2000) following the methodology suggested by Calvet et al. (2007) in Section 4 of their paper. As in Calvet et al. (2007), the world dollar CAPM, in conjunction with covered interest rate parity, is assumed in pricing all assets.

The beta for a sample asset (individual stock or mutual fund) is the slope coefficient in the regression of the asset's monthly Deutsche Mark [DEM] return in excess of the 3-month German T-bill on the U.S. Dollar [USD] return of the MSCI World Index in excess of the USD return on the 3-month U.S. T-bill during the period January 1987 to December 2007 (or the available subsample thereof). The dollar-denominated MSCI World Index plays the role of the market portfolio that, given the assumption of covered interest rate parity, can be hedged from the perspective of a German investor. The resulting vector of betas is multiplied with the investor's portfolio weights and the historical USD excess return of the MSCI World Index to yield the expected DEM excess return of the investor's portfolio.

The covariance matrix of returns is estimated as

$$\mathbf{\Sigma} = \sigma_m^2 \beta\beta' + \mathbf{R} \tag{7}$$

where σ_m^2 is the variance of USD denominated MSCI World Index returns in excess of the 3-month U.S. T-bill, β is the $N \times 1$-vector of betas (with N as the number of assets), and $\mathbf{R}$ is the $N \times N$ covariance matrix of residuals from the beta regressions. Pre- and postmultiplying this covariance matrix with the portfolio weights yields the expected variance of the investor's portfolio.

A given portfolio efficiency loss relative to the MSCI World Index can be measured as the relative Sharpe ratio loss – the relative difference between the portfolio's Sharpe ratio and the index's Sharpe ratio. A relative Sharpe ratio loss of 40% indicates that the portfolio's Sharpe ratio is 40% below that of the MSCI World Index. Alternatively, one could also measure Sharpe ratio losses relative to the unhedged MSCI World Index, or an index of German stocks. However, the main interest here lies in comparing the portfolio efficiency of investors who differ in their tendency to specialize in volatility. A particular choice of index does not affect this comparison.

Panel C of Table IX reports the averages of relative Sharpe ratio losses for investors grouped by their tendency to specialize in stock and fund volatility. When all investors are considered, the average Sharpe ratio loss in the quintile of the most specialized investors is 43.2%, significantly higher than the average loss of 37.6% for the quintile of the least specialized investors.

If sample investors have stock and fund holdings outside the observed account, their relative Sharpe ratio loss is likely overestimated. It is also possible that investors who specialize more in component volatility in the observed account are more likely to have outside holdings which would invalidate the above inference.

These concerns do not apply to the sample investors who participate in a survey at the end of the sample period and report that the observed account is their only brokerage account (roughly one third of the 1,300 survey respondents). The average relative Sharpe ratio loss of these investors is indeed lower than the average across the full sample (37.9% versus 39.4%), but the difference in Sharpe ratio losses between the least and most specialized investors is even more pronounced (33.4% versus 43.5%).

It is possible that the greater Sharpe ratio losses associated with greater volatility specialization are offset by a larger position in approximately (nominally) risk-free assets such as savings or money-market accounts. In other words, although the risky portfolios of more specialized investors are further away from the efficient frontier, their complete portfolios need not be. Complete portfolios can be estimated for survey respondents since they also report the fraction of their financial wealth invested in risk-free assets. Panel D of Table IX compares the expected return losses of the complete portfolios of investors grouped by volatility specialization. Expected return loss is the difference in expected return between the investor's portfolio and the efficient portfolio that carries the same risk as the investor's portfolio. The quintile of the most specialized portfolios (of survey respondents with only one account) generate an average expected return loss of 8% per year, twice the loss of 4% for the quintile of the least specialized portfolios.

Portfolio concentration appears to be main driver of the performance difference between investors grouped by their tendency to specialize in volatility. The HHI of the most specialized investors averages 40% which corresponds to positions in two to three individual stocks. The HHI of the least specialized investors averages 20% which corresponds to positions in five individual stocks. In contrast, the differences in ACV and the pairwise correlations of the components are small.

In sum, volatility specialization does not appear to be associated with better performance. Stock picks of specialized investors fail to fare significantly better (relative to size and industry benchmarks) than those of their peers. Moreover, investors who specialize in volatility also focus on fewer stocks which reduces their Sharpe ratios.

D Less Sophisticated Investors Hold More Specialized Portfolios

Behavioral and rational explanations imply different predictions about who specializes (most). If volatility specialization were the result of a behavioral bias, one would expect the portfolios of more experienced and smarter investors to be less specialized, that is, display relatively greater volatility dispersion. In contrast, rational models of portfolio choice are (almost by definition) mum on the effects of differences in experience across investors.

A cross-sectional regression of the time-series average of volatility specialization in individual stocks (the logarithm of the ratio of actual to simulated dispersion) on a wide range of investor and portfolio attributes helps to further distinguish between explanations for the observed volatility specialization.

Table X reports the results of the regression. Other things being equal, investors with less stock market investing experience and investors who hold more concentrated portfolios (that is, portfolios with higher HHIs) specialize significantly more in stock volatility. Variation in other investor and portfolio attributes fails to explain variation in volatility specialization. In particular, the value of the observed account as a fraction of self-reported wealth is unrelated to volatility specialization, suggesting that the observed specialization is not driven by unimportant accounts. If borrowing constraints drove the results, one would expect volatility specialization among those for whom these constraints are more binding. Such constraints are presumably more important to the least risk-averse investors or those with a small fraction of their wealth in safe assets such as cash, money market accounts, certificates of deposit, and savings bonds. However, neither risk aversion nor the fraction of wealth invested in safe assets appear to be systematically related to volatility specialization.

Volatility specialization is widespread. That it is particularly pronounced among investors with less experience and relatively concentrated portfolios points to a behavioral bias as an explanation for the observed specialization.

VII Conclusion

The Markowitz one-period mean variance optimization is an elegant and parsimonious formulation of the investor's problem. Its implementation, however, is quite challenging, once attention is paid to real-world issues such as parameter estimation and the temporal evolution of the portfolio. The nature of stock selection does not lend itself to a Markowitz-like program, unless aided by a computer or otherwise done methodically. Thus, it is reasonable to expect that individual investors apply heuristics to their portfolio selection: they select a few stocks, each stock selection based on the stock's own merits (including the stock's volatility) and invest in more than one stock to reduce the portfolio risk. Within this loose framework, the investor pays little attention to the portfolio' overall risk; risk considerations are secondary to return temptations.

However, the overall picture is not chaotic. Investors specialize in the stocks they follow and pick. According to the preferred risk habitat hypothesis, the more risk averse investors will buy the less volatile stocks.

The main evidence consistent with the preferred risk habitat hypothesis is twofold: the volatilities of the stocks in individuals' portfolios are less dispersed than they would be if the portfolio holders chose the stocks at random, and the holders of the less volatile stocks tend to be individuals who are more risk averse according to survey-based indicators of risk aversion.

Investors with a preferred risk habitat sacrifice portfolio performance. More specialized investors hold portfolios with lower Sharpe ratios because they expose themselves to more unsystematic risk.

This paper focuses on the role of preferred risk habitats in portfolio construction. Aside from its relevance for portfolio choices and investor welfare, the preferred risk habitat hypothesis may also have implications for asset pricing. Ang et al. (2006) and Ang et al. (2009) report that stocks with high realized volatility deliver low future returns, on average. If markets for volatile and docile stocks are sufficiently segmented, the lower risk aversion of holders of volatile stocks may translate into a lower risk premium for volatile stocks.

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Table I: Summary Statistics

Annualized portfolio volatility (VOL), value-weighted average component volatility (ACV), Herfindahl-Hirschmann Index (HHI), weighted average correlation of portfolio components (RHO), and portfolio value are calculated based on the sample investors' holdings of individual stocks and stock funds as of January 1, 2000 for the period January 1, 2000 to May 31, 2000. Portfolio values are in Deutsche Mark [DEM] and calculated as of January 1, 2000. To ensure the consistency of the different portfolio risk components, portfolio weights are assumed to stay constant throughout the sample period. Panel A reports summary statistics for holdings of individual stocks; Panel B reports the summary statistics for holdings of individual stocks and stock funds. For the purpose of the HHI calculation, stock funds are assumed to hold 100 equally-weighted positions that do not appear in another holding of the investor. All summary statistics for RHO are calculated for investors with at least two positions. During the sample period, the average USD/DEM exchange rate was roughly 2 DEM for 1 USD.

Panel A: only stocks	VOL	ACV	HHI	RHO	Portfolio value [DEM]
Number of investors	17,913	17,913	17,913	14,575	17,913
Mean	52%	69%	47%	18%	100,733
Bottom quartile	32%	51%	20%	9%	8,719
Median	46%	65%	36%	16%	29,044
Top quartile	65%	86%	70%	26%	85,352
Pairwise correlations					
ACV	0.90				
HHI	0.58	0.21			
RHO	0.35	0.27	-0.11		
ln(Portfolio value)	-0.46	-0.25	-0.65	0.25	
Panel B: stocks and stock funds					
Number of investors	19,731	19,731	19,731	17,440	19,731
Mean	43%	59%	28%	25%	119,650
Bottom quartile	28%	42%	5%	12%	14,845
Median	37%	55%	17%	22%	42,511
Top quartile	53%	72%	40%	34%	112,797
Pairwise correlations					
ACV	0.90				
HHI	0.60	0.40			
RHO	0.09	-0.11	-0.36		
ln(Portfolio value)	-0.33	-0.15	-0.46	0.14	

Table II: Dispersion of Volatility

The sample consists of all investor-months in which an investor holds at least two stocks (for Columns (1) to (4)) or at least two stocks or stock funds (for Column (5)). Actual dispersion of volatility D_{actual} is the value-weighted variance of the volatilities of portfolio components. Artificial dispersions $D_{simulated}$ are simulated by replacing actual stock holdings with random stock holdings such that the simulated portfolio matches the HHI and the ACV of the actual portfolio. Details of the simulation policies are given in Section IV.A. Standardized dispersion for a given investor-month is the difference between actual dispersion and the average of the simulated dispersions for that investor-month, divided by the standard deviation of the simulated dispersions for that investor-month. In calculating the t-statistics, it is assumed that standardized dispersions are independent across investors but not across time.

	(1)	(2)	(3)	(4)	(5)
Sample selection	All investors	Top quartile Average portfolio value	Bottom quartile Portfolio HHI	Survey respondents with only 1 account	All investors Stocks and stock funds
Actual/simulated dispersion across investor-months					
Bottom quartile	17%	43%	48%	43%	21%
Median	37%	61%	64%	62%	44%
Top quartile	73%	82%	84%	87%	82%
Average of standardized dispersion					
$(D_{actual} - \bar{D}_{simulated})/(\sigma(D_{simulated}))$	-0.405	-0.559	-0.633	-0.432	-0.372
T-statistic	-100	-101	-124	-23	-93
Number of independent observations	18,201	4,541	4,541	442	20,226

Table III: When Stock X Is Replaced by Stock Y in the Same Portfolio, They Have Similar Volatilities

For the transition matrix shown in Panel A, the unit of observation is an investor-quarter in which an investor both sells and buys stocks. Transactions in the same stock (an investor sells and buys the same stock during the quarter) are excluded. First investors are sorted by the value-weighted component volatility of stocks sold during the quarter and then by the value-weighted component volatility of stocks bought during the quarter. Category 1 is the lowest volatility category; the categories are equally sized. The interpretation of the 15% in the top left cell in Panel A's matrix is that 15% of all investors sell and buy low-volatility stocks during a given quarter; the unit of observation is a investor-quarter. For the transition matrix shown in Panel B, investors are included if they hold stocks during the first quarter of 1996 and also during the first quarter of 2000. Investors are sorted twice based on their portfolios' ACVs during the first quarter of 1996 and during the first quarter of 2000. To be included in the matrix shown in Panel C, investors not only have to have active accounts in both 1996 and 2000, but they also have to completely turn over their portfolio between 1996 and 2000 (i.e., none of the positions at the end of March 1996 appears in the portfolio at the end of March 2000).

Panel A		Buy volatility		
		1	2	3
Sell	1	15%	11%	7%
volatility	2	11%	12%	10%
category	3	6%	11%	16%
Panel B		ACV rank in 1/2000		
		1	2	3
ACV	1	16%	11%	7%
rank	2	11%	12%	10%
in 1/1996	3	6%	11%	17%
Panel C		ACV rank in 1/2000		
		1	2	3
ACV	1	16%	10%	7%
rank	2	10%	12%	11%
in 1/1996	3	7%	11%	15%

Table IV: Actual risk postures versus self-reported risk attitudes

The sample consists of investors who assess their risk attitude in a survey conducted in July 2000. The survey respondent's willingness to trade off high risk and high expected returns – (1) very willing to bear high risk in exchange for high expected returns, (2) willing to bear high risk in exchange for high expected returns, (3) unwilling to bear high risk in exchange for high expected returns, and (4) not at all willing to bear high risk in exchange for high expected returns – is used as a proxy for risk aversion. Annualized volatility (VOL), average component volatility (ACV), Herfindahl-Hirschmann Index (HHI), and weighted average correlation (RHO) are calculated based on the respondents' holdings of individual stocks (for observations with at least two stocks, in Panel A) or of both individual stocks and stock funds (for observations with at least two positions, in Panel B) or of one individual stock (in Panel C) as of January 1, 2000 for the period January 1, 2000 to May 31, 2000. To ensure the consistency of the different portfolio risk components, portfolio weights are assumed to stay constant throughout the sample period. Portfolio values are in Deutsche Mark [DEM] and calculated as of January 1, 2000. The Fraction in Funds is the fraction of a client's portfolio invested in stock funds as of January 1, 2000. The reported statistics are mean VOL, ACV, HHI, RHO, and Fraction in Funds across investors grouped by their self-professed risk attitude.

	Nobs	VOL	ACV	HHI	RHO	Portfolio Value [DEM]	Mean Fraction in Funds
Panel A: individual stocks only							
Lowest risk aversion	155	53%	78%	35%	19%	93,918	n/a
2	293	47%	70%	32%	18%	89,272	n/a
3	384	43%	63%	32%	19%	95,664	n/a
Highest risk aversion	117	37%	56%	31%	18%	127,332	n/a
Panel B: individual stocks and stock funds							
Lowest risk aversion	172	48%	70%	24%	24%	109,980	23%
2	335	42%	63%	21%	23%	100,860	26%
3	456	37%	55%	19%	25%	115,210	31%
Highest risk aversion	153	33%	48%	16%	26%	130,360	36%
Panel C: single stock							
Lowest risk aversion	26	98%	n/a	n/a	n/a	7,738	n/a
2	53	91%	n/a	n/a	n/a	28,018	n/a
3	69	82%	n/a	n/a	n/a	10,832	n/a
Highest risk aversion	32	77%	n/a	n/a	n/a	8,642	n/a

Table V: Sensitivities of Risk Taking Attributes to Attitudes to Risk Based on Holdings of Individual Stocks Only

The dependent variables in the underlying cross-sectional OLS regressions are average component volatility (ACV), Herfindahl-Hirschmann Index (HHI), average return correlations (RHO), and portfolio volatility (VOL). The explanatory variables, objective investor attributes and self-reported risk attitudes, are available for a subsample of investors who participate in a survey at the end of the sample period (see Dorn and Huberman (2005)). The portfolio risk measures are based on the survey respondents' holdings of individual stocks as of January 1, 2000 for the period January 1, 2000 to May 31, 2000. Sample investors need to have at least two positions to be included in the regression (a requirement for the calculation of RHO). To ensure the consistency of the different portfolio risk components, portfolio weights are assumed to stay constant throughout the sample period. The objective investor attributes are gleaned from survey responses. Gender is a dummy that is one if the survey respondent is male. College education is a dummy that is one if the survey respondent is college educated. Self-employed is a dummy that is one if the survey respondent is self-employed. The proxy for risk aversion is defined as in Table IV. The standard errors in parentheses are corrected for heteroskedasticity as suggested by White (1980). Note: ***/**/* indicate that the coefficient estimates are significantly different from zero at the 1%/5%/10% level.

Dependent variable	(1) ACV	(2) ACV	(3) HHI	(4) HHI	(5) RHO	(6) RHO	(7) VOL	(8) VOL	(9) VOL
Constant	0.807***	0.873***	0.485***	0.498***	0.222***	0.217***	0.624***	0.674***	-0.051**
	(0.044)	(0.047)	(0.047)	(0.050)	(0.030)	(0.031)	(0.039)	(0.042)	(0.024)
Gender	0.038	0.017	-0.023	-0.023	-0.007	-0.005	0.016	0.001	-0.013
	(0.023)	(0.022)	(0.025)	(0.025)	(0.015)	(0.015)	(0.022)	(0.022)	(0.011)
Age	-0.003***	-0.002***	0.000	0.001	-0.002***	-0.002***	-0.003***	-0.002***	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)
College education	0.004	0.010	-0.016	-0.014	-0.001	0.000	0.004	0.008	0.000
	(0.015)	(0.014)	(0.016)	(0.016)	(0.010)	(0.010)	(0.014)	(0.013)	(0.007)
Self-employed	0.016	0.005	-0.014	-0.015	0.008	0.008	0.003	-0.005	-0.009
	(0.019)	(0.018)	(0.020)	(0.020)	(0.012)	(0.012)	(0.017)	(0.017)	(0.008)
ln(Income)	-0.006	-0.004	0.016**	0.016**	-0.016***	-0.016***	-0.006	-0.004	-0.001
	(0.008)	(0.007)	(0.007)	(0.007)	(0.005)	(0.005)	(0.006)	(0.006)	(0.003)
ln(Wealth)	-0.002	-0.002	-0.039***	-0.039***	0.019***	0.019***	-0.009	-0.010	-0.008***
	(0.008)	(0.007)	(0.007)	(0.007)	(0.004)	(0.004)	(0.007)	(0.006)	(0.003)
Risk aversion category (Lowest category omitted)									
2		-0.066***		-0.030		-0.003		-0.056**	-0.002
		(0.024)		(0.021)		(0.013)		(0.022)	(0.010)
3		-0.132***		-0.016		0.011		-0.092***	0.018*
		(0.023)		(0.021)		(0.013)		(0.021)	(0.009)
4 - highest		-0.208***		-0.027		-0.004		-0.149***	0.024**
		(0.028)		(0.026)		(0.016)		(0.026)	(0.012)
ACV									0.830***
									(0.018)
Ancillary statistics									
Number of observations					855				
R-squared	3.8%	12.4%	4.6%	4.8%	3.2%	3.4%	3.9%	8.7%	80.3%

Table VI: Sensitivities of Risk Taking Attributes to Attitudes to Risk Based on Holdings of Individual Stocks and Stock Funds

The dependent variables in the underlying cross-sectional OLS regressions are average component volatility (ACV), Herfindahl-Hirschmann Index (HHI), average return correlations (RHO), and portfolio volatility (VOL). The portfolio risk measures are based on the survey respondents' holdings of individual stocks and stock funds as of January 1, 2000 for the period January 1, 2000 to May 31, 2000. To ensure the consistency of the different portfolio risk components, portfolio weights are assumed to stay constant throughout the sample period. All other variables are defined as in Table V. The standard errors in parentheses are corrected for heteroskedasticity as suggested by White (1980). Note: ***/**/* indicate that the coefficient estimates are significantly different from zero at the 1%/5%/10% level.

Dependent variable	(1) ACV	(2) ACV	(3) HHI	(4) HHI	(5) RHO	(6) RHO	(7) VOL	(8) VOL	(9) VOL
Constant	0.753***	0.835***	0.370***	0.403***	0.282***	0.275***	0.588***	0.650***	0.027
	(0.040)	(0.042)	(0.040)	(0.043)	(0.033)	(0.034)	(0.032)	(0.035)	(0.021)
Gender	0.034	0.009	-0.016	-0.024	-0.022	-0.018	0.016	-0.001	-0.008
	(0.022)	(0.020)	(0.022)	(0.022)	(0.018)	(0.018)	(0.019)	(0.018)	(0.009)
Age	-0.003***	-0.002***	0.000	0.000	-0.001**	-0.001**	-0.002***	-0.002***	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)
College education	-0.019	-0.012	-0.027*	-0.024*	0.009	0.008	-0.011	-0.006	0.003
	(0.014)	(0.013)	(0.014)	(0.014)	(0.011)	(0.011)	(0.012)	(0.011)	(0.006)
Self-employed	0.019	0.009	-0.009	-0.012	0.003	0.004	0.006	-0.001	-0.008
	(0.018)	(0.017)	(0.017)	(0.017)	(0.012)	(0.012)	(0.015)	(0.015)	(0.007)
ln(Income)	-0.008	-0.005	0.010	0.011	-0.007	-0.007	-0.005	-0.003	0.001
	(0.007)	(0.007)	(0.007)	(0.006)	(0.005)	(0.005)	(0.006)	(0.006)	(0.002)
ln(Wealth)	-0.005	-0.007	-0.030***	-0.031***	0.009*	0.009**	-0.015**	-0.016***	-0.011***
	(0.007)	(0.006)	(0.007)	(0.007)	(0.005)	(0.005)	(0.006)	(0.005)	(0.002)
Risk aversion category									
(Lowest category omitted)									
2		-0.071***		-0.041**		-0.003		-0.061***	-0.008
		(0.023)		(0.020)		(0.015)		(0.019)	(0.009)
3		-0.148***		-0.051**		0.018		-0.104***	0.007
		(0.022)		(0.020)		(0.014)		(0.019)	(0.008)
4 - highest		-0.220***		-0.069***		0.023		-0.154***	0.011
		(0.024)		(0.023)		(0.019)		(0.021)	(0.010)
ACV									0.746***
									(0.019)
Ancillary statistics									
Number of observations					1,002				
R-squared	3.7%	14.3%	3.8%	4.8%	0.9%	1.4%	5.2%	12.1%	80.0%

Table VII: Self-reported risk aversion versus actual risk postures

The dependent variable in the underlying ordered probit regressions is self-reported risk aversion, available for a subsample of survey respondents and modeled as four dummy variables as in Table V. The independent variables are portfolio volatility (VOL), average component volatility (ACV), the Herfindahl-Hirschmann Index (HHI), average return correlations (RHO), and objective investor attributes. In Columns (1)-(4), the portfolio risk measures are calculated using holdings of individual stocks only. In Columns (5)-(8), the portfolio risk measures are calculated using holdings of both individual stocks and stock funds. All other variables are defined as in Table V. Note: ***/**/* indicate that the coefficient estimates are significantly different from zero at the 1%/5%/10% level.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep. var.	Risk aversion							
Holdings	Stocks only				Stocks and stock funds			
VOL	1.225***	1.250***			0.775*	0.846*		
	(0.427)	(0.431)			(0.435)	(0.444)		
ACV	-2.800***	-2.680***	-1.947***	-1.823***	-2.599***	-2.525***	-2.057***	-1.927***
	(0.398)	(0.402)	(0.193)	(0.196)	(0.369)	(0.373)	(0.185)	(0.187)
HHI			-0.019	-0.020			0.138	0.128
			(0.178)	(0.182)			(0.187)	(0.190)
RHO			0.842***	0.909***			0.254	0.299
			(0.294)	(0.298)			(0.231)	(0.233)
Gender		-0.313**		-0.320**		-0.358***		-0.355***
		(0.126)		(0.126)		(0.116)		(0.117)
Age		0.014***		0.015***		0.015***		0.015***
		(0.004)		(0.004)		(0.004)		(0.004)
College		0.102		0.104		0.089		0.093
		(0.082)		(0.082)		(0.076)		(0.076)
Self-employed		-0.182*		-0.199**		-0.144		-0.139
		(0.100)		(0.100)		(0.093)		(0.093)
ln(Income)		0.035		0.049		0.026		0.029
		(0.044)		(0.045)		(0.042)		(0.042)
ln(Wealth)		-0.006		-0.035		-0.032		-0.040
		(0.037)		(0.038)		(0.034)		(0.034)
Ancillary statistics								
Nobs	855				1002			
Pseudo R^2	4.8%	5.9%	4.8%	6.0%	5.4%	6.5%	5.3%	6.4%

Table VIII: Is Volatility Dispersion a By-Product of Investors Specializing in Some Other Stock Characteristic?

The sample consists of all investor-months in which an investor holds at least two stocks. Actual dispersion of volatility D_{actual} is the value-weighted variance of the volatilities of portfolio components. Artificial dispersions $D_{simulated}$ are simulated by replacing actual stock holdings with random stock holdings such that the simulated portfolio matches the HHI and the ACV or the volatility of the actual portfolio as well as different characteristics of the individual stocks. In Column (1), a German firm is randomly replaced by another German firm headquartered in the same state and a foreign firm is randomly replaced by another firm headquartered in the same country. In Columns (2) through (7), German firms are replaced by other German firms and foreign firms are replaced by other foreign firms. The additional stock characteristics matched: Datastream industry codes (40 industries), dividend yield (50 quantiles), nominal share price (50 quantiles), past returns (50 quantiles), market capitalization (50 quantiles), and popularity (the number of sample investors who hold the stock (50 quantiles)). Characteristics other than industry codes are matched using values at the end of the month prior to the observation. Standardized dispersion for a given investor-month is the difference between actual dispersion and the average of the simulated dispersions for that investor-month, divided by the standard deviation of the simulated dispersions for that investor-month. In calculating the t-statistics, it is assumed that standardized dispersions are independent across investors but not across time.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Simulation policy	Match by HHI, ACV, Region, and Country	Match by HHI, ACV, domestic versus foreign allocation, and						Match by HHI and Portfolio volatility
		Industry	Dividend Yield	Nominal Share price	Past Returns	Size	Popularity	
Actual/simulated dispersion across investor months								
Bottom quartile	19%	23%	24%	23%	23%	34%	36%	12%
Median	41%	48%	49%	48%	49%	66%	70%	29%
Top quartile	78%	88%	90%	89%	90%	111%	117%	63%
Average of standardized dispersion								
$(D_{actual} - \bar{D}_{simulated})/(\sigma(D_{simulated}))$	-0.422	-0.365	-0.406	-0.418	-0.391	-0.217	-0.137	-0.411
T-statistic	-109	-112	-153	-139	-129	-63	-40	-68
Number of independent observations				18,201				

Table IX: Performance of Investors Grouped by Their Tendency to Specialize in Volatility

Five equally-sized investor groups are formed by ranking investors by the time-series average of the log ratio of actual to simulated dispersion. For Panel A, dispersions are computed using only individual stocks; for Panels B-E, dispersions are computed using both stocks and mutual funds. Quintile 1 consists of the least specialized investors (those with the highest ratios of actual to simulated dispersion). Quintile 5 consists of the most specialized investors (those with the lowest ratios of actual to simulated dispersion). Panels A and B report average raw returns, excess returns, and excess returns after trading costs for each investor group as outlined in Section VI. Panel C reports the average Sharpe Ratio Loss of members in each group relative to the MSCI World Index for two samples: the full sample and the subsample of 450 survey respondents who report that the observed account is their only brokerage account. Panel D reports the average return loss – the difference in expected return between the investor's portfolio and the efficient portfolio that carries the same risk as the investor's portfolio – for the different groups. ***/**/* indicate that the corresponding average is significantly different from zero at the 1%/5%/10% level, assuming that returns are independent across months in Panels A and B and that the Sharpe ratio and return losses are independent across investors in Panels C and D.

	Specialization quintile					
Panel A: Individual stocks only	1	2	3	4	5	5-1
Average return	1.4%	1.9%	2.1%	2.2%	2.2%	0.8%
Average excess return	-0.1%	0.0%	0.0%	0.0%	0.0%	0.1%
Average excess return net of trading costs	-0.4%***	-0.4%***	-0.3%***	-0.5%***	-0.3%***	0.1%
Panel B: Stocks and mutual funds						
Average return	1.5%	1.8%	2.0%	2.1%	2.1%	0.6%
Average excess return	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Average excess return net of trading costs	-0.4%***	-0.3%***	-0.3%***	-0.6%***	-0.3%***	0.1%
Panel C: Relative sharpe ratio loss of portfolios consisting of stocks and mutual funds						
All investors	37.6%	37.5%	38.5%	40.2%	43.2%	5.6%***
Survey investors with only one account	33.4%	38.2%	36.7%	38.1%	43.5%	10.1%***
Panel D: Return loss of complete portfolios						
Survey investors with only one account	4.0%	5.1%	5.0%	5.7%	8.0%	3.9%***
Panel E: Portfolio statistics						
Average portfolio value [DEM]	104,661	148,349	145,651	125,615	100,658	-4,004
Average HHI	20%	19%	22%	29%	41%	21%***

Table X: Determinants of Cross-Sectional Variation in Volatility Specialization

The sample considered here consists of investors who participate in a survey administered at the end of the sample period. The dependent variable in the cross-sectional OLS regression is the time-series average of volatility specialization (the logarithm of the ratio of actual to simulated dispersion). The simulation policy matches the HHI and the ACV of the actual portfolio. Survey responses reveal the respondents' gender, age, education (coded as a college dummy variable; almost 70% of the respondents have or are working towards a college degree), professional status (coded as a self-employed dummy; 15% of the respondents are self-employed, most of the remainder are white-collar employees), gross annual income, total wealth, and the length of their stock market experience. HHI is the time-series average of portfolio HHI. The survey respondent's willingness to trade off high risk and high expected returns – (1) very willing to bear high risk in exchange for high expected returns, (2) willing to bear high risk in exchange for high expected returns, (3) unwilling to bear high risk in exchange for high expected returns, and (4) not at all willing to bear high risk in exchange for high expected returns – is used as a proxy for risk aversion (the least risk averse category dummy is omitted). Allocation to safe assets is the fraction of wealth invested in cash, certificates of deposit, money market accounts, or savings bonds. Account as a fraction of wealth is the value of the observed account at the end of the sample period as a fraction of total wealth reported in the survey. Note: Standard errors, corrected for heteroskedasticity as suggested by White (1980), are in parentheses. ***/**/* indicate that the coefficient estimates are significantly different from zero at the 1%/5%/10% level.

Dependent variable	Time-series average of ACV-matched ln(Actual dispersion/Simulated dispersion)
Constant	-0.867***
	(0.283)
Gender 0,1=male	0.081
	(0.059)
Age [years]	0.000
	(0.002)
College education 0,1=college	-0.005
	(0.044)
Self-employed 0,1=self-employed	0.031
	(0.054)
ln(Income)	-0.025
	(0.027)
ln(Wealth)	0.018
	(0.035)
Stock market experience [years]	0.009*
	(0.005)
Average HHI	-1.090***
	(0.124)
ln(Average portfolio value)	-0.003
	(0.036)
Risk aversion	
Risk aversion = 2	0.115*
	(0.067)
Risk aversion = 3	0.007
	(0.067)
Risk aversion = 4 (most risk averse)	0.008
	(0.077)
Allocation to cash and bonds	-0.065
	(0.145)
Account as a fraction of wealth	0.030
	(0.105)
Ancillary statistics	
Number of observations	866
R-squared	16.6%