

## Equity Portfolio Diversification\*

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**Abstract.** This study shows that U.S. individual investors hold under-diversified portfolios, where the level of under-diversification is greater among younger, low-income, less-educated, and less-sophisticated investors. The level of under-diversification is also correlated with investment choices that are consistent with over-confidence, trend-following behavior, and local bias. Furthermore, investors who over-weight stocks with higher volatility and higher skewness are less diversified. In contrast, there is little evidence that portfolio size or transaction costs constrains diversification. Under-diversification is costly to most investors, but a small subset of investors under-diversify because of superior information.

*JEL Classification:* G11, G12

### 1. Introduction

U.S. equity risk has a large idiosyncratic component, much of which could be reduced through portfolio diversification. Most rational models of portfolio choice suggest that investors hold diversified portfolios to reduce or eliminate non-compensated risk, and virtually all asset pricing models posit that securities are priced by a diversified, marginal investor who demands little or no compensation for holding idiosyncratic risk. But do investors hold well-diversified portfolios? Which individual characteristics or behavioral patterns are associated with under-diversification? And what are the economic costs (if any) of under-diversification?

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In this study, we analyze the diversification choices of more than 60,000 individual investors at a large U.S. discount brokerage house during a six-year period in recent (1991 to 1996) capital market history. Our study focuses on three key issues. First, we estimate the extent of under-diversification in investors' portfolios and examine whether the level of diversification improves over time. Second, we document how investors' diversification choices correlate with their individual characteristics and their trading and investment patterns. From these correlations, we try to gauge whether the evidence is consistent with explanations of under-diversification based on trading costs, information, stock preferences, or behavioral biases. Third, to quantify the potential welfare effects of portfolio under-diversification, we investigate the relation between portfolio diversification and performance.

Our results indicate that a large proportion of individual investors are under-diversified, and the extent of under-diversification is greater for investors who hold only retirement accounts (IRA and Keogh). This evidence, however, is not the most salient finding of our paper. Using the same brokerage sample, Barber and Odean (2000) report that a typical individual investor holds a portfolio with only four stocks. Additionally, using data from the Survey of Consumer Finances (SCF), Polkovnichenko (2005) provides evidence of under-diversification among U.S. households.<sup>1</sup> These results indicate that, on average, individual investors hold under-diversified portfolios.

Our study extends these results. While the number of stocks in a portfolio is a useful heuristic for identifying the degree of diversification, this measure is insufficient to accurately characterize the diversification characteristics of a portfolio. To measure diversification more accurately, we exploit the covariance structure of investors' portfolios and decompose the level of portfolio diversification into two components: (i) the risk reduction due to holding more than one security, i.e., passive diversification, and (ii) the risk reduction due to choosing imperfectly correlated stocks, i.e., diversification skill. We find evidence of the former but not of the latter.

Although we have a relatively short six-year sample period, the time-series of average diversification level exhibits interesting patterns. We find that during the 1991–96 sample period, the average number of stocks in investor portfolios increases from four to seven. This increase in the number of stocks held is associated with a decrease in the average normalized portfolio variance. However, the improved diversification over time does not necessarily imply that investors' portfolio

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<sup>1</sup> For additional evidence of under-diversification among U.S. households, see Lease et al. (1974), Blume and Friend (1975), and Kelly (1995). Guiso et al. (2002) contains a collection of papers that examine the structure of household portfolios in different countries. For evidence of under-diversification in retirement and pension accounts, see Benartzi (2001), Benartzi and Thaler (2001), Agnew et al. (2003), Huberman and Sengmuller (2004), and Meulbroeck (2005).

composition skills have improved. We do not find evidence of diversification improvement by active means, where investors select less correlated stocks.

In the cross-section, we find that the degree of diversification varies considerably across households. Diversification level increases with age, income, wealth, and education. We also find that relatively more sophisticated investors – investors who trade options, engage in short-selling, and have greater investment experience – hold relatively better diversified portfolios. The variation in the degree of diversification across occupation categories also indicates that diversification increases with sophistication. Investors who belong to the non-professional job category hold the least diversified portfolios, while retired investors hold the most diversified portfolios. Furthermore, investors are consistent in their diversification choices. Investors who hold mutual funds and foreign equities also exhibit a greater propensity to diversify using domestic stocks.

The diversification decisions of investors are also correlated with their affinity for certain stock characteristics and with patterns of trading and investment that are consistent with behavioral biases. Specifically, we find that investors who over-weight certain industries or stocks with greater volatility and skewness hold relatively less diversified portfolios. Moreover, investors who trade excessively and earn lower returns, tilt their portfolios toward local stocks, and are sensitive to past price trends exhibit greater under-diversification.

The unexpectedly high idiosyncratic risk in investor portfolios results in a welfare loss as measured by the Sharpe ratio of individual portfolios. This evidence in itself is not very surprising. More surprising is our finding of significant differences in the portfolio alphas. The least diversified (lowest decile) group of investors earns 2.40% lower return annually than the most diversified group (highest decile) of investors on a risk-adjusted basis. The economic cost of under-diversification is higher for the group of older investors, where the risk-adjusted performance differential between the least diversified and the most diversified investors is 3.12%. The alpha estimates indicate that better diversified investors are likely to have better stock selection abilities, perhaps due to their higher levels of financial sophistication.

Most surprisingly, we find that high-turnover, under-diversified portfolios perform better than high-turnover, better-diversified portfolios. Among active (highest turnover quintile) investors, we find that, relative to the group of better diversified investors, less diversified investors have a higher characteristic-adjusted return (0.26 versus 0.13), higher Jensen's alpha ( $-0.17$  versus  $-0.37$ ), and higher four-factor alpha ( $-0.18$  versus  $-0.33$ ). This evidence indicates that a small, active group of under-diversified investors might be skilled.

The rest of the paper is organized as follows: In the next section, we provide evidence of under-diversification. In Section 3, we document the investor characteristics and behavioral patterns associated with under-diversification. In Section 4, we estimate the economic costs of under-diversification and in Section 5 we conclude.

## 2. Evidence of Under-Diversification

### 2.1 DIVERSIFICATION MEASURES

We use three related diversification measures to capture the extent of under-diversification in individual investors' portfolios. The first measure is the normalized portfolio variance ( $NV$ ), which is obtained by dividing the portfolio variance by the average variance of stocks in the portfolio:

$$NV = \frac{\sigma_p^2}{\bar{\sigma}^2}. \quad (1)$$

The covariance matrix is estimated using the past five years of monthly returns data.<sup>2</sup> The  $NV$  measure indicates that portfolio variance can be reduced by increasing the number of stocks in the portfolio or by a proper selection of stocks such that the average covariance (or correlation) among stocks in the portfolio is lower. Variance reduction through active and proper stock selection reflects "skill" in portfolio composition, while addition of stocks in the portfolio without lowering the average portfolio correlation is likely to reflect "portfolio breadth" (Goetzmann et al., 2005).

The diversification level of a portfolio can also be measured as its deviation from the market portfolio (Blume and Friend, 1975). The weight of each security in the market portfolio is very small. Thus, the diversification measure can be approximated as the sum of squared portfolio weights ( $SSPW$ ):

$$SSPW = \sum_{i=1}^N (w_i - w_m)^2 = \sum_{i=1}^N \left( w_i - \frac{1}{N_m} \right)^2 \approx \sum_{i=1}^N w_i^2, \quad (2)$$

where  $N$  is the number of securities held by the investor,  $N_m$  is the number of stocks in the market portfolio,  $w_i$  is the portfolio weight assigned to stock  $i$  in the investor portfolio, and  $w_m$  is the weight assigned to a stock in the market portfolio ( $w_m = 1/N_m$ ). A lower value of  $SSPW$  reflects a higher level of diversification.

Last, we use the total number of stocks in the portfolio as a "crude" measure of diversification:

$$NSTKS = N. \quad (3)$$

This diversification measure is commonly used, but it often overstates the level of diversification (Blume et al., 1974).

### 2.2 INDIVIDUAL INVESTOR DATABASE

The primary data for the empirical investigation consist of trades and monthly portfolio positions of retail investors at a major U.S. discount brokerage house for

<sup>2</sup> Stocks with less than two years of monthly returns data are excluded from the analysis.

the 1991 to 1996 period. There are 77,995 households in the database, but we focus on the 62,387 investors who trade stocks. More than half of the households in our sample have two or more accounts. All accounts for a given investor are combined to obtain a portfolio at the household level, where we only consider directly held equities. An average investor holds a four-stock portfolio (median is three) with an average size of \$35,629 (median is \$13,869). For a subset of households, demographic information such as age, income, location (zip code), total net worth, occupation, marital status, family size, gender, etc. is available. Further details about the investor database are available in Barber and Odean (2000).

To benchmark our individual investor sample to the overall population of individual investors in the U.S., we compare the stock holdings of our sample with those reported by the Federal Reserve (Survey of Consumer Finances (SCF), 1992, 1995).<sup>3</sup> According to the 1992 SCF, a typical household held \$63,143 in stocks (median of \$11,000). The stock ownership increased in the 1995 SCF to \$90,571 in stocks (median of \$14,500). The median portfolio size of an investor in our sample is \$13,869, which is similar to the median portfolio sizes reported in the SCF. Overall, the portfolio size of investors in our sample appears to be reasonably representative of the portfolios of U.S. households.<sup>4</sup>

In addition to the individual investor data, we use other standard data sets. For each stock in the sample, we obtain monthly prices, returns, and market capitalization data from the Center for Research in Security Prices (CRSP) and quarterly book value of common equity data from COMPUSTAT. We obtain the monthly time-series of the three Fama-French factors and the momentum factor, monthly returns of various size and B/M portfolios, and the monthly New York Stock Exchange (NYSE) size break-points and B/M break-points from Professor Kenneth French's data library.<sup>5</sup>

### 2.3 PORTFOLIO DIVERSIFICATION: SUMMARY STATISTICS

To set the stage, we examine the correlations among the three diversification measures. The correlation estimates vary between 0.531 and 0.639, which indicates that, although the three measures are related, they capture different characteristics of investor portfolios. Furthermore, we find that, holding the number of stocks in a portfolio fixed, there is considerable cross-sectional variation in the *NV* measure.

<sup>3</sup> See Kennickell et al. (1997) for details on the SCF data.

<sup>4</sup> See Ivković et al. (2005) and Ivković et al. (2007) for additional discussion on the representativeness of the individual investor data.

<sup>5</sup> The data library is available at <http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/>.

Table I. Aggregate Level Diversification Measures: Summary Statistics

This table reports the aggregate level diversification statistics of investor portfolios for each of the six years in the sample period. Panel A reports the percentage of investor portfolios holding a certain number of stocks, Panel B reports the mean normalized variance for portfolios with different number of stocks, and Panel C reports the mean average correlation among stocks in portfolios with different number of stocks. The normalized variance ( $NV$ ) of a portfolio is the ratio of portfolio variance and the average variance of stocks in the portfolio. The covariance matrix is estimated using past five years of monthly returns data. The individual investor data are from a large U.S. discount brokerage house for the period from 1991 to 1996.

Num of Stocks	1991	1992	1993	1994	1995	1996	1991–96
Panel A: Percentage of Portfolios							
1	33.02	29.71	27.88	27.06	26.75	25.50	28.20
2	20.55	19.60	18.65	17.91	17.99	17.37	18.59
3	13.51	13.59	13.14	13.03	12.50	12.01	12.90
4	8.86	9.20	9.50	9.46	9.36	9.30	9.22
5	6.11	6.55	6.87	6.87	6.70	6.59	6.57
6–10	12.36	14.49	15.56	16.26	16.81	17.40	15.36
11–15	3.28	3.93	4.80	5.18	5.30	6.13	4.72
Over 15	2.31	2.93	3.59	4.23	4.59	5.70	4.44
Panel B: Normalized Portfolio Variance							
2	0.645	0.612	0.601	0.589	0.570	0.563	0.597
3	0.508	0.470	0.459	0.443	0.417	0.407	0.451
4	0.441	0.397	0.385	0.366	0.337	0.329	0.376
5	0.396	0.347	0.338	0.322	0.293	0.278	0.329
6–10	0.355	0.300	0.291	0.267	0.234	0.218	0.278
11–15	0.309	0.246	0.239	0.217	0.182	0.163	0.226
Over 15	0.291	0.224	0.220	0.192	0.151	0.130	0.201
Panel C: Average Correlation Among Stocks in the Portfolio							
2	0.323	0.251	0.228	0.203	0.160	0.146	0.218
3	0.312	0.250	0.231	0.203	0.157	0.143	0.216
4	0.314	0.251	0.233	0.202	0.154	0.143	0.216
5	0.314	0.246	0.231	0.202	0.158	0.139	0.215
6–10	0.325	0.259	0.245	0.210	0.161	0.139	0.223
11–15	0.329	0.260	0.249	0.214	0.165	0.140	0.226
Over 15	0.341	0.271	0.264	0.224	0.168	0.143	0.235

This evidence indicates that a diversification measure that ignores correlations is likely to provide biased estimates.

Table I reports annual statistics for the three diversification measures. In any given month, only 5–10% of the portfolios contain more than ten stocks (see Panel A). In fact, more than 25% of investor portfolios contain only one stock, more than 50% contain one to three stocks, and more than 70% of households hold

five or fewer stocks. These stock-holding estimates are broadly consistent with the evidence in related studies that examine diversification levels of U.S. household portfolios using data from other sources (e.g., Blume and Friend, 1975; Kelly, 1995; Polkovnichenko, 2005).

Table I, Panel B reports the normalized variance ( $NV$ ) statistics. As expected, the normalized variance decreases as the number of stocks in the portfolio increases. The  $NV$  of concentrated portfolios is roughly three to four times the  $NV$  of better-diversified portfolios. For example, in 1996, the  $NV$  of better-diversified portfolios with 11 to 15 stocks is 0.163, while concentrated portfolios with only two stocks, on average, have an  $NV$  of 0.407. We also compute the average correlation among the stocks in investor portfolios (see Table I, Panel C) and find that it does not vary significantly across portfolios with different numbers of stocks.<sup>6</sup> These summary statistics indicate that the level of portfolio diversification varies in the cross-section, but investors' portfolio composition skills remain invariant.

#### 2.4 INVESTOR PORTFOLIOS RELATIVE TO BENCHMARK PORTFOLIOS

To further quantify the level of under-diversification, we compare investors' portfolios with two benchmark portfolios: (i) the market portfolio (the S&P500 index), and (ii) a large number of randomly constructed portfolios.<sup>7</sup> The market portfolio represents the risk-return trade-off investors could have achieved by following the prescriptions of the CAPM, and the set of random portfolios represent the risk-return trade-off achieved by a "naive" investor, who might randomly select stocks. These benchmark portfolios represent a "minimum" level of risk-return trade-off an investor portfolio should achieve.

Figure 1 shows the positions of investor portfolios relative to the market portfolio and the capital market line (CML) in the mean-standard deviation ( $\mu$ - $\sigma$ ) plane. We arbitrarily choose two monthly time-periods in the first half of the sample period (February 1991 and June 1993) and two monthly time-periods in the second half of the sample period (September 1995 and June 1996). We use the past five years of monthly returns data to estimate the means and the standard deviations of the market portfolio and investor portfolios. The risk-free rate corresponds to the 90-day T-Bill rate.

We find that only a small fraction of investor portfolios are above the capital market line. For instance, in February 1991, only 9.53% of the portfolios are above the CML, and in June 1996, 13.96% of the portfolios are above the CML. Even in other months, only a small fraction of investor portfolios are above the CML. Overall, the graphical evidence indicates that most portfolios have significantly higher

<sup>6</sup> The results in Panels B and C are similar when we compute value-weighted diversification measures, where portfolio size is used to obtain the weights.

<sup>7</sup> We thank John Campbell for suggesting the S&P500 index benchmark.

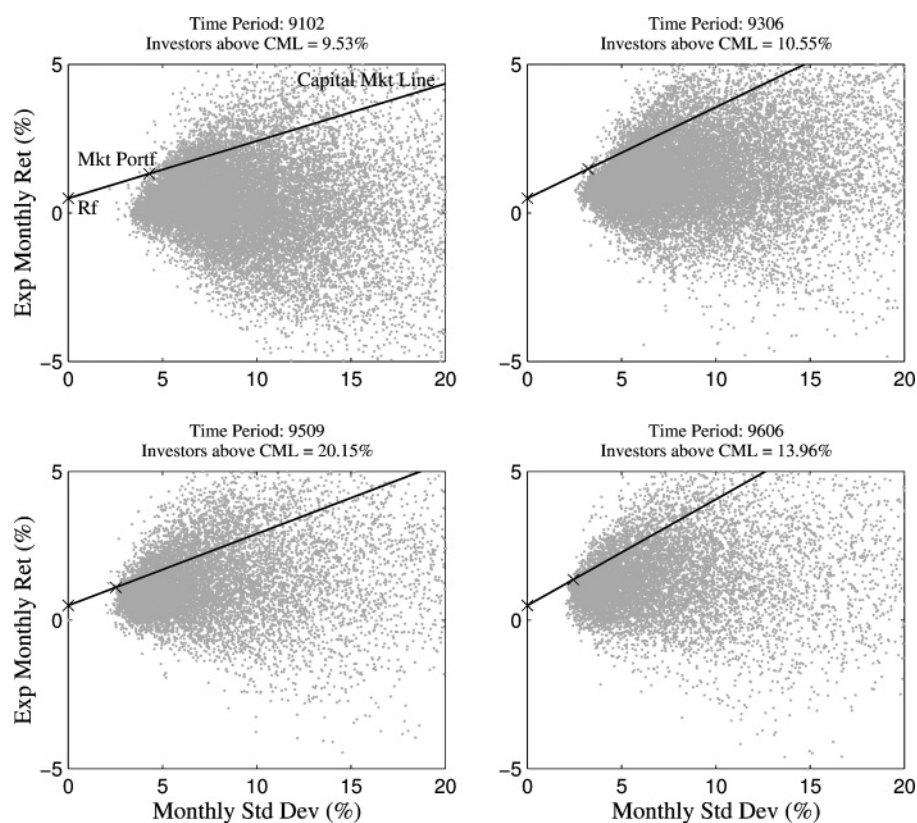


Figure 1. Investor portfolios relative to the market portfolio. This figure shows the positions of investor portfolios relative to the market portfolio (and the Capital Market Line). We arbitrarily choose two monthly time periods in the first half of the sample period (February 1991 and June 1993) and two monthly time periods in the second half of the sample period (September 1995 and June 1996). The past five years of monthly returns data are used to estimate the means and the standard deviations of the market portfolio and investor portfolios. The risk-free rate corresponds to the 90-day T-Bill rate. The individual investor data are from a large U.S. discount brokerage house for the period from 1991 to 1996.

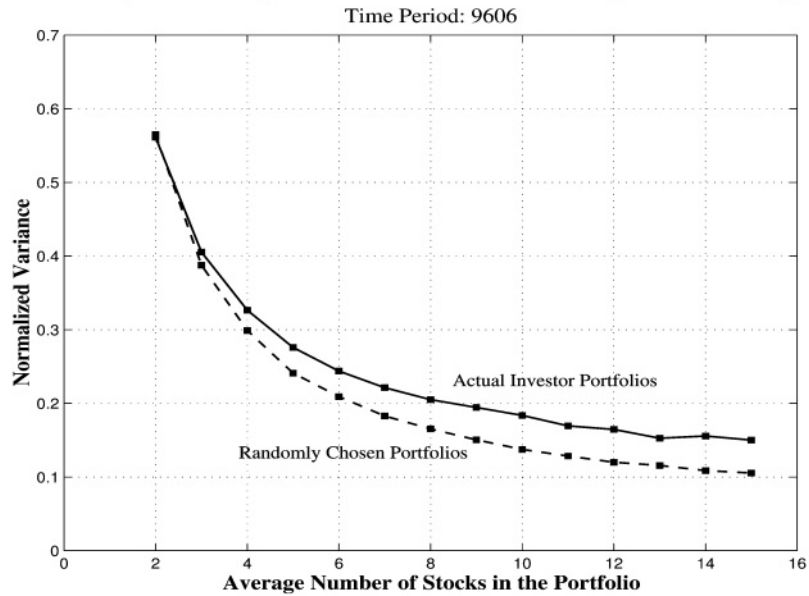
volatility levels relative to the market portfolio, and investors are not compensated for their higher risk exposures.<sup>8</sup>

For a more accurate comparison between the volatilities of the actual investor portfolios and the market portfolio, in Figure 2, Panel A, we plot the rolling volatility (using a 12-month window) of the market portfolio along with the rolling volatility statistics (25<sup>th</sup> percentile, median, and 75<sup>th</sup> percentile) of investor portfolios. The plot shows that, in any given time period, more than 75% of investor portfolios have

<sup>8</sup> When we examine the *realized* performance of investor portfolios during the sample-period, we find that the degree of inefficiency is even greater. Only 4.01% of portfolios are above the CML.



Panel A: Volatility of investor portfolios relative to the volatility of the market portfolio.



Panel B: Normalized variance of investor portfolios relative to randomly chosen portfolios.

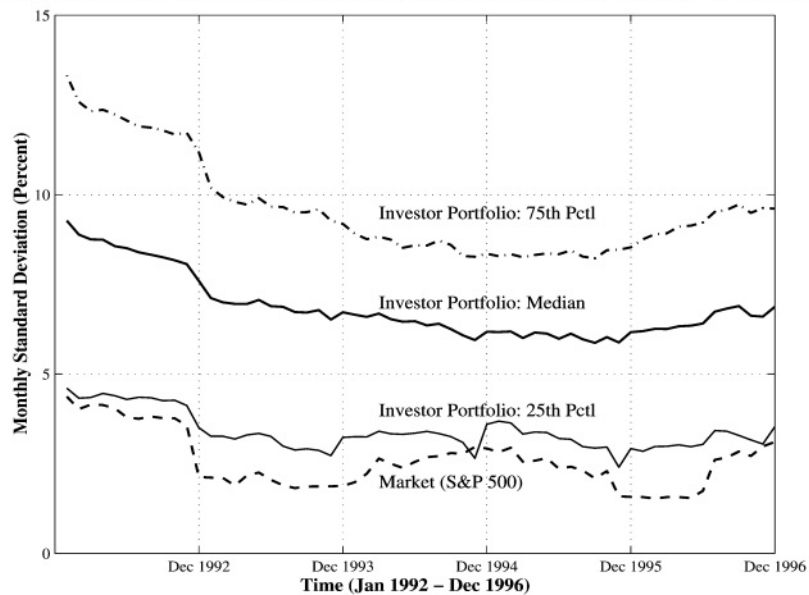


Figure 2. Diversification level relative to benchmark portfolios. Panel A shows selected volatility statistics of investor portfolios and the volatility of the market portfolio using a 12-month rolling window. Panel B shows the normalized variance of actual investor portfolios and 2,000 randomly constructed portfolios (the benchmark portfolios) during the month of June 1996. The individual investor data are from a large U.S. discount brokerage house for the period from 1991 to 1996.

greater volatility than the market portfolio. Even accounting for the likelihood that we have selected a group of speculators, the evidence of such high volatility levels in investor portfolios is quite surprising.

To obtain another perspective on the attained levels of diversification, we compare the variance of observed investor portfolios with the variance of randomly constructed matching portfolios. For this comparison, we construct several sets of portfolios, each set containing 2,000  $k$ -stock portfolios, where  $k = 2, \dots, 15$ . The average diversification measures of these randomly chosen sets of portfolios are compared to the average diversification levels of matching investor portfolios.

Again, we find that investor portfolios have relatively higher risk exposures. Figure 2, Panel B shows the average normalized variance of investor portfolios of different sizes relative to the matching benchmark portfolios in the month of June 1996. We find evidence of *systematic* under-diversification. The mean normalized variance of investor portfolios is approximately 25% higher than the mean normalized variance of benchmark portfolios, and this difference increases with the average size of investor portfolio. This finding indicates that, in terms of their risk-return characteristics, actual investor portfolios are worse than even those portfolios that provide a lower bound on the attainable risk-return trade-off.

## 2.5 DIVERSIFICATION CHANGES THROUGH TIME

Although we have a relatively short six-year sample period, the time-series of the average level of diversification reveals interesting patterns. We find that during the 1991 to 1996 period, the average number of stocks in investor portfolios increases almost monotonically from 4.28 in 1991 to 6.51 in 1996 – an increase of almost 48% (see Table II, Panel A). Furthermore, the normalized portfolio variance steadily decreased from 0.47 in 1991 to 0.31 in 1996 – a decrease of more than 34%. These two observations seem to imply that the portfolio composition skills of investors have improved over time.

However, when we compare investors' portfolios to a benchmark of randomly constructed matching portfolios, we find that the average risk exposures of investor portfolios are significantly higher than those of matching benchmark portfolios. In fact, during the sample period, the mean excess normalized variance relative to benchmark portfolios increased from 44.14% in 1991 to 67.80% in 1996.

This evidence indicates that, to a large extent, the observed improvements in the diversification characteristics of investor portfolios result from changes in the correlation structure of the U.S. equity market and do not reflect investors' improved abilities to construct better diversified portfolios.<sup>9</sup> Our evidence of skill

<sup>9</sup> The portfolios of both the "original" (i.e., investors who were in the sample at the beginning of the sample period) as well as the "new" investors (i.e., investors who entered the sample after January 1991) exhibit diversification improvements, where the effects are stronger for the latter group.

Table II. Time Variation in Portfolio Diversification

This table reports the actual and the expected aggregate level diversification measures for each of the six years in the sample period. Three diversification measures are reported: (i) number of stocks in the portfolio (*NSTKS*), (ii) sum of squared portfolio weights (*SSPW*), and (iii) normalized portfolio variance (*NV*). The normalized variance of a portfolio is the ratio of portfolio variance and the average variance of stocks in the portfolio. The covariance matrix is estimated using past five years of monthly returns data. The expected values of *NV* and average portfolio correlation are computed using a set of random portfolios – each month, 2,500 investor portfolios are randomly chosen and each stock in each of these portfolios is replaced by a randomly chosen stock. The portfolio weights are kept fixed. Panel A reports the means for all investors, while Panel B reports the results for only those investors who were present at the beginning of the sample period (January 1991). The Kolmogorov-Smirnov test is used to examine the statistical significance of the difference in diversification measures. \* and \*\* denote significance at the 5% and 1% levels, respectively. The individual investor data are from a large U.S. discount brokerage house for the period from 1991 to 1996.

Diversification Measure	1991	1992	1993	1994	1995	1996	1996–1991 (%)
Panel A: Diversification Measures of All Investors							
Number of Stocks	4.28	4.79	5.25	5.54	5.63	6.32	47.64**
Sum of Squared Portfolio Weights	0.558	0.519	0.495	0.485	0.476	0.468	–16.19**
Normalized Variance	0.470	0.411	0.390	0.363	0.325	0.309	–34.24**
Average Correlation	0.319	0.251	0.234	0.201	0.151	0.137	–57.03**
Expected Normalized Variance	0.327	0.262	0.257	0.233	0.197	0.184	–43.78**
Expected Average Correlation	0.170	0.141	0.139	0.118	0.092	0.085	–50.15**
Excess Normalized Variance (%)	44.14**	56.75**	51.77**	56.21**	64.90**	67.80**	
Excess Average Correlation (%)	87.24**	77.60**	68.08**	70.75**	63.39**	61.69**	
Panel B: Diversification Measures of January 1991 Investors Only							
Number of Stocks	3.82	4.30	4.67	4.93	4.92	5.53	44.80**
Sum of Squared Portfolio Weights	0.601	0.568	0.550	0.538	0.523	0.524	–12.86**
Normalized Variance	0.480	0.421	0.403	0.379	0.338	0.329	–31.41**
Average Correlation	0.318	0.250	0.234	0.206	0.155	0.142	–55.23**
Expected Normalized Variance	0.327	0.262	0.257	0.233	0.197	0.184	–43.78**
Expected Average Correlation	0.170	0.141	0.139	0.118	0.092	0.085	–50.15**
Excess Normalized Variance (%)	47.32**	60.62**	57.04**	63.27**	71.38**	78.90**	
Excess Average Correlation (%)	86.33**	76.85**	68.58**	74.91**	67.35**	67.62**	

deterioration is consistent with the findings in Biliias et al. (2005), who show that the spread of “equity culture” attracts less sophisticated investors and lowers the average skill of investors in the market.

We also compare the average correlation of investor portfolios with a set of randomly chosen benchmark portfolios. Each month, we form 2,000 portfolios containing up to ten stocks by selecting stocks randomly from the set of stocks in the sample. Using the historical monthly returns, we compute the average correlation among stocks in each of these portfolios. We obtain the average monthly

correlation by averaging the average correlations of the randomly chosen portfolios. As expected, we find that the average correlations for both actual and random portfolios decrease during the sample period. However, the average return correlation in the observed investor portfolios is higher than the average correlation in randomly constructed portfolios. For instance, the average correlation differential is 87.24% in 1991 and 61.69% in 1996. Again, these results indicate that investors' portfolio composition skills have not improved over time.

## 2.6 ARE RETIREMENT PORTFOLIOS BETTER DIVERSIFIED?

Many investors in our sample hold personal retirement accounts. About 42% of the accounts in our sample are retirement accounts (IRA or Keogh).<sup>10</sup> In this section, we examine whether investors hold better diversified retirement portfolios. Specifically, we compare the portfolios of investors who hold only retirement accounts with those who hold only non-retirement accounts.

We find that the degree of under-diversification is higher among retirement portfolios. For instance, within large (top quintile) portfolios, investors who hold only retirement accounts hold an average of 6.77 stocks in their portfolios, while investors with only non-retirement accounts hold an average of 8.81 stocks. The normalized variance of their respective portfolios is 0.357 and 0.389, and in both cases, the diversification differentials are statistically significant at the 5% level. Even when we compare the retirement and non-retirement portfolios of investors who hold both types of accounts, we find that retirement accounts are relatively less diversified. A typical retirement account holds an average of 2.5 stocks, while a non-retirement account contains an average of 3.6 stocks.

These results echo the findings from previous studies (e.g., Benartzi, 2001; Benartzi and Thaler, 2001; Agnew et al., 2003; Huberman and Sengmuller, 2004) that provide evidence of under-diversification in retirement accounts. What is new in our evidence is the relative diversification levels of retirement and non-retirement accounts.

## 2.7 ARE WE ANALYZING INVESTORS' "PLAY ACCOUNTS"?

Our evidence of under-diversification is robust. Nevertheless, one might argue that our under-diversification estimates are noisy because the brokerage portfolios represent investors' "play money" accounts meant primarily for gambling and entertainment purposes. The bulk of their real investments, including their retirement

<sup>10</sup> There are 158,031 accounts in our sample, which includes 64,416 IRA and 1,299 Keogh accounts. A typical household holds multiple accounts. Out of 77,995 households in the sample, 43,706 hold at least one retirement account.

accounts, may be held elsewhere and cannot be observed. This seems quite unlikely for several reasons. First, as mentioned in the previous section, about 42% of accounts in our sample are retirement accounts (IRA or Keogh), and investors are unlikely to use their retirement accounts as “play money” accounts.

Second, we find that the average portfolio size to annual income ratio (*SIR*) is 0.79. In other words, a typical equity portfolio in the sample is roughly 79% of the annual income of an investor. Furthermore, the *SIR* is considerably higher for lower income groups. For example, the *SIR* is 3.62 for investors who earn less than \$15,000 per year and 1.79 for investors with annual income between \$20,000 and \$30,000. We also examine the size of investor portfolios relative to their self-reported net worth. The mean portfolio size to net-worth ratio is 0.322 (median is 0.127) for the entire sample, which indicates that a typical equity portfolio in the sample is roughly 32% of an investor’s total net worth. The ratio is slightly higher for low income investors (investors with annual income < \$40,000), where the mean ratio is 0.347 (median is 0.154). But even among high income investors, the equity portfolio is roughly 30% of their total net worth.

Based on these comparisons, it seems unlikely that our evidence of under-diversification reflects the speculative nature of investors’ “play money” accounts. While it is likely that some portfolios in the sample represent play money accounts, especially those of high-income households, most portfolios represent serious investment accounts.

### 3. Correlates of Portfolio Diversification

Are investors aware of the benefits of diversification but yet choose to hold under-diversified portfolios? Or, are the observed levels of under-diversification more strongly correlated with measures of financial sophistication and behavioral biases? In this section, we identify the factors that are strongly correlated with the level of portfolio diversification.

#### 3.1 THEORETICAL MOTIVATION

Traditional portfolio theory posits that high transaction costs (e.g., Brennan, 1975), high search costs (e.g., Merton, 1987), small portfolio size, and investors’ inability to buy in round lots could prevent investors from diversifying appropriately. Under-diversification can also stem from a belief that any multiple-stock portfolio, irrespective of its covariance structure, will be well-diversified. Similarly, investors could adopt an “erroneous” diversification strategy where they hold stocks with lower volatility and ignore correlations among them.

Investors' attraction to certain types of stocks could be correlated with the level of portfolio diversification. For instance, under-diversified investors may over-weight stocks from certain categories or styles (e.g., small-cap stocks, growth stocks, etc.) or certain industries (e.g., technology stocks), or they might prefer stocks with higher variance and positive skewness (e.g., Simkowitz and Beedles, 1978; Golec and Tamarkin, 1998; Polkovnichenko, 2005; Barberis and Huang, 2007).

Furthermore, lack of diversification could be related to various psychological factors and behavioral biases. First, investors could ignore correlations (e.g., Kroll et al., 1988; Kroll and Levy, 1992) if they adopt the availability heuristics (Tversky and Kahneman, 1973) or follow price trends (e.g., Odean, 1999; Dhar and Kumar, 2001). In addition, people who frame their investment decisions narrowly (e.g., Kahneman and Lovallo, 1993; Barberis et al., 2006; Kumar and Lim, 2008) would ignore the interactions among their individual stock selection decisions and might be insensitive to correlations among the stocks in their respective portfolios.<sup>11</sup> Alternatively, investors could take correlations into account, but they might misestimate the strength of correlations.

Second, investors who are over-confident about the accuracy of their private information or in their ability to interpret their private information (e.g., Odean, 1999) would intentionally choose to hold focused and under-diversified portfolios. And third, investors might prefer to invest in stocks they are familiar with (e.g., local stocks, employer stock, etc.), and this preference for the familiar (e.g., Grinblatt and Keloharju, 2001; Huberman, 2001; Zhu, 2002) could be correlated with the level of portfolio diversification.

Some investors might hold under-diversified portfolios for informational reasons. It is possible that some investors possess useful, time-sensitive information about a few stocks, and they would optimally choose to hold an under-diversified portfolio containing only those stocks. Additionally, due to limitations in investors' information processing abilities, they could optimally choose to gather information about only a subset of assets or asset classes (Merton, 1987). In this setting, the costs associated with learning about assets or asset classes could induce under-diversification. These investors are likely to hold a layered financial portfolio consisting of a small, under-diversified stock portfolio and a relatively larger, well-diversified mutual fund portfolio.

With this motivation, in the following sections, we identify the key correlates of portfolio diversification. A potential limitation of our analysis is that we cannot convincingly establish a causal relation because both dependent and several independent variables are computed using investors' portfolio choices and trading decisions. We can only measure correlations and, whenever appropriate, we use

<sup>11</sup> Investors could ignore correlations for non-psychological reasons too. For instance, they might ignore or pay relatively less attention to correlations due to the sequential nature of the portfolio formation process.

economic reasoning to conjecture about the potential causal relation. It is also important to note that although our study is motivated by the extant psychological evidence, and we assign behavioral interpretations to various trade and position based measures, these are only proxies for behavioral biases. They do not accurately correspond to the definitions of these behavioral biases in the psychological literature.

### 3.2 SMALL PORTFOLIO SIZE AND TRANSACTION COSTS

To identify the key factors that are correlated with the level of portfolio diversification, we first focus on the role of two traditional measures. The most common traditional explanation for portfolio under-diversification posits that investors fail to diversify appropriately because they hold small portfolios. Moreover, high transaction costs would prevent investors from diversifying, especially if they hold smaller portfolios (e.g., Brennan, 1975; Goldsmith, 1976).

While it is true that smaller portfolios are relatively less diversified than larger portfolios, about 16% of investors with very small portfolios (portfolio size  $< \$5,830$ ) and roughly 10% of investors with moderate size portfolios ( $\$5,830 \leq$  portfolio size  $< \$10,560$ ) hold more than five stocks in their portfolios. This evidence shows that small portfolio size is unlikely to act as a barrier to proper diversification.

We also observe that less diversified investors trade more frequently and pay considerable transaction costs. The average annual trading cost for investors in our sample is 1.46% of their annual income. Using the brokerage data, Barber and Odean (2001) estimate that the average trading cost of active investors is 3.90% of their annual income. These transaction cost estimates indicate that investors in our sample pay considerable transaction costs but still fail to diversify appropriately.

### 3.3 INVESTOR DEMOGRAPHICS AND FINANCIAL SOPHISTICATION

Investors' attitude toward risk is likely to influence their diversification decisions. An investor with a high (low) tolerance for risk may hold a less (more) diversified portfolio. Previous studies (e.g., Blume and Friend, 1975; Morin and Suarez, 1983) suggest that risk aversion increases with age and wealth, which suggests that portfolio diversification would increase with age and income (wealth). Portfolio diversification could also increase with age because with experience, investors acquire more information about the market (E.G., King and Leape, 1987). At the same time, younger investors could be less diversified due to their over-confidence.

In addition to age and wealth, education level and financial sophistication are likely to influence investors' diversification decisions. The average correlation among stocks in investor portfolios could be high because investors do not fully

understand why diversification reduces portfolio risk. They might incorrectly believe that any multiple-stock portfolio, irrespective of its covariance structure, will be well-diversified. Alternatively, investors might adopt an “erroneous” diversification strategy where they hold stocks with lower volatility and ignore correlations among them. The evidence from experimental studies indicates that the insensitivity to correlations is greater among people who are financially less sophisticated (e.g., Kroll et al., 1988).

To examine the relation between investor sophistication and portfolio diversification, we assume that investors who engage in short-selling, trade options, and have greater investment experience are likely to be more sophisticated than the typical investor in the sample. We also assume that the amount of resources available to an investor and her education level are likely to be correlated with the degree of financial sophistication. Wealthier investors and those who hold professional jobs are likely to have access to better resources. With these assumptions, we use occupation, income (wealth), and investment experience as proxies for investor sophistication.

To examine whether investors are consistent in their diversification choices, we identify whether they hold mutual funds and foreign equities (ADRs, foreign stocks, and closed-end country funds). If investors are consistent in their choices, those who hold mutual funds and foreign stocks are also likely to exhibit a greater propensity to hold relatively better diversified domestic stock portfolios.

In our first set of tests, we define investor groups on the basis of (i) age, (ii) income, (iii) occupation, and (iv) financial sophistication, and measure the average diversification levels of investors in these groups. The results are reported in Table III. We find that all three diversification measures vary in a predictable manner with age and income. Older investors are more diversified than younger investors and high-income investors are better diversified than low-income investors. Furthermore, investors with greater experience hold better diversified portfolios.

In Table III, we also report the average diversification measures for three broad occupation categories: (i) professional, consisting of investors who hold technical or managerial positions, (ii) non-professional, consisting of investors who are blue-collar workers, sales and service workers, clerical workers, house-makers or students, and (iii) retired. We find that investors in the non-professional category hold the least diversified portfolios, while investors in the retired category fall on the other end of the diversification spectrum. They hold the most diversified portfolios. The average diversification level of the professional category falls between the other two.

Examining the portfolios of mutual fund holders and investors who hold foreign equities, we find that both groups hold relatively better diversified stock portfolios. For instance, investors who trade foreign equities hold an average of seven stocks (median is five) and they hold better diversified portfolios, even according to other



Table III. Investor Demographics, Sophistication, and Portfolio Diversification

This table reports the mean diversification measures of investor groups formed on the basis of age, income, occupation, financial sophistication, diversification motive, and investment experience. Three diversification measures are reported: (i) number of stocks in the portfolio (*NSTKS*), (ii) sum of squared portfolio weights (*SSPW*), and (iii) normalized portfolio variance (*NV*). The normalized variance (*NV*) of a portfolio is the ratio of portfolio variance and the average variance of stocks in the portfolio. The covariance matrix is estimated using past five years of monthly returns data. Age is the age of the head of the household and income is the total annual income of the household. The three occupation categories are defined as: (i) professional category, consisting of investors that hold technical or managerial positions, (ii) non-professional category, consisting of investors who are blue-collar workers, sales and service workers, clerical workers, house-wives or students, and (iii) the retired category. Short Sellers are investors who engaged in at least one short-sell during the sample period, Option Traders are investors who executed at least one option trade during the sample period, Holds Foreign investors are those who executed at least one foreign equity trade during the sample period, and Holds Mutual Funds investors are those who held mutual funds at least once during the sample period. Investment experience is defined as the time between brokerage account opening date and December 31, 1996. The individual investor data are from a large U.S. discount brokerage house for the period 1991 to 1996.

Group	NSTKS	SSPW	NV
<b>All Investors</b>	4.71	0.544	0.431
<b>Age</b>			
Below 45	3.80	0.588	0.450
45–65	4.67	0.539	0.426
Above 65	5.69	0.490	0.408
<b>Income</b>			
Below 40K	4.02	0.535	0.383
40–75K	4.84	0.513	0.379
Above 75K	5.04	0.505	0.378
<b>Occupation</b>			
Non-Professional	4.06	0.557	0.416
Professional	4.86	0.513	0.383
Retired	6.15	0.447	0.358
<b>Sophistication and Div Motive</b>			
Short Sellers	5.86	0.509	0.404
Option Traders	5.52	0.522	0.405
Holds Foreign	6.69	0.458	0.380
Holds Mutual Funds	5.77	0.486	0.399
Low Experience	4.07	0.580	0.452
Medium Experience	4.48	0.551	0.432
High Experience	5.74	0.490	0.403

diversification measures. Overall, the sorting results reveal that older, wealthier, more experienced, and financially sophisticated investors and those who exhibit a stronger propensity to diversify in other settings hold relatively better diversified stock portfolios.

### 3.4 STOCK CHARACTERISTICS AND UNDER-DIVERSIFICATION

Do a considerable number of investors hold under-diversified portfolios due to their attraction toward stocks with certain characteristics? For example, skewness-seeking investors could rationally choose to hold under-diversified portfolios. While diversification reduces portfolio variance, it reduces the skewness of the portfolio (e.g., Arditti, 1967; Simkowitz and Beedles, 1978; Conine and Tamarkin, 1981; Golec and Tamarkin, 1998). So, even if investors dislike variance, they might exhibit a greater propensity to hold under-diversified portfolios if they seek skewness.

To examine whether under-diversified investors over-weight certain types of stocks, we estimate stock-level Fama-MacBeth regressions using two diversification-based (low and high) group portfolios. The aggregate group portfolio is formed by combining the portfolios of all investors within the group. In these regressions, the excess weight assigned to a stock in the aggregate group portfolio is the dependent variable, and various stock characteristics are used as the independent variables.<sup>12</sup> Specifically, motivated by the specifications in previous studies (e.g., Bennett et al., 2003), we consider the following independent variables: total volatility, total skewness, market beta, firm size, stock price, book-to-market ratio, past one-month stock return, past twelve-month stock return, an S&P500 dummy, a dividend-paying stock dummy, and the monthly stock turnover rate.

The Fama-MacBeth estimates are reported in Table IV. To ensure that extreme values are not affecting our results, we winsorize all variables at their 0.5 and 99.5 percentile levels. The dependent and independent variables have been standardized so that each variable has a mean of zero and a standard deviation of one. We follow the Pontiff (1996) methodology to correct the Fama-MacBeth standard errors for potential higher order serial correlations. The regression estimates indicate that less diversified investors overweight stocks with higher volatility, higher market beta, higher skewness, and higher turnover. They also underweight larger, higher-priced stocks, value stocks, and dividend paying stocks. Overall, less diversified investors overweight riskier stocks and stocks with greater skewness. The systematic differences in the portfolio tilts of the two diversification-based investor groups suggest that stock characteristics could shape investors' portfolio diversification decisions.

### 3.5 BEHAVIORAL PROXIES

At least three psychological biases could be associated with investors' diversification choices. First, investors might hold under-diversified portfolios due to a

<sup>12</sup> The excess portfolio weight allocated to stock  $i$  in month  $t$  is given by:  $EW_{ipt} = \frac{w_{ipt} - w_{imt}}{w_{imt}} \times 100$ , where  $w_{ipt}$  is the actual weight assigned to stock  $i$  in group portfolio  $p$  in month  $t$  and  $w_{imt}$  is the weight of stock  $i$  in the aggregate market portfolio in month  $t$ .

Table IV. Stock Characteristics and Portfolio Diversification: Fama-MacBeth Regression Estimates

This table reports the Fama-MacBeth cross-sectional regression estimates for low and high diversification investor groups (quintiles), where the excess weight assigned to a stock in the aggregate group portfolio is the dependent variable. The excess portfolio weight allocated to stock  $i$  in month  $t$  is given by:  $EW_{ipt} = \frac{w_{ipt} - w_{imt}}{w_{imt}} \times 100$ , where,  $w_{ipt}$  is the actual weight assigned to stock  $i$  in group portfolio  $p$  in month  $t$  and  $w_{imt}$  is the weight of stock  $i$  in the aggregate market portfolio in month  $t$ . The low and high diversification groups are defined by sorting investors according to the normalized variance estimates of their portfolios. The normalized variance of a portfolio is the ratio of portfolio variance and the average variance of stocks in the portfolio. The covariance matrix is estimated using past five years of monthly returns data. The set of independent variables include: (i) total volatility, which is the variance of the daily stock returns in the previous six months, (ii) total skewness, which is the third moment of the daily stock returns in the previous six months, (iii) market beta, which is estimated using the previous six months of daily returns data, (iv) firm size, (v) stock price, (vi) book-to-market ratio, (vii) short-term momentum (past one-month stock return), (viii) longer-term momentum (past twelve-month stock return), (ix) an S&P500 dummy that is set to one if the stock belongs to the S&P500 index, (x) a dividend paying stock dummy that is set to one if the stock is a dividend paying stock during the previous year, and (xi) monthly stock turnover. We follow the Pontiff (1996) methodology to correct the Fama-MacBeth standard errors for potential higher order serial correlation. To ensure that extreme values are not affecting our results, we winsorize all variables at their 0.5 and 99.5 percentile levels. The dependent and independent variables have been standardized so that each variable has a mean of zero and a standard deviation of one. The  $t$ -statistics for the coefficient estimates are shown in smaller font below the estimates. The individual investor data are from a large U.S. discount brokerage house for the period from 1991 to 1996.

Variable	(1): Low	Portfolio Diversification	
		(2): High	(3): Low-High
Intercept	0.118 15.69	0.105 12.74	0.019 6.31
Total Volatility	0.125 11.34	0.057 9.11	<b>0.068</b> 5.07
Total Skewness	0.036 7.28	-0.031 -5.16	<b>0.071</b> 6.76
Market Beta	0.177 11.06	0.089 5.95	<b>0.092</b> 7.17
Firm Size	-0.197 -9.39	-0.084 -6.71	<b>-0.110</b> -7.04
Stock Price	-0.044 -5.91	-0.016 -5.54	<b>-0.032</b> -6.16
Book-To-Market Ratio	-0.165 -7.39	-0.080 -8.54	<b>-0.081</b> -6.79
Past 1-Month Stock Return	0.003 0.43	0.004 0.52	-0.001 -0.57
Past 12-Month Stock Return	-0.088 -6.11	-0.062 -6.39	-0.037 3.36
S&P500 Dummy	0.013 3.22	0.017 4.44	-0.016 -1.88
Dividend Paying Stock Dummy	-0.083 -9.42	-0.048 -5.18	<b>-0.038</b> 6.38
Monthly Turnover	0.087 8.42	0.042 8.35	<b>0.038</b> 5.59
Average Number of Stocks	1,987	1,987	1,987
Average Adjusted $R^2$	0.065	0.131	0.039

sense of over-confidence in their investment abilities. In experimental settings, it has been observed that when factors such as involvement, choice, and familiarity are introduced into chance situations, people begin to believe that they can control the outcome of those events. Similarly, when formulating their stock investment decisions, some investors could develop an illusory sense of control (e.g., Langer, 1975) because they are directly involved in the investment process and make their own choices instead of relying on others. An “illusion of control” could create an inappropriate level of over-confidence. Over-confident investors might choose not to diversify because they might mistakenly believe that they will earn superior performance by active trading.

To examine the overconfidence-diversification relation, we define an over-confidence proxy and examine whether it is correlated with portfolio diversification. The proxy is set to one for investors who are in the highest portfolio turnover quintile and lowest performance quintile, i.e., those investors who trade the most but attain the worst performance.

Second, a stronger propensity to hold local stocks could be correlated with the level of portfolio diversification. Several studies (e.g., Huberman, 2001; Zhu, 2002; Ivković and Weisbenner, 2005) indicate that individual investors exhibit a preference for local stocks. Familiarity with local stocks could exacerbate the illusion of control, and investors might fail to realize that more knowledge about the selected stocks does not necessarily imply control over the outcome (i.e., returns earned by the portfolio). Because of familiarity, investors might also perceive local stocks to be relatively less risky.<sup>13</sup> Motivated by these factors, some investors could hold under-diversified portfolios containing local stocks and/or employer stock.<sup>14</sup>

Last, investors with greater sensitivity to past price trends could hold less diversified portfolios. To examine whether investors with a higher sensitivity to past price trends are less diversified, we compute a trend score for each investor using the methodology developed in Dhar and Kumar (2001). A large negative trend score indicates a contrarian tendency (investors expect trends to reverse), while a large positive trend score indicates a trend-chasing tendency (investors expect trends to continue). The trend-following measure for an investor is defined as the absolute value of the trend score because we want to capture investors’ trend sensitivity, irrespective of its type. In the next section, we use a multivariate regression framework to examine whether behavioral bias proxies are strongly correlated with investors’ diversification choices.

<sup>13</sup> Previous studies (e.g., Heath and Tversky, 1991) find that people perceive gambles in familiar settings to be less risky.

<sup>14</sup> The local bias (LB) measure for an investor is defined as the proportion of her portfolio that is invested in stocks of firms located within a 250 mile radius from her location (zip code).

## 3.6 INVESTOR-LEVEL REGRESSION ESTIMATES

We estimate several investor-level cross-sectional regressions. In these regressions, the negative value of normalized variance of an investor portfolio is used as the dependent variable, and several household- and portfolio-level variables are used as explanatory variables. In the first regression specification, we use the following demographic characteristics as explanatory variables: investor's age, annual income, education, and occupation.<sup>15</sup> To examine whether investors make better diversification choices in their retirement accounts, we define a Retirement Account Dummy. This variable is set to one for investors who only hold retirement (IRA or Keogh) accounts.

The estimation results are presented in Table V (column 1). We find that diversification is positively related to Age (estimate = 0.117,  $t$ -stat = 10.80), Income (estimate = 0.035,  $t$ -stat = 4.61), and Education (estimate = 0.107,  $t$ -stat = 7.72). These coefficient estimates indicate that older, high-income (wealthy), and better educated investors are relatively better diversified.<sup>16</sup> The positive coefficient estimate of the Professional Dummy indicates that more sophisticated investors hold better diversified portfolios. And the negative coefficient estimate of the Retirement Account Dummy (estimate = -0.054,  $t$ -stat = -4.79) indicates that investors' retirement portfolios are relatively more concentrated.

In the second regression specification, we consider a set of variables that are likely to reflect consistency in investors' diversification choices and capture their levels of financial sophistication. Specifically, we use Investment Experience as an explanatory variable, which is defined as the number of days between the account opening date and December 31, 1996. In addition, we consider a Short-Sell Dummy, which is set to one if an investor executed at least one short-sell during the sample period, an Option Dummy, which is set to one if an investor made at least one trade in an option during the sample period, a Mutual Fund Dummy, which is set to one if an investor held a mutual fund in at least one month during the sample period, and a Foreign Dummy, which is set to one if an investor made at least one trade in a foreign asset (ADR, foreign stock, or a closed-end country fund) during the sample period. Last, to measure the industry tilt of investor portfolios, we compute the sample period average portfolio weights (or concentration) in 48 Fama-French industries (Fama and French, 1997) for each investor using their

<sup>15</sup> Because we do not have information about investors' education levels, we use the education level of the investor's zip code to proxy for her education level.

<sup>16</sup> The regression estimates are very similar when we use investors' self-reported Net Worth instead of Income as a proxy for wealth. When both Income and Net Worth variables are used, both variables have positive and significant coefficient estimates. We report the results with the Income measure because the income information is available for more investors.

Table V. Investor-Level Cross-Sectional Regression Estimates

This table reports the estimates of cross-sectional regressions, where the negative of the normalized variance ( $NV$ ) of a household is the dependent variable and a set of household and portfolio characteristics are used as independent variables. The normalized variance of a portfolio is the ratio of portfolio variance and the average variance of stocks in the portfolio. The covariance matrix is estimated using past five years of monthly returns data. Age is the age of the head of the household, Income is the total annual household income, and Education represents the proportion of people in investor's zip code that has attained a bachelor's or higher educational degree. The Professional and Retired dummy variables reflect investors' occupation. The professional dummy is set to one for investors who hold technical and managerial positions while retired dummy is set to one for investors who are retired. The remaining investors belong to the non-professional category, which consists of blue-collar workers, sales and service workers, clerical workers, house-makers, and students. The Retirement Account Dummy is set to one for investors who only hold retirement (IRA or Keogh) accounts. Several variables that capture an investor's level of financial sophistication and diversification motive are defined: (i) Investment Experience is the number of days between account opening date and December 31, 1996, (ii) Short-Sell Dummy that is set to one if an investor executed at least one short-sell during the sample period, and (iii) Option Dummy that is set to one if an investor made at least one trade in an option during the sample period, (iv) Mutual Fund Dummy that is set to one if an investor held mutual fund in at least one month during the sample period, (v) Foreign Dummy that is set to one if an investor made at least one trade in a foreign asset (ADR, foreign stock or a closed-end country fund) during the sample period, and (vi) Industry Concentration, which is defined as the largest industry weight in the investor portfolio. Among the behavioral bias proxies, the Overconfidence Proxy is set to one for an investor if she belongs to the highest portfolio turnover quintile and the lowest risk-adjusted performance quintile. Local Bias measure is defined as the proportion of investor portfolio that is invested in stocks of firms located within a 250 mile radius from her location (zip code). The Trend-Following Proxy is defined following Dhar and Kumar (2001) and measures the trend-following (trend-chasing or contrarian) tendencies of an investor. The Adjusted Disposition Effect variable is the difference between an investor's actual propensity to realize gains and the expected propensity to realize gains. The set of control variables includes: Portfolio Size, which is the sample-period average market capitalization, Portfolio Turnover, which is the average of the monthly buy and sell turnover rates, and Portfolio Dividend Yield, which is the sample-period average dividend yield of an investor's portfolio. Both independent and dependent variables have been standardized so that the coefficient estimates can be compared directly within a regression specification and also across various specifications. The individual investor data are from a large U.S. discount brokerage house for the period from 1991 to 1996.

	Regression Specification			
	(1)	(2)	(3)	(4)
Intercept	0.018 2.00	−0.010 −1.55	0.030 2.37	0.025 2.096
<b>Investor Characteristics</b>				
Age	0.117 10.80			0.057 4.04
Income	0.035 4.61			0.017 2.59

Table V. Investor-Level Cross-Sectional Regression Estimates (continued)

	Regression Specification			
	(1)	(2)	(3)	(4)
Education	0.107			0.075
	7.72			6.39
Professional Dummy	0.012			0.007
	2.06			1.47
Retired Dummy	0.030			0.008
	2.82			1.46
Retirement Account Dummy	−0.054			−0.046
	−4.79			−4.01
<b>Sophistication Proxies</b>				
Investment Experience		0.131		0.106
		15.39		8.92
Short-Sell Dummy		0.031		0.042
		4.42		3.21
Option Dummy		0.020		0.013
		2.44		2.22
Mutual Fund Dummy		0.083		0.072
		12.92		6.35
Foreign Dummy		0.202		0.193
		18.39		11.92
Industry Concentration		−0.136		−0.065
		−9.93		−5.35
<b>Behavioral Bias Proxies</b>				
Overconfidence Proxy			−0.093	−0.104
			−10.73	−8.55
Local Bias			−0.083	−0.054
			−9.23	−4.36
Trend-Following Proxy			−0.053	−0.043
			−5.93	−3.50
Adjusted Disposition Effect			0.055	0.041
			6.17	3.44
(Coefficient estimates of control variables have been suppressed.)				
Number of Investors	18,808	22,309	12,598	11,658
Adjusted $R^2$	0.028	0.092	0.032	0.137

end-of-month portfolio positions. The maximum value of the industry weights is used as a measure of portfolio's Industry Concentration.

The estimation results are presented in Table V (column 2). We find that the coefficient estimates of *Investment Experience* and the four dummy variables are positive and statistically significant, while *Industry Concentration* has a negative estimate. The exceptionally large coefficient estimate of *Foreign Dummy* is quite striking. It suggests that investors who are aware of the benefits of diversification invest abroad to reap the benefits of international diversification and they also hold better diversified domestic portfolios. The large negative estimate of

*Industry Concentration* indicates that investors who overweight a specific industry hold more concentrated portfolios. Overall, the estimates from the second specification indicates that financially sophisticated investors and those who are aware of the potential benefits of diversification hold relatively better diversified stock portfolios.

In the third regression specification, we examine whether our proxies for behavioral biases are correlated with the diversification decisions of investors. We consider an Over-confidence Proxy, a Local Bias measure, and a proxy for Trend-Following behavior. Additionally, to control for the possibility of inadvertent diversification due to the disposition effect (e.g., Shefrin and Statman, 1985; Odean, 1998), we use the Adjusted Disposition Effect of each investor as a control variable.<sup>17</sup> It is possible that when investors are more reluctant to sell their “loser” and exhibit a stronger disposition effect, they end up with a relatively diversified portfolio of losers.

The estimation results for the third specification are presented in Table V (column 3).<sup>18</sup> The negative signs on Over-confidence Proxy, Local Bias, and Trend-Following Proxy indicate that stronger behavioral biases are associated with lower levels of diversification. Furthermore, the Adjusted Disposition Effect variable has a positive and significant coefficient estimate, which indicates that a certain degree of diversification might be associated with investors’ reluctance to realize losses.

In the last regression specification, we consider the full set of explanatory variables. In addition, the following control variables are used: (i) Portfolio Size, which is the average market capitalization of the household portfolio during the sample-period, (ii) Portfolio Turnover, which is the average of the monthly buy and sell turnover rates, and (iii) the average Portfolio Dividend Yield of each investor’s portfolio.

The full specification estimation results are presented in Table V (column 4). In comparison to the estimates above, the new coefficient estimates differ in their magnitudes, but most estimates maintain their signs and significance levels in the full specification. Furthermore, the control variables have the expected signs. For instance, we find that larger portfolios are better diversified. While this effect could be mechanically induced, it is also likely that investors with larger portfolios apply more effort to properly diversify their portfolios. The Portfolio Turnover variable

<sup>17</sup> The adjusted disposition effect (ADE) measure for an investor is defined as the difference between an investor’s actual propensity to realize gains and the expected propensity to realize gains. A positive value of ADE indicates that a greater than expected proportion of winners is sold (or a smaller than expected proportion of losers is sold) and, thus, the investor exhibits the disposition effect. See Kumar and Lim (2008) for details of this measure.

<sup>18</sup> The number of observations is considerably lower for this specification because we need at least five sell trades to meaningfully estimate the adjusted disposition effect measure for an investor.



has a negative coefficient, which indicates that less diversified investors trade more frequently. This evidence is also consistent with the over-confidence-based interpretation of under-diversification. Collectively, the investor-level regression estimates indicate that investors' personal characteristics, their financial sophistication, their stock preferences, and their behavioral biases are strongly correlated with their propensity to diversify.

#### 4. Economic Costs of Under-Diversification

##### 4.1 DIVERSIFICATION LEVELS AND REALIZED PERFORMANCE STATISTICS

If under-diversified investors are taking large idiosyncratic risks for which they are not compensated appropriately, their portfolios would exhibit lower risk-adjusted performance. To examine the relation between portfolio diversification and portfolio performance, we consider two performance measures: (i) the mean monthly excess (relative to the market) portfolio return and (ii) the Sharpe ratio. Using the sample-period normalized variance ( $NV$ ), we rank investors and divide them into ten categories. Table VI reports the performance statistics for the ten diversification-sorted investor categories.

We find that as the level of diversification increases, both performance measures increase. For instance, the mean monthly excess portfolio return for decile 1 (decile 10) investors is  $-0.12\%$  ( $0.05\%$ ). On an annual basis, the most diversified investor group earns a  $2.04\%$  higher return than the least diversified investor group. The mean Sharpe ratio differential between the extreme diversification groups is also positive ( $= 0.08$ ). Because less diversified investors trade more frequently, these performance estimates indicate that the net returns earned by under-diversified investors are likely to be even lower. Consequently, the net performance differential between the least diversified and the most diversified investor groups is likely to be higher.

Given the relatively large idiosyncratic risk exposures of the less diversified investor group, we also find a greater number of extreme performers in this category. The standard deviations of the performance measures are higher in lower diversification deciles. For instance, the standard deviation of the mean monthly excess portfolio return measure is 1.74 for investors with the least diversified portfolios (decile 1), but only 0.80 for investors with the most diversified portfolios (decile 10). The 10<sup>th</sup> and the 90<sup>th</sup> percentile measures provide additional evidence of extreme performance in the less diversified investor groups. We find that in deciles one to five, more than a quarter of investors have negative Sharpe ratios. These investors earn lower returns than even the risk-free rate, while taking considerable risks.

Table VI. Economic Costs of Under-Diversification: Summary Statistics

This table reports the performance statistics for investor groups (deciles) formed by sorting on the portfolio diversification measure (normalized variance). The normalized variance ( $NV$ ) of a portfolio is the ratio of portfolio variance and the average variance of stocks in the portfolio. The covariance matrix is estimated using past five years of monthly returns data. The mean diversification measure for the 1991–96 sample period is used to define the investor groups. For each investor group, two performance measures are reported: (i) the mean monthly excess (relative to the market) portfolio return (Panel A) and the mean Sharpe ratio (Panel B). The sample period portfolio returns are used to compute the performance measures. For both performance measures, the following statistics are reported: mean, median, cross-sectional standard deviation, 25<sup>th</sup> percentile, 75<sup>th</sup> percentile, 10<sup>th</sup> percentile, and 90<sup>th</sup> percentile. The individual investor data are from a large U.S. discount brokerage house for the period from 1991 to 1996.

Div Decile	Mean	Median	Std Dev	25 <sup>th</sup> Pctl	75 <sup>th</sup> Pctl	10 <sup>th</sup> Pctl	90 <sup>th</sup> Pctl
Panel A: Monthly Excess (Relative to the Market) Return Statistics							
Low Div	−0.12	−0.18	1.74	−1.19	0.93	−2.34	2.17
D2	−0.10	−0.14	1.60	−1.09	0.90	−2.08	1.92
D3	−0.12	−0.19	1.55	−1.10	0.78	−2.03	1.90
D4	−0.10	−0.14	1.46	−1.02	0.76	−1.87	1.78
D5	−0.09	−0.17	1.34	−0.94	0.71	−1.74	1.64
D6	−0.04	−0.12	1.25	−0.87	0.69	−1.56	1.63
D7	−0.10	−0.17	1.16	−0.84	0.57	−1.52	1.48
D8	−0.01	−0.10	1.08	−0.72	0.63	−1.30	1.40
D9	0.00	−0.11	0.96	−0.63	0.54	−1.08	1.29
High Div	0.05	−0.07	0.80	−0.50	0.47	−0.83	1.13
Panel B: Sharpe Ratio Statistics							
Low Div	0.08	0.09	0.19	−0.03	0.21	−0.16	0.33
D2	0.09	0.09	0.17	−0.02	0.20	−0.12	0.31
D3	0.08	0.08	0.16	−0.03	0.19	−0.12	0.29
D4	0.09	0.09	0.15	−0.02	0.19	−0.11	0.28
D5	0.09	0.09	0.15	−0.01	0.19	−0.10	0.28
D6	0.10	0.10	0.14	0.00	0.20	−0.08	0.29
D7	0.10	0.10	0.14	0.01	0.19	−0.08	0.28
D8	0.11	0.12	0.13	0.02	0.21	−0.06	0.28
D9	0.13	0.12	0.13	0.04	0.21	−0.03	0.29
High Div	0.16	0.16	0.11	0.08	0.23	0.01	0.31

#### 4.2 CROSS-SECTIONAL VARIATION IN ECONOMIC COSTS

To examine whether the economic costs of under-diversification vary cross-sectionally, we first define investor groups by sorting on age, income, occupation, and trading frequency. We examine the cross-sectional performance differentials between the most diversified (highest quintile) and the least diversified (lowest quintile) categories of investors within these investor groups. We use the

Table VII. Cross-Sectional Variation in Economic Costs of Under-Diversification

This table reports the cross-sectional variation in the performance levels of less diversified and more diversified investor groups. Investors are independently sorted using their normalized portfolio variance measures and one of the following demographic characteristics: Age, income, occupation, and trading frequency. The age, income, and occupation categories are defined in Table III. The portfolio turnover measure, which is the mean of purchase and sales turnover, is used as a measure of trading frequency. The normalized variance ( $NV$ ) of a portfolio is the ratio of portfolio variance and the average variance of stocks in the portfolio. The covariance matrix is estimated using past five years of monthly returns data. Five performance measures are reported: (i) monthly portfolio return, (ii) Sharpe ratio, (iii) characteristic-adjusted return obtained using the Daniel et al. (1997) methodology, (iv) Jensen's alpha, and (v) four-factor alpha. \* and \*\* denote significance at the 10% and 5% levels respectively. The individual investor data are from a large U.S. discount brokerage house for the period from 1991 to 1996.

	Age			Income			Occupation			Turnover		
DIV	<45	45–65	>65	<40K	40–75K	>75K	NonProf	Prof	Retired	Low	Med	High
<b>Mean Monthly Return</b>												
Low	1.13	1.12	0.95	1.04	1.06	1.18	1.00	1.19	0.94	1.02	1.09	1.39
High	1.20	1.27	1.17	1.20	1.20	1.25	1.24	1.25	1.16	1.21	1.30	1.24
Diff	0.07	0.15*	0.22**	0.16*	0.14*	0.07	0.24**	0.06	0.24**	0.19**	0.21**	–0.15**
<b>Sharpe Ratio</b>												
Low	0.28	0.29	0.28	0.28	0.28	0.30	0.26	0.30	0.28	0.30	0.28	0.32
High	0.30	0.32	0.34	0.32	0.31	0.32	0.30	0.32	0.33	0.35	0.32	0.27
Diff	0.02	0.03*	0.06**	0.04*	0.03*	0.02	0.04**	0.02	0.05**	0.05**	0.04**	–0.05**
<b>Characteristic-Adjusted Return</b>												
Low	0.13	0.12	–0.07	0.01	0.09	0.18	0.04	0.20	–0.11	–0.07	0.08	0.26
High	0.11	0.15	0.01	0.13	0.10	0.17	0.18	0.13	0.01	0.05	0.20	0.13
Diff	–0.02	0.03	0.08	0.12*	0.01	–0.01	0.09*	–0.02	0.12*	0.12*	0.12**	–0.13**
<b>Jensen's Alpha</b>												
Low	–0.37	–0.35	–0.41	–0.40	–0.42	–0.31	–0.47	–0.32	–0.41	–0.38	–0.39	–0.17
High	–0.28	–0.22	–0.21	–0.20	–0.24	–0.25	–0.23	–0.24	–0.21	–0.18	–0.19	–0.37
Diff	0.09	0.13*	0.20**	0.20**	0.18**	0.06	0.24**	0.08	0.20**	0.20**	0.20**	–0.20**
<b>Four-Factor Alpha</b>												
Low	–0.21	–0.25	–0.44	–0.31	–0.33	–0.25	–0.37	–0.18	–0.42	–0.29	–0.23	–0.18
High	–0.19	–0.18	–0.16	–0.22	–0.19	–0.18	–0.21	–0.15	–0.23	–0.18	–0.13	–0.33
Diff	0.02	0.07	0.26*	0.09	0.14*	0.07	0.16**	0.03	0.19**	0.11*	0.10*	–0.15**

equal-weighted average returns of the investors in a group to obtain the group-level performance measure.

Table VII reports the group-level performance estimates. We find that the performance differentials between the extreme diversification categories are significantly positive within most investor groups. For instance, within the older investor group (Age > 65), the mean monthly return is 0.95% for the less diversified investors and 1.17% for the more diversified category of investors.

Surprisingly, we also find that within most investor groups, the alphas are higher for the better diversified investor category. When we consider all investors in the

sample, the less diversified investors earn 2.40% lower annual, risk-adjusted return than the more diversified group. The risk-adjusted performance differential is even higher for older investors, where the annual risk-adjusted performance differential is 3.12%. These performance differentials are likely to be higher after accounting for transaction costs because less diversified investors trade more frequently. Interpreting alpha as a measure of stock-picking ability, the performance comparisons indicate that better diversified investors have better stock-selection abilities. These results are consistent with our earlier findings, which indicate that relatively more sophisticated and more resourceful investors hold better diversified portfolios.

Most surprisingly, we find that high-turnover, under-diversified portfolios perform better than high-turnover, better-diversified portfolios. Among active (highest turnover quintile) investors, we find that, relative to the group of better diversified investors, less diversified investors have higher characteristic-adjusted return (0.26 versus 0.13), higher Jensen's alpha ( $-0.17$  versus  $-0.37$ ), and a higher four-factor alpha ( $-0.18$  versus  $-0.33$ ). This evidence suggests that a small, active group of investors who hold concentrated portfolios might have some investment skill.<sup>19</sup>

Overall, the cross-sectional performance estimates indicate that a small group of investors benefit from holding under-diversified portfolios, but the economic costs of under-diversification are significant for most investors. Consistent with previous studies (e.g., Brennan and Torous, 1999; Meulbroek, 2005), our results show that better portfolio diversification corresponds to higher risk-adjusted performance. Of course, most investors could have achieved even higher levels of performance by simply investing in one of the many available index funds.

The systematic under-performance of less diversified investors is somewhat puzzling. Why do those investors systematically accept lower returns? It is likely that these investors are optimizing along other dimensions that need not be consistent with return maximization. For instance, less diversified investors might "gamble" with high skewness stocks (e.g., Mitton and Vorkink, 2007; Kumar, 2007) or they might be driven by other motives such as bequest (e.g., Carroll, 2002).

## 5. Summary and Conclusion

This study examines the diversification choices of individual investors during a six-year period in recent U.S. capital market history. Using data from a large U.S. discount brokerage house, we find that investors in our sample are under-diversified, where under-diversification is greater in retirement accounts. Over time, the average diversification level improves, but the improved diversification does not necessarily imply that investors' portfolio composition skills have improved. To a large extent,

<sup>19</sup> In a related study, Ivković et al. (2007) find that among investors who hold large portfolios, investors with concentrated portfolios outperform investors who hold better diversified portfolios.

the improvements in the diversification characteristics of investor portfolios are induced by changes in the correlation structure of the U.S. equity market.

There is considerable heterogeneity in the diversification choices of individual investors. In the cross-section, older, wealthier, more experienced, and financially sophisticated investors and those who diversify with assets other than domestic stocks also hold relatively better diversified domestic stock portfolios. For instance, investors who hold mutual funds and foreign equities also hold better diversified domestic stock portfolios. In contrast, investors whose trading decisions are consistent with stronger behavioral biases exhibit greater under-diversification. Furthermore, investors who overweight certain specific industries or stock characteristics such as volatility and skewness are less diversified. In contrast, traditional factors such as small portfolio size and high transaction costs are not strongly correlated with investors' diversification choices.

The unexpectedly high idiosyncratic risk in investor portfolios results in a welfare loss. Examining the relation between diversification and performance, we find that some investors under-diversify because they might have superior private information. However, most investors could have improved the performance of their portfolios by simply investing in one of the many available passive index funds.

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