R^2: A Market-Based Measure of Portfolio and Mutual Fund Diversification*

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The ability to diversify a portfolio across a broad range of stocks leads to efficient risk-sharing, but how do investors know if they are well-diversified? There are many commonly accepted measures of corporate diversification, but measures of portfolio and mutual fund diversification are lacking. Barnea and Logue (1973) argue that R^2 from the market model regression is a measure of diversification. In this study, I evaluate R^2 as a valid measure of portfolio and mutual fund diversification. I provide evidence that diversified portfolios and diversified mutual funds have significantly higher R^2s than undiversified portfolios and undiversified mutual funds, respectively. With the complexities of portfolio theory and the varied educational backgrounds of stockholders, an unambiguous, objective, and easily calculated measure of diversification such as R^2 is of great value.

Introduction

According to the investments literature, the ability to diversify a portfolio across a broad range of stocks leads to efficient risk-sharing. Diversification enables investors to reduce those risks that bear no compensation without sacrificing expected returns. Today's volatile stock market reinforces the importance of diversification, and the enormous popularity of mutual funds exhibits investors' interest in being diversified. But how do investors know if they are diversified? In other words, how is the diversification of a portfolio measured? There are many commonly accepted measures of corporate diversification, such as the number of segments reported by management, the Herfindahl index, the entropy measure, and the number of SIC codes; however, measures of portfolio and mutual fund diversification are lacking.

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Hirshleifer and Riley (1992) note that "we have no handy rule for deciding when a portfolio may be considered well-diversified." (P 72) To fill this void, I examine the coefficient of determination as a possible measure of portfolio and mutual fund diversification.

Barnea and Logue (1973) argue that the coefficient of determination, R^2, from the market model regression is a measure of diversification because as R^2 increases, the more closely a portfolio's returns move with the market's returns. Wagner and Lau (1971) present evidence consistent with Barnea and Logue's belief when they find that the R^2 of a portfolio increases as the number of securities held in the portfolio increases. Arguing that diversification is increased by increasing the number of securities in a portfolio, Wagner and Lau conclude that a portfolio's R^2 increases as the portfolio's diversification increases. Barnea and Logue argue that the portfolio results can be generalized to a single security case where R^2 represents the market estimate of the diversification within a firm. When Barnea and Logue test their theory, however, they present results that are mixed and inconclusive.

In this study, I evaluate Barnea and Logue's argument that R^2 is a measure of diversification.[1] Because Barnea and Logue's results are inconclusive, and Wagner and Lau define portfolio diversification simply by counting the number of firms in a portfolio, I first examine R^2 as a measure of portfolio diversification. Instead of just adding securities to a portfolio as Wagner and Lau did, I analyze a more direct measure of portfolio diversification. I form 96 undiversified and diversified portfolios from a sample of firms that have only *one* Standard Industrial Classification code. Controlling for the number of firms in a portfolio, I provide evidence that the diversified portfolios have significantly higher R^2s than the undiversified portfolios. I also test if Barnea and Logue's theory can be extended to publicly quoted mutual funds by analyzing the R^2s of mutual funds. R^2 already appears to be a measure of importance in the mutual fund industry because industry players such as *Morningstar* and *Fidelity Investments* provide the R^2s of the mutual funds that they monitor. Neither defines R^2 as a measure of diversification or in terms of diversification. They define R^2 only in statistical terms. *Morningstar* notes that R^2 reflects the percentage of a fund's movements that is explained by movements in its benchmark index. *Fidelity Investments* defines R^2 as a measure of correlation between the portfolio and a benchmark index. Using the investment objective of a mutual fund supplied by *Barron's, Morningstar*, and *Fidelity Investments*, I find that diversified mutual funds

[1] Previous studies on portfolio diversification analyze the benefits of diversification and not measures of portfolio or mutual fund diversification. For example, Tole (1982), Statman (1987), Bierman (1980), Elton and Gruber (1977), Bierman (1978), and Evans and Archer (1968) analyze the relationship between the risk of a portfolio of securities and the number of securities held in that portfolio, and O'Neal (1997) studies the relationship between the risk of a portfolio of mutual funds and the number of mutual funds held in that portfolio.

have significantly higher R^2s than less-diversified specialty or sector funds. This study introduces another way to interpret R^2 of a mutual fund.

The great appeal of R^2 as a measure of portfolio and mutual fund diversification is its simplicity. The New York Stock Exchange (NYSE) reports that more than one-third of the shareowners have no more than a high school education (*Shareownership2000*). Statman (1987) and Rode (2000) note that individuals do not properly diversify their portfolios. Rode argues that portfolio diversification rarely occurs as recommended by portfolio theory because portfolio theory is too difficult for the average investor to understand. Thus, with the complexities of portfolio theory and the varied educational backgrounds of stockholders, a simple measure of diversification is of great value.[2] Today, with so many portfolios and mutual funds in existence, an unambiguous, objective, easily calculated, and intuitively appealing measure of diversification like R^2 is valuable to managers of portfolios, managers of mutual funds, and individuals who manage their own money.

Model: The Coefficient of Determination

Barnea and Logue argue that the coefficient of determination, R^2, from the market model regression is a measure of diversification because as R^2 increases, the more closely a firm's returns move with the market's returns. The coefficient of determination is from the market model regression, which is written as:

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + \varepsilon_{i,t}, \quad \varepsilon_{i,t} \text{ iid } N(0,\sigma^2) \tag{1}$$

where $R_{i,t}$ is the return on security i at time t, $R_{m,t}$ is the return on the market at time t, α_i and β_i are the parameters, and $\varepsilon_{i,t}$ is the error term of the model. Taking the variance of the above equation, the result is

$$\mathrm{Var}(R_{i,t}) = \beta_i^2 \mathrm{Var}(R_{m,t}) + \mathrm{Var}(\varepsilon_{i,t}), \tag{2}$$

or in qualitative terms,

$$\text{Total Risk} = \text{Systematic Risk} + \text{Unsystematic Risk.} \tag{3}$$

From equation (3), R^2 is systematic risk divided by total risk. Because R^2 is bound by 0 and 1, it is an intuitive meaningful numerical estimate of diversification.[3] Barnea and Logue note that an implication of the market model is that the degree of diversification is a direct function of the amount of unsystematic risk that remains in a combination of risky assets. For a perfectly diversified portfolio, R^2 is 1 and

[2] Fabozzi, Gupta, and Markowitz (2002), Fisher and Statman (1997), Rode (2000), and Zweig (1998) discuss the complexities of implementing portfolio theory.

[3] For any simple regression, the total sum of squares (SST) is equal to the regression sum of squares (SSR) plus the error sum of squares (SSE). R^2, which is equal to SSR/SST, is a measure commonly used to describe how well the sample regression line fits the observed data. When the portfolio's returns are regressed on the market's returns, the higher the R^2, the more closely the portfolio's returns move with the market's returns, where the market is a diversified collection of assets.

unsystematic risk is zero. For a less than perfectly diversified portfolio, R^2 is equal to or greater than 0 and less than 1, and unsystematic risk is greater than zero.

The Demand for a Simple, Intuitively Appealing Measure of Portfolio and Mutual Fund Diversification Such as R^2

According to the NYSE, there has been rapid growth in the numbers of individuals who own stock. With this growth and the rising importance of self-directed retirement plans, it is important that investors understand portfolio theory to properly manage their money.[4] Fabozzi, Gupta, and Markowitz (2002), Fisher and Statman (1997), and Rode (2000) argue the portfolio theory is difficult for investors to understand. Fabozzi, Gupta, and Markowitz recognize that modern portfolio theory is relatively straightforward, but complex to implement. According to Fisher and Statman, practitioners have a problem with mean-variance analysis because it does not appeal to investors' intuition. Rode notes that even though investors may understand the benefits to diversification in general terms, they don't understand the concept of diversification well enough to properly apply it.[5] Rode contends that investors address the perception of diversification, not the reality of diversification. According to the NYSE, 34 percent of shareowners have no more than a high school education and 62 percent do not hold a four-year degree (Shareownership2000). Given the findings of the NYSE and the arguments of Fabozzi, Gupta, and Markowitz; Fisher and Statman; and Rode; it may be unrealistic to expect the majority of investors to understand and apply portfolio theory.

Measures of diversification are, at the extremes, either technical or naive. For example, Sharpe (1972) introduces a complex measure of portfolio diversification that may be hard for investors to comprehend and difficult to apply. The Sharpe measure of portfolio diversification requires that each security's non-market risk relative to that of a typical security be estimated. Values of relative non-market risk, however, are not readily available. At the other extreme, naive diversification measures have been employed that do not necessarily measure diversification. For example, the New York Stock Exchange measures a lack of diversification simply by the percentage of stockholders who invest in only one firm.[6] The coefficient of

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[4] The NYSE notes that the structural shifts in the United States economy have stimulated interest in the stock market. According to the NYSE, there were an estimated 84 million shareowners in 1998, a 61 percent increase from 1989. They conclude that with 51.8 percent of all household heads or spouses of household heads owning stock, this is the first time that share ownership exceeds fifty percent (Shareownership2000).

[5] Rode notes that the evidence of professional investors being diversified is mixed.

[6] The NYSE notes that there is a trend toward growing shareholder diversification because there is a decrease in the percentage of stockholders who hold shares in only one firm. The evidence that the NYSE presents to support the increase in shareholder diversification is based

determination, however, is an unambiguous, objective, easily calculated, and intuitively appealing measure of portfolio and mutual fund diversification. With the complexities of portfolio theory and the varied educational backgrounds of stockholders, a simple measure of diversification like R^2 is of great value.

R^2 as a Measure of Portfolio Diversification

Barnea and Logue argue that R^2 is a measure of diversification. When they generalize their theory to a single security case where R^2 represents the market estimate of the diversification within a firm, however, their results are mixed and inconclusive. Wagner and Lau present evidence consistent with Barnea and Logue's belief when they assume that diversification is increased by increasing the number of securities in a portfolio. Because Barnea and Logue's results are inconclusive, and because Wagner and Lau define portfolio diversification simply by counting the number of firms in the portfolio, I first examine R^2 as a measure of portfolio diversification. Instead of just adding securities to a portfolio as Wagner and Lau do in their study, I analyze a more direct measure of portfolio diversification.

Comparing R^2s of Diversified Portfolios to R^2s of Undiversified Portfolios

Consistent with Barnea and Logue's argument that R^2 is a measure of diversification, it is expected that a portfolio of firms spread across many different industries will be more diversified and, therefore, have a higher R^2, than a portfolio of firms in the same industry. Sharpe (1972) notes that a portfolio of ten chemical securities is likely to offer less effective diversification than a portfolio of ten securities, each from a different industry. Adding firms to a portfolio should offer a greater diversification benefit if the firms are not all from the same industry. This concept is tested by comparing the R^2s of portfolios of firms all from *different* industries to the R^2s of portfolios of firms all from the *same* industry. For simplicity, I label a portfolio of firms all from *different* industries as a diversified portfolio and a portfolio of firms all from the *same* industry as an undiversified portfolio.

Data and Method

To begin constructing diversified and undiversified portfolios, 3,450 corporations that have common stocks traded on the New York Stock Exchange (NYSE), the American Stock Exchange (AMEX), and the NASDAQ national market are randomly selected. Because R^2 results from regressing firm returns on market returns, daily stock returns for the firms and the market are collected over a thirteen year period from 1980 through 1992 from the University of Chicago's Center for

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on a survey that found that 22 percent of direct stockholders reported holding shares in only one firm in 1989 compared to only 15 percent in 1995. (*Shareownership2000)*

Research in Securities Prices (CRSP). Five different proxies for the market are employed to determine if the market proxy influences the results:

1. The Standard & Poor's 500 index (the S&P index hereafter);
2. The value-weighted market portfolio of NYSE, AMEX, and NASDAQ securities *including* dividends (the VD index throughout the rest of the paper);
3. The value-weighted market portfolio of NYSE, AMEX, and NASDAQ securities *excluding* dividends (the VM index throughout the rest of the paper);
4. The equal-weighted market portfolio of NYSE, AMEX, and NASDAQ securities *including* dividends (the ED index throughout the rest of the paper); and
5. The equal-weighted market portfolio of NYSE, AMEX, and NASDAQ securities *excluding* dividends (the EM index throughout the rest of the paper).[7]

Because industry data are required, the Standard Industrial Classification codes are collected annually from the COMPUSTAT tapes over a fourteen year period from 1979 through 1992.

The sample of 3,450 companies leads to 22,661 observations. Of these 22,661 observations, 19,297 are eliminated for one of three reasons. Daily returns are calculated over 249 trading days within each calendar year resulting in 248 returns. If a firm does not have 248 returns within a calendar year, that observation is eliminated. This is done because I want to have returns for every firm in the portfolio for each trading day. For example, if there are fifteen firms in a portfolio, I want to have returns for all fifteen firms for each day. Next, I pick firms that serve only one industry and thus have only one four-digit SIC code. This process eliminates any subjectivity as to how to weight the different industries because each firm serves only one industry. For example, assume that I construct two portfolios. One portfolio consists of Culp Incorporated and California Microwave, and the other comprises Culp Incorporated and Bowmar Instrument Corporation. Culp Incorporated has SIC codes of 2211 and 5131, California Microwave has SIC codes of 3663 and 3825, and Bowmar Instrument Corp. has SIC codes of 3663, 3679, 3824, and 3825. It appears that the portfolio of Culp and Bowmar is more diversified because Bowmar has two additional SIC codes than the two it has in common with California Microwave. Suppose, however, that Bowmar has 97 percent of its sales from industry 3663 and 1 percent from each of the other three industries? Suppose California Microwave has 50 percent of its sales from industry 3663 and 50 percent of its sales from industry

[7] Because different researchers use different proxies for the market in their respective studies, I analyze five market proxies to determine if the proxy employed drives the results. For example, the S&P 500 Index is the market proxy in the Barnea and Logue study, while Wagner and Lau use an index consisting of equal holdings in all stocks on the New York Stock Exchange.

3825? Given this information, is the portfolio of Culp and California Microwave more diversified than the portfolio of Culp and Bowmar?[8] To avoid any weighting complications, only firms that have at most one four-digit SIC code are selected for a portfolio because all aspects of the company (sales, assets, number of employees, size, etc.) are related to that one industry classification. Finally, the final sample must consist only of firms that service the same one industry at the end of the calendar year as they did at the beginning of the calendar year.[9] Thus, if a firm's four-digit SIC code changes from one year to the next, the observation for that year is excluded from the sample.[10] The final sample consists of 797 firms with 3,364 observations over a thirteen year period. The results using this data set are presented in Tables 1 through 3.

Portfolio Construction

Using a sample of firms that have only *one* four-digit SIC code, I create undiversified and diversified portfolios. Each undiversified portfolio is an equally-weighted portfolio consisting of firms which all have the *same* four-digit SIC code for a particular year.[11] This leads to 48 different undiversified portfolios varying in size from eight to 25 firms.[12] The year, the four-digit SIC code, and the number of firms in each portfolio are presented in Table 1. A diversified portfolio is then constructed to be matched with each undiversified portfolio of homogeneous firms. Each diversified portfolio is an equally-weighted portfolio consisting of firms all from *different* industries.

[8] There is also subjectivity with respect to what the weighting component should be. Should the different industries be weighted by sales, assets, employees or some other component?

[9] Because the composition of a firm can change over time, the only observations that I keep are those of firms having the same set of SIC codes from one year to the next. For example, American Healthcare Management has SIC codes of 8051 and 8062 in 1988; 8062 in 1989; and 8062 in 1990. From the end of 1988 to the end of 1989, the firm reduced the number of industries it serves. Sometime in 1989 the composition of the firm changed, and, therefore, American Healthcare Management for 1989 is not included in my final data set, but is included for 1990.

[10] SIC codes are collected in 1979 to check for changes in SIC codes from 1979 to 1980. The first year that daily returns are collected is 1980.

[11] Constructing equally-weighted portfolios is consistent with other studies, such as Evans and Archer (1968) and Elton and Gruber (1977).

[12] I originally wanted to have at least ten firms in each portfolio. This results in 35 different undiversified portfolios. Evans and Archer (1968) find that a portfolio of eight securities offers adequate diversification because much of the unsystematic variation is eliminated at that point. By lowering the minimum number of firms in a portfolio to eight, my sample size increases to almost 50 observations. Therefore, I require each undiversified portfolio to have at least eight observations. I find that the conclusions are the same whether I require a minimum of ten firms or eight firms per portfolio.

Table 1—Coefficients of Determination of Diversified Portfolios and the Coefficients of Determination of Undiversified Portfolios

				S&P Index		VD Index		VM Index		ED Index		EM Index	
	Year	SIC Code	n	R^2 Nondiverse Portfolio	R^2 Diverse Portfolio	R^2 Nondiverse Portfolio	R^2 Diverse Portfolio	R^2 Nondiverse Portfolio	R^2 Diverse Portfolio	R^2 Nondiverse Portfolio	R^2 Diverse Portfolio	R^2 Nondiverse Portfolio	R^2 Diverse Portfolio
1	1980	4911	20	0.1528	0.4857	0.1953	0.5775	0.1960	0.5766	0.2771	0.7520	0.2771	0.7508
2	1980	6798	18	0.2336	0.3763	0.3041	0.4547	0.3040	0.4549	0.5228	0.6115	0.5238	0.6113
3	1981	1321	11	0.3860	0.4628	0.4628	0.5313	0.4643	0.5340	0.5488	0.6271	0.5495	0.6273
4	1981	4911	21	0.2117	0.4504	0.2365	0.5180	0.2356	0.5212	0.3152	0.6302	0.3138	0.6302
5	1981	6798	24	0.1694	0.3786	0.2053	0.4556	0.2077	0.4588	0.3260	0.6601	0.3258	0.6612
6	1982	1311	20	0.1026	0.3131	0.1257	0.3660	0.1270	0.3679	0.2467	0.5068	0.2467	0.5064
7	1982	4911	20	0.3621	0.5620	0.3843	0.6187	0.3823	0.6209	0.2754	0.6663	0.2742	0.6661
8	1982	6798	17	0.1964	0.3548	0.2250	0.4018	0.2259	0.4037	0.2687	0.4878	0.2683	0.4877
9	1983	1311	11	0.0910	0.2356	0.1127	0.3114	0.1143	0.3101	0.1831	0.4709	0.1838	0.4717
10	1983	4911	15	0.2466	0.3725	0.2698	0.4240	0.2679	0.4247	0.2242	0.4827	0.2239	0.4834
11	1983	6798	17	0.1786	0.3774	0.2032	0.4473	0.2017	0.4484	0.2255	0.5615	0.2253	0.5623
12	1984	1311	10	0.0256	0.1704	0.0333	0.1939	0.0336	0.1956	0.0496	0.2222	0.0500	0.2219
13	1984	4911	21	0.2443	0.5236	0.2893	0.5995	0.2879	0.6005	0.2881	0.6210	0.2882	0.6205
14	1984	6792	8	0.0389	0.2198	0.0457	0.2533	0.0461	0.2532	0.0637	0.2642	0.0639	0.2642
15	1984	6798	24	0.1293	0.4538	0.1661	0.5210	0.1678	0.5226	0.2923	0.5822	0.2931	0.5819
16	1985	4911	23	0.2411	0.5577	0.2796	0.6354	0.2783	0.6376	0.1943	0.6005	0.1938	0.6001
17	1985	6792	10	0.0308	0.4693	0.0383	0.5305	0.0382	0.5319	0.0738	0.4924	0.0734	0.4919
18	1985	6798	21	0.0752	0.3040	0.0899	0.3539	0.0910	0.3562	0.1147	0.3836	0.1147	0.3858
19	1986	1311	12	0.0017	0.0984	0.0013	0.1278	0.0013	0.1282	0.0001	0.2141	0.0002	0.2139
20	1986	6792	9	0.1089	0.2984	0.1128	0.3456	0.1129	0.3456	0.1335	0.3926	0.1337	0.3922
21	1987	1311	14	0.0613	0.1663	0.0875	0.2715	0.0874	0.2714	0.1794	0.5742	0.1795	0.5742
22	1987	3845	9	0.2723	0.3224	0.3354	0.4393	0.3358	0.4397	0.4257	0.6388	0.4260	0.6392
23	1987	4213	9	0.1844	0.3224	0.2745	0.4393	0.2753	0.4397	0.5037	0.6388	0.5043	0.6392
24	1987	4911	21	0.7347	0.7196	0.7401	0.8362	0.7397	0.8359	0.4864	0.8465	0.4861	0.8465
25	1987	6792	9	0.1874	0.4665	0.2759	0.5889	0.2754	0.5891	0.4537	0.7228	0.4534	0.7232
26	1987	6798	21	0.4430	0.7196	0.5488	0.8362	0.5480	0.8359	0.6432	0.8465	0.6430	0.8465
27	1988	2834	9	0.0855	0.0196	0.0993	0.0279	0.0972	0.0278	0.1410	0.0849	0.1407	0.0851
28	1988	3845	10	0.0735	0.0011	0.0892	0.0029	0.0900	0.0030	0.1451	0.0393	0.1454	0.0398

Table 1 (cont.)—Coefficients of Determination of Diversified Portfolios and Undiversified Portfolios

				S&P Index		VD Index		VM Index		ED Index		EM Index	
	Year	SIC Code	n	R^2 Nondiverse Portfolio	R^2 Diverse Portfolio	R^2 Nondiverse Portfolio	R^2 Diverse Portfolio	R^2 Nondiverse Portfolio	R^2 Diverse Portfolio	R^2 Nondiverse Portfolio	R^2 Diverse Portfolio	R^2 Nondiverse Portfolio	R^2 Diverse Portfolio
29	1988	6792	9	0.0430	0.3520	0.0546	0.3858	0.0549	0.3853	0.0944	0.4185	0.0943	0.4182
30	1988	7373	9	0.0182	0.1138	0.0254	0.1283	0.0254	0.1288	0.0616	0.1713	0.0618	0.1712
31	1989	1311	16	0.0283	0.1369	0.0358	0.1498	0.0364	0.1505	0.0647	0.1898	0.0648	0.1915
32	1989	2834	12	0.0560	0.0357	0.0560	0.0415	0.0568	0.0421	0.0565	0.0750	0.0569	0.0750
33	1989	4213	9	0.0203	0.0904	0.0276	0.1010	0.0277	0.1019	0.0728	0.1581	0.0738	0.1587
34	1989	7372	11	0.0997	0.2712	0.1138	0.3034	0.1145	0.3025	0.1784	0.3259	0.1786	0.3244
35	1990	2834	8	0.0656	0.1390	0.0754	0.1646	0.0762	0.1649	0.1034	0.2316	0.1032	0.2313
36	1990	3845	11	0.0831	0.0353	0.0962	0.0454	0.0971	0.0457	0.1364	0.0994	0.1363	0.0994
37	1990	4911	20	0.5318	0.4079	0.5650	0.4574	0.5659	0.4567	0.4947	0.5214	0.4952	0.5196
38	1990	7372	10	0.2318	0.1268	0.2678	0.1422	0.2670	0.1414	0.3159	0.1271	0.3158	0.1265
39	1991	2834	9	0.1224	0.1555	0.1499	0.1663	0.1488	0.1669	0.1904	0.1455	0.1897	0.1458
40	1991	3845	13	0.0089	0.1457	0.0143	0.1645	0.0145	0.1656	0.0419	0.2137	0.0421	0.2146
41	1991	4911	24	0.3006	0.3108	0.3206	0.3467	0.3197	0.3464	0.2658	0.3730	0.2654	0.3721
42	1991	6798	25	0.0657	0.6683	0.0771	0.7274	0.0766	0.7276	0.1099	0.6357	0.1093	0.6353
43	1991	7372	16	0.3133	0.2374	0.3607	0.2678	0.3596	0.2683	0.3836	0.3092	0.3832	0.3093
44	1992	1311	9	0.0064	0.0433	0.0030	0.0596	0.0030	0.0598	0.0023	0.1214	0.0023	0.1207
45	1992	2834	9	0.0816	0.0433	0.1170	0.0596	0.1184	0.0598	0.2649	0.1214	0.2650	0.1207
46	1992	4213	10	0.0001	0.0607	0.0020	0.0756	0.0018	0.0762	0.0199	0.1030	0.0196	0.1035
47	1992	6798	20	0.0278	0.4171	0.0377	0.4893	0.0375	0.4904	0.0986	0.4606	0.0984	0.4594
48	1992	7372	12	0.1568	0.0373	0.2169	0.0499	0.2177	0.0501	0.2992	0.1038	0.2999	0.1034
Mean of all 48 portfolios				0.1569	.2924	.1844	.3425	.1845	.3431	.2262	.4069	.2262	.4068

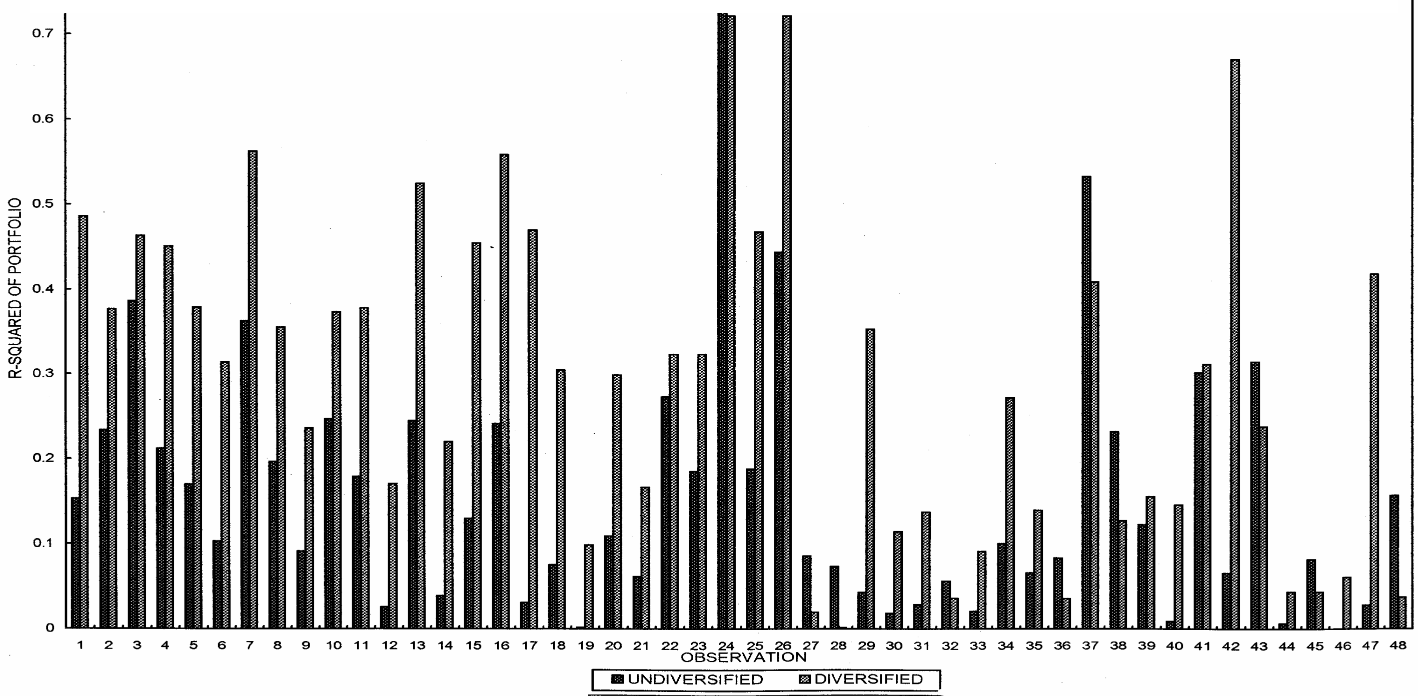
Using a sample of firms that have only one four-digit SIC code, 48 diversified and 48 undiversified portfolios are formed. Each undiversified portfolio is an equally-weighted portfolio consisting of firms with the same SIC code in a particular year. Each diversified portfolio is an equally weighted portfolio consisting of firms that all have a unique four-digit SIC code for a particular year. A diversified portfolio is constructed to be matched with each undiversified portfolio. The diversified portfolio has the same number of firms, N, as does the undiversified portfolio with which it is matched. Each diversified (undiversified) portfolio's returns are regressed on the market's returns, resulting in an R^2 for each diversified (undiversified) portfolio. The market proxies in the market model regressions are the S&P, VD, VM, ED, and EM indexes. The last row in this table is the mean R^2 of the 48 undiversified portfolios and the 48 diversified portfolios. SIC codes: 1311 is crude petroleum and natural gas, 1321 is natural gas liquids, 2834 is pharmaceutical preparations, 3845 is electromedical and electrotherapeutic apparatus, 4213 is trucking, except local, 4911 is electric services, 6792 is oil royalty companies, 6798 is real estate investment trusts, 7372 is prepackaged software, and 7373 is computer integrated systems design

No two firms in the diversified portfolio have the same four-digit SIC code for a particular year. Thus, each firm in the diversified portfolio has a unique SIC code so that an industry is represented only once in each portfolio. Each diversified portfolio is constructed for the same year that its matched undiversified portfolio is constructed. Also, each diversified portfolio is composed of the same number of firms as is the undiversified portfolio with which it is matched. This is done because of Wagner and Lau's finding that R^2 of a portfolio increases as the number of securities held in the portfolio increases. Therefore, by controlling for the number of firms in each portfolio, the size of a portfolio will not have any significance in explaining any differences between the R^2s of the diversified portfolios and the R^2s of the undiversified portfolios. Any differences between R^2s will be explained by the different industries and not the number of firms in each portfolio. In 1980, for example, there are 20 firms that have one and only one four-digit SIC code, 4911. I combine these 20 firms into a portfolio and calculate the R^2 of this undiversified portfolio. A diversified portfolio is then constructed to be compared to this undiversified portfolio. The diversified portfolio, using data from 1980, is also formed of 20 firms, all of which have only one four-digit SIC code. No two firms in the diversified portfolio have the same four-digit SIC code. This matched diversified portfolio has 20 firms with the following SIC codes: 1211, 1311, 2065, 2834, 3241, 3823, 3829, 3842, 4011, 4511, 4911, 5211, 5311, 5331, 5334, 5812, 5944, 5949, 6795, and 6798.

Results

For each of the 48 undiversified portfolios, I regress the undiversified equally-weighted portfolio's returns on the market's returns according to equation (1), resulting in an R^2 for each undiversified portfolio. For each of the 48 diversified portfolios, I regress the diversified equally-weighted portfolio's returns on the market's returns according to equation (1), resulting in an R^2 for each diversified portfolio. Table 1 presents R^2 for each of the 48 undiversified portfolios and R^2 for each of the 48 diversified portfolios using five different market proxies in the market model regression. The five market proxies, the S&P, VD, VM, ED, and EM indexes, are analyzed to determine if the market proxy affects the results. When using the S&P index as the market proxy, the diversified portfolio has a higher R^2 than the undiversified portfolio 38 times of a possible 48 times (79.2%). This is shown in Figure 1. The mean R^2 of .2924 for the 48 diversified portfolios is 86.4 percent higher than the mean R^2 of .1569 for the 48 undiversified portfolios. When using the VD index or VM index, the diversified portfolio has a higher R^2 than the undiversified portfolio 39 times of a possible 48 times (81.3 percent). For these two indexes, the mean R^2 of the 48 diversified portfolios is more than 85.7 percent higher than the mean R^2 of the 48 undiversified portfolios. When using the ED index or EM index, the diversified portfolio has a higher R^2 than the undiversified portfolio 40 times of a

Figure 1—R^2s of Undiversified Portfolios Matched with R^2s of Diversified Portfolios



This figure presents the R-squareds of the 48 undiversified portfolios matched with the R-squareds of the 48 diversified portfolios using the S&P index as the market proxy. The horizontal axis is represented by column 1 of Table 1. The first, darker bar for each observation is the undiversified portfolio's R-squared. The second, lighter bar for each observation is the diversified portfolio's R-squared. The diversified portfolio has a higher R-squared 38 of a possible 48 times.

possible 48 times (83.3 percent). For these two indexes, the mean R^2 of the 48 diversified portfolios is more than 79.8 percent higher than the mean R^2 of the 48 undiversified portfolios.

Table 2 presents evidence from several different tests that the diversified portfolios have statistically significant higher R^2s than the undiversified portfolios. The proportions test is the first test employed. If R^2 is not a measure of diversification, then the diversified portfolio should only have a higher R^2 than the undiversified portfolio half of the time and should have a lower R^2 than the undiversified portfolio half of the time. The proportions test (Panel A) is testing whether the diversified portfolios have a higher R^2 than the undiversified portfolios more than 50 percent of the time. For all five market indexes, the proportions test statistics are positive and significant at the .01 level of significance.

The mean difference between the diversified portfolios' R^2s and the undiversified portfolios' R^2s is presented in Panel B for each of the five market indexes. The mean R^2 of the diversified portfolios exceeds the mean R^2 of the undiversified portfolios by .1354 using the S&P index, by .1581 using the VD index, by .1586 using the VM index, and by .1806 using the ED and EM indexes. Three different tests are employed to determine if there is any statistical difference between the diversified and undiversified portfolios. One test is the paired t test. This test, however, assumes that the distribution of R^2 is normal. According to Amihud and Lev (1981), the distribution of R^2s is not normal. Therefore, I use two alternative tests that adjust for nonnormality. One alternative test is provided by transforming the square root of R^2 into a normal variable, $NR = \ln(1 + R)/(1 - R)$.[13] I perform the paired t test on this transformed variable, NR. The third test employed is the nonparametric Wilcoxon signed-rank test. As presented in Panel B of Table 2, all of the p-values for the paired t tests on R^2, the paired t tests on NR, and the Wilcoxon signed-rank tests are .000 for all indexes. Thus, this is convincing evidence that the diversified portfolios have significantly higher R^2s than the undiversified portfolios.

Relationship Between R^2 of a Portfolio and the Number of Securities Held in a Portfolio

In the previous section, a portfolio was classified as undiversified if all of the firms are from the same industry and diversified if all of the firms are from different industries. From another perspective, Wagner and Lau relate diversification to the

[13] This transformation is explained in detail by Freund (1971). Throughout this paper, when analyzing R^2 as a measure of diversification, I always incorporate R^2 and NR into the statistical tests. This is done because some of the previous researchers make the transformation and others do not. For example, Barnea and Logue (1973) perform their tests on R^2, while Amihud and Lev (1981) argue that the transformation should be made. As will be presented throughout this paper, the conclusions are the same under both methods.

Table 2—Testing for a Difference Between a Diversified Portfolio's Coefficient of Determination and an Undiversified Portfolio's Coefficient of Determination

Panel A: Proportions	S&P Index	VD Index	VM Index	ED Index	EM Index
The number of times that the diversified portfolio has a higher R-squared than the undiversified portfolio, with the percentage in parentheses	38 of 48 (.792)	39 of 48 (.813)	39 of 48 (.813)	40 of 48 (.833)	40 of 48 (.833)
The number of times that the undiversified portfolio has a higher R-squared than the diversified portfolio, with the percentage in parentheses	10 of 48 (.208)	9 of 48 (.187)	9 of 48 (.187)	8 of 48 (.167)	8 of 48 (.167)
Proportions test statistic testing if the percentage of times that the diversified portfolio has a higher R-squared than the undiversified portfolio is significantly different from 50%	4.98**	5.55**	5.55**	6.20**	6.20**

** Significant at .01 level of significance using a two-tailed test

Panel B: Testing for a difference between the diversified and undiversified portfolios using the Paired t test and the Wilcoxon sign-rank test

	Mean Difference Between the Diversified and Undiversified Portfolios[a]	Paired t Test on R^2		Paired t Test on NR		Wilcoxon Sign-Rank Test	
Index		Test Statistic	P-value	Test Statistic	P-value	Test Statistic	P-value
S&P Index	0.1354	6.10	.000	6.03	.000	116	.000
VD Index	0.1581	6.42	.000	6.43	.000	105	.000
VM Index	0.1586	6.43	.000	6.44	.000	104	.000
ED Index	0.1806	7.16	.000	7.37	.000	92	.000
EM Index	0.1806	7.15	.000	7.36	.000	92	.000

[a] The mean difference is equal to R-squared of the diversified portfolios minus R-squared of the undiversified portfolios. Table 1 presents the R-squareds of the 48 undiversified portfolios and the 48 diversified portfolios for five different market proxies used in the market model regression equation. In this table, I test if the diversified and undiversified portfolios have significantly different R-squareds. Panel A presents the number of times that the diversified portfolio has a higher (and lower) R-squared than the undiversified portfolio and the proportions tests. Panel B presents the results of the Paired t test on R-squared, the Paired t test on NR, and the Wilcoxon sign-rank test. NR is a result of transforming the square root of R-squared into a normal variable, $NR = \ln(1 + R)/(1 - R)$

number of securities held in a portfolio.[14] They note that diversification is increased by increasing the number of securities in a portfolio. Empirically, they find that R^2 of

[14] Other studies (Tole, 1982; Statman, 1987; Bierman, 1980; Elton and Gruber, 1977; Bierman, 1978; Evans and Archer, 1968) also analyze the relationship between the risk of a portfolio and the number of securities held in that portfolio.

a portfolio increases as the number of securities held in the portfolio increases. The securities in each of their portfolios were randomly selected. In this section, I investigate whether this relationship still holds for my diversified portfolio data as well as my undiversified portfolio data. I analyze whether there is a positive relationship between R^2 and the number of securities held in an undiversified portfolio and whether there is a positive relationship between R^2 and the number of securities held in a diversified portfolio.

The relationship between R^2 of a portfolio and the total number of securities held in a portfolio is statistically analyzed across portfolios by estimating the following two regression equations for the undiversified and diversified portfolios:

$$R^2_i = \beta_o + \beta_1 N_i + \varepsilon_i \qquad (4)$$

where R^2_i is R^2 of portfolio i, N_i is the total number of securities in portfolio i, and i is equal to 1 to 48 portfolios; and

$$NR_i = \alpha_o + \alpha_1 N_i + \varepsilon_I \qquad (5)$$

where NR_i is the transformed R for portfolio i, N_i is the total number of securities in portfolio i, and i is equal to 1 to 48 portfolios. NR is the transformation to normalize R^2. The undiversified and diversified portfolios' R^2s using the S&P index as the market proxy are in columns 5 and 6, respectively, and the total number of securities in each portfolio is in column 4 of Table 1.[15]

Only the results using equation (5) are presented in Table 3 because the results from equations (4) and (5) mirror each other. As presented in Table 3, when NR of the undiversified portfolio is regressed on the total number of securities in the undiversified portfolio, the slope of .0391 is positive and statistically significant (test statistic of 3.40 and p-value of .001). When NR of the diversified portfolio is regressed on the total number of securities in the diversified portfolio, the slope of .0692 is positive and statistically significant (test statistic of 5.97 and p-value of .000). Thus, there is statistical evidence that the more securities held in both a diversified and an undiversified portfolio, the larger the R^2 of the portfolio. [16]

The slope coefficient for the diversified portfolios is greater than the slope coefficient for the undiversified portfolios. Thus, as the number of securities in the portfolio is increased, the diversified portfolios' R^2s increase at a faster rate than the

[15] The relationship between R^2 and the number of securities held in a portfolio is also analyzed using the VD, VM, ED, and EM indexes to calculate R^2. The results are the same for all five market proxies; therefore, only the regression results using the S&P index are reported.

[16] The relationship between R^2 and the number of securities in a portfolio is also analyzed separately for each of the 48 undiversified portfolios and for each of the 48 diversified portfolios. Consistent with the results presented, I find statistical evidence that as the number of securities held in a diversified and an undiversified portfolio increases, R^2 increases.

Table 3—Regressing the Coefficient of Determination on the Number of Securities Held in a Portfolio

Regression Model	Regression Coefficient	Test Statistic	P-value	R-squared
Regressing NR of the undiversified portfolio on the Number of securities held in the undiversified portfolio	0.0391	3.40	.001	.201
Regressing NR of the diversified portfolio on the Number of securities held in the diversified portfolio	0.0692	5.97	.000	.437
Regressing the Difference in NR on the Number of securities held in the portfolio	0.0301	2.58	.013	.127

This table presents the regression results obtained from analyzing the relationship between R-squared and the number of securities held in a portfolio for both the diversified and undiversified portfolios. R-squared of the undiversified portfolio is in column five of Table 1 and R-squared of the diversified portfolio is in column six of Table 1. The number of securities held in a portfolio for both the diversified and undiversified portfolios is in column four of Table 1. The relationship is analyzed by regressing NR on the number of securities in an undiversified portfolio and regressing NR on the number of securities in a diversified portfolio. NR is the transformation used to normalize R-squared. Also, the difference in NR is regressed on the number of securities in a portfolio. The difference in NR is equal to NR of the diversified portfolio minus NR of the undiversified portfolio for each matched pair of portfolios

undiversified portfolios' R^2s. To determine if the difference between the R^2s is statistically significant, the following two regression equations are estimated:

$$\mathrm{Diff}(R^2_i) = \alpha_o + \alpha_1 N_i + \varepsilon_i \tag{6}$$

where $\mathrm{Diff}(R^2_i)$ is R^2 of diversified portfolio i minus R^2 of undiversified portfolio i, N_i is the total number of securities in portfolio i, and i is equal to 1 to 48 portfolios; and

$$\mathrm{Diff}(NR_i) = \alpha_o + \alpha_1 N_i + \varepsilon_i \tag{7}$$

where $\mathrm{Diff}(NR_i)$ is NR of diversified portfolio i minus NR of undiversified portfolio i. NR is the transformed R that is normally distributed for portfolio i. N_i is the total number of securities in portfolio i, and i is equal to 1 to 48 portfolios.

The results using equations (6) and (7) mirror each other; therefore, only the results using equation (7) are presented in Table 3. The slope coefficient of .0301 is highly significant (test statistic of 2.58 and p-value of .013). Thus, as the number of securities held in the portfolio increases, the greater the difference between R^2 of the diversified portfolio and R^2 of the undiversified portfolio. This is what is expected if R^2 is a measure of diversification. These results are consistent with Wagner and Lau's findings that R^2 increases as the number of securities held in the portfolio increases, and that increasing the number of securities in a portfolio tends to be less efficient at achieving diversification for the highest-quality A+ issues. Wagner and Lau attribute this to the A+ companies being more homogenous than the companies grouped under other quality codes. My sample of undiversified portfolios is, by definition, homogeneous.

R^2 as a Measure of Mutual Fund Diversification

Thus far, I find that portfolios consisting of firms each from *different* industries have significantly higher R^2s than portfolios of firms each from the *same* industry. This finding is consistent with R^2 being a measure of portfolio diversification. I now examine if Barnea and Logue's argument that R^2 is a measure of diversification also holds for publicly quoted mutual funds. In this section, I compare the R^2s of diversified mutual funds to the R^2s of undiversified mutual funds, such as sector or specialty mutual funds. Index mutual funds are not included in the diversified mutual fund data set because, by definition, they should have high R^2s.[17] Because there may be some subjectivity as to how a fund is classified, I use three different sources for the investment objectives. A separate analysis is performed for each of the three sources to determine if the classification source influences the results. Classification of mutual funds as diversified or undiversified is based on the investment objective supplied by *Barron's, Morningstar*, and *Fidelity Investments*. In subsection A, when *Barron's* is the source, the R^2s of the mutual funds are calculated for each year using daily returns. In subsections B and C, when *Morningstar* and *Fidelity* are the sources, respectively, the R^2s of the mutual funds are calculated over a three year period using monthly returns. The conclusions are independent of the source used for the investment objective, the time period analyzed, and the holding period returns used to calculate R^2.

Two parametric tests and one nonparametric test are used to determine if diversified mutual funds have significantly higher R^2s than do undiversified mutual funds. One parametric test is the difference of means test on the R^2s for the diversified and undiversified mutual funds. This test, however, assumes that the distribution of R^2s is normal. As was mentioned earlier, Amihud and Lev note that the distribution of R^2s is not normal. Therefore, I also incorporate an alternative parametric test and a nonparametric test that adjust for nonnormality. The alternative parametric test is provided by transforming the square root of R^2 into a normal variable, $NR = \ln(1 + R)/(1 - R)$. The difference of means test is performed on the transformed variable NR. The nonparametric test is the Wilcoxon rank sum test. The results of all three tests mirror each other; therefore, only the results of the latter two tests are presented.

Barron's

In this subsection, *Barron's* is the source of the investment objective for each mutual fund. Diversified mutual funds are those funds that have one of the following investment objectives according to *Barron's*: balanced, flexible, growth, or growth and income. For example, a flexible fund aims for high total return by allocating its

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[17] Even though index mutual funds are not included in my diversified mutual fund dataset, I did analyze their R^2s. Consistent with what we would expect, the index mutual funds do have high R^2s.

portfolio among a wide range of asset classes. Undiversified mutual funds are sector funds that, according to *Barron's*, have as an investment objective to invest at least 65 percent of their assets in a particular sector or to invest in a specific industry. They are environmental funds, financial services funds, gold funds, health/biotech funds, natural resources funds, real estate funds, science and technology funds, specialty funds, and utility funds.

R^2 is calculated for each mutual fund for each year using daily mutual fund prices over a five year period from 1990 through 1994. To determine R^2 of a mutual fund for a particular year, I regress that mutual fund's returns on the market's returns for that particular year using equation (1), $R_{i,t} = \alpha_i + \beta_i R_{m,t} + \varepsilon_{i,t}$, where $R_{i,t}$ is the return on mutual fund i on day t of a calendar year, and $R_{m,t}$ is the return on the S&P 500 market index on day t of a calendar year. Because I find in the previous section that the market proxy employed does not influence the results for portfolio diversification, I only use the S&P index as the market proxy to be consistent with other mutual fund databases, such as *Morningstar* and *Fidelity*. Worden Brothers, Inc. is the source of the daily mutual fund data.

Table 4 presents the mean and median R^2s of the diversified and undiversified mutual funds, while Figure 2 gives a graphic representation of the mean R^2s of the diversified and undiversified mutual funds. Panel A of Table 4 introduces the mean and median R^2s of all the diversified mutual funds and the mean and median R^2s of all the undiversified mutual funds. The individual diversified funds and the individual undiversified funds based on investment objectives are in Panels B and C of Table 4, respectively. Columns 3 and 4 are the mean and median R^2s, respectively, of the mutual funds each pooled over the five-year period from 1990 through 1994. In the rest of the columns, the mutual funds are presented by year.

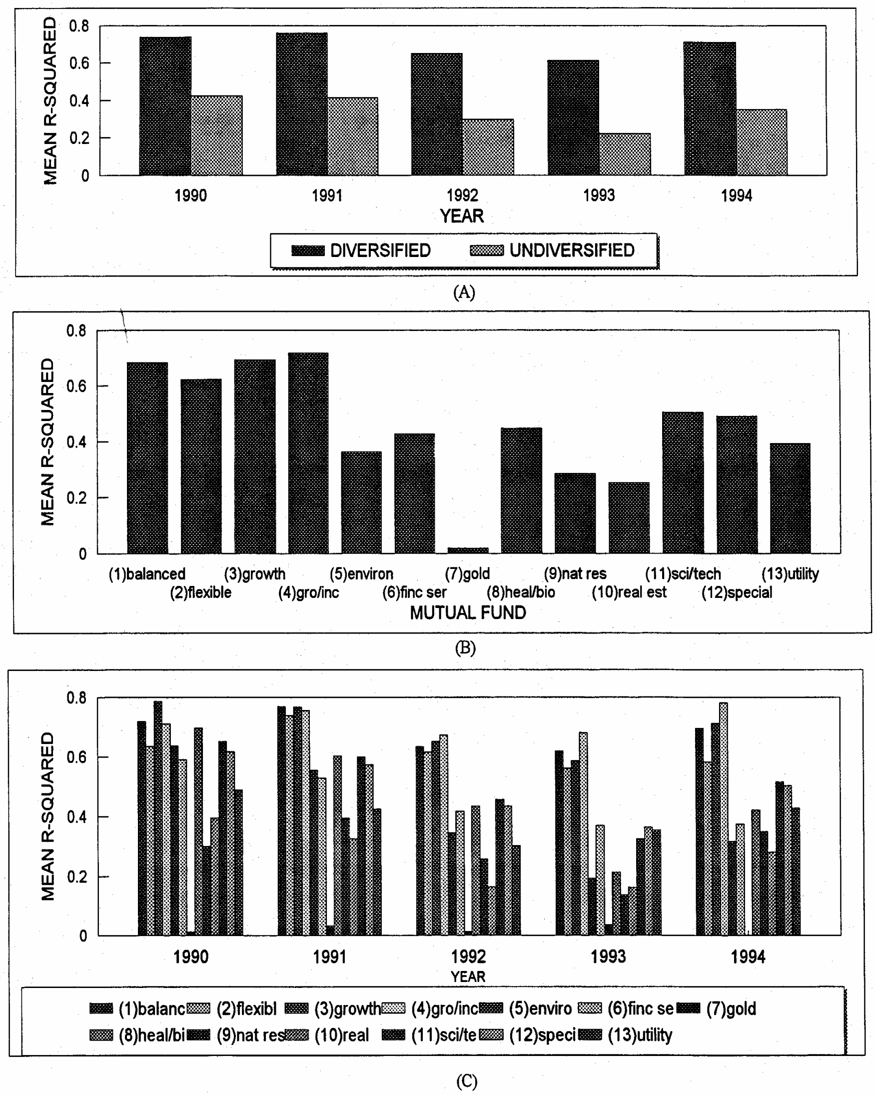
From Panel A of Figure 2, and Panel A of Table 4, the diversified mutual funds always have higher mean and median R^2s than the undiversified mutual funds. When comparing individual diversified mutual funds with individual undiversified mutual funds over the whole five year period from 1990 through 1994, the balanced, flexible, growth, and growth and income funds all have higher R^2s than any of the sector funds. This is seen in Panels B and C of Table 4 and in Panel B of Figure 2 for mean R^2s. When comparing individual diversified mutual funds with individual undiversified mutual funds for each year, in every case but one, the balanced, flexible, growth, and growth and income funds all have higher R^2s than any of the sector funds. This is seen in Panels B and C of Table 4 and in Panel C of Figure 2 for mean R^2s. Only in 1990 does the flexible fund have a lower mean or median R^2 than some of the sector funds. The flexible fund has a mean R^2 of .6353, while the environment, health/bio, and science and technology funds have mean R^2s of .6356, .6957, and .6504, respectively. The median R^2 of the flexible fund is .6961, while the median R^2 of the specialist fund is .7067. When looking at the small sample sizes of these subsamples, however, these findings are less alarming.

Table 4—Mean and Median Coefficients of Determination of Diversified and Undiversified Mutual Funds Using Barron's as the Source of the Investment Objective

	1990-1994			1990			1991			1992			1993			1994		
Investment Objective	N	Mean	Median	N	Mean	Median	N	Mean	Median	N	Mean	Median	N	Mean	Median	N	Mean	Median
Panel A: Diversified and Undiversified Mutual Funds for All Years Combined from 1990 through 1994 and Each Year Individually from 1990 through 1994																		
Diversified	229	.6902	.7148	38	.7379	.7428	40	.7609	.7833	47	.6497	.6856	51	.6132	.6319	53	.7125	.7449
Undiversified	308	.3337	.3500	49	.4237	.5835	55	.4149	.5350	62	.2962	.3191	69	.2204	.1941	73	.3509	.3693
Panel B: Individual Diversified Mutual Funds for All Years Combined from 1990 through 1994 and Each Year Individually from 1990 through 1994																		
Balanced	38	.6833	.7118	7	.7177	.7273	7	.7688	.7938	8	.6326	.6307	8	.6177	.6241	8	.6945	.7235
Flexible	27	.6225	.6278	5	.6353	.6961	5	.7376	.7647	5	.6151	.6312	6	.5616	.5980	6	.5830	.5844
Growth	105	.6940	.7024	18	.7864	.7833	18	.7678	.7833	21	.6504	.6856	23	.5850	.6206	25	.7110	.7186
Growth and Income	59	.7188	.7317	8	.7104	.7112	10	.7544	.7895	13	.6723	.7164	14	.6790	.7019	14	.7811	.7875
Panel C: Individual Undiversified Mutual Funds for All Years Combined from 1990 through 1994 and Each Year Individually from 1990 through 1994																		
Environment	8	.3639	.3191	1	.6356	.6356	1	.5543	.5543	2	.3470	.3470	2	.1946	.1946	2	.3191	.3191
Financial Services	12	.4286	.4194	1	.5895	.5895	2	.5294	.5294	3	.4173	.4144	3	.3716	.3660	3	.3760	.5220
Gold	59	.0201	.0137	10	.0127	.0130	11	.0348	.0390	12	.0141	.0056	13	.0377	.0366	13	.0012	.00102
Health/Bio	33	.4484	.4378	5	.6957	.6890	6	.6027	.6175	6	.4353	.4622	8	.2141	.1938	8	.4223	.4288
Natural Resources	66	.2849	.2559	11	.3022	.1937	12	.3960	.3930	13	.2589	.2564	15	.1389	.1443	15	.3519	.3542
Real Estate	9	.2523	.2201	1	.3962	.3962	2	.3266	.3266	2	.1648	.1648	2	.1640	.1640	2	.2820	.2820
Science and Tech	44	.5057	.5399	8	.6504	.6130	8	.5991	.5836	8	.4560	.4652	9	.3272	.3205	11	.5146	.5614
Specialist	52	.4920	.5456	9	.6160	.7067	10	.5731	.5892	11	.4342	.4704	11	.3648	.3873	11	.5017	.5566
Utility	25	.3930	.4322	3	.4880	.6620	3	.4250	.5990	5	.3041	.3290	6	.3555	.4005	8	.4289	.4497

This table presents the mean and median R^2s of the diversified and undiversified mutual funds. Using daily returns, R^2 is calculated for each mutual fund for each year from 1990 through 1994. The S&P 500 index is the market proxy in the market model regression. Diversified mutual funds are those funds that have one of the following investment objectives according to Barron's: balanced, flexible, growth, or growth and income. Undiversified mutual funds are sector funds that, according to Barron's, have as an investment objective to invest at least 65 percent of its assets in a particular sector or to invest in a specific industry. They are environmental funds, financial services funds, gold funds, health/bio funds, natural resources funds, real estate funds, science and technology funds, specialty funds, and utility funds. Worden Brothers, Inc. is the source of the daily mutual fund data

Figure 2—Mean R^2s of Mutual Funds Based on Investment Objectives According to Barron's



These plots present the mean R^2s of mutual funds with different investment objectives as supplied by Barron's. R^2 is calculated for each mutual fund for each year using daily mutual fund prices from 1990 through 1994. Panel A is the mean R^2s of all diversified mutual funds and all undiversified mutual funds for each year. Panel B is the mean R^2s of mutual funds based on their investment objectives for all years combined from 1990 through 1994. Panel C is the mean R^2s of mutual funds based on their investment objectives for each individual year

The test statistics testing for differences between diversified and undiversified mutual funds are presented in Table 5. From Panel A, diversified mutual funds have significantly higher R^2s than undiversified sector funds for the whole five year period as well as for each individual year. The p-values are .000 for both the parametric (difference of means) and nonparametric (Wilcoxon rank sum) tests over the whole five year period and for each individual year. In Panel B, the balanced, flexible, growth, and growth and income funds are compared with each sector fund over the whole five year period. In every case, the balanced, flexible, growth, and growth and income funds have significantly higher R^2s than any of the sector funds. The p-values are .005 or less. In Panel C, each diversified mutual fund with at least seven observations is compared to each undiversified mutual fund with at least seven observations for each year. Thus, the balanced, growth, and growth and income funds are compared with each sector fund with at least seven observations for each year.[18] In just about all of the cases, the balanced, growth, and growth and income funds have significantly higher R^2s than any of the sector funds. Only in 1990 are the balanced and growth and income funds not statistically larger than the science and technology and specialty funds, and only in 1992 is the balanced fund not statistically larger than the science and technology fund according to the nonparametric test. The small sample sizes may explain why these differences are not significant.

Morningstar

Another database is now employed to determine if the data source drives the previous findings. In this subsection, I compare the R^2s of diversified mutual funds to the R^2s of undiversified mutual funds using *Morningstar* as the source of both the investment objective and R^2 for each mutual fund. *Morningstar* derives the investment objective from the fund's prospectus. Diversified mutual funds are those funds that have one of the following investment objectives: balanced, growth, or growth and income. Undiversified mutual funds are sector funds that seek capital appreciation by concentrating their investments in a single economic sector. They are communication funds, financial funds, health funds, precious metal funds, natural resource funds, real estate funds, technology funds, utility funds, and all other specialty funds.

Morningstar calculates R^2 by regressing mutual fund monthly returns on the S&P 500 monthly returns over a 36-month period. In this study, the 36-month period is from October 1, 1992 through September 30, 1995. R^2 supplied by *Morningstar* is on a scale from 0 to 100, where an R^2 of 100 means that all movements of a fund are completely explained by movements in the S&P index.

[18] Some of the observations are lost because of small sample sizes. For example, when broken up by year, the flexible fund has at most six observations.

Table 5—Comparing the Coefficients of Determination of Diversified Mutual Funds to Undiversified Mutual Funds Using Barron's as the Source of the Investment Objective

Panel A: Testing for a Difference Between the Diversified Mutual Funds and the Undiversified Mutual Funds for All Years Combined from 1990 through 1994 and for Each Year Individually from 1990 through 1994

Year	Diversified N	Undiversified N	Parametric Test	Nonparametric Test
1990 through 1994	229	308	19.53 (.000)	15.33 (.000)
1990	38	49	6.39 (.000)	4.96 (.000)
1991	40	55	8.27 (.000)	6.48 (.000)
1992	47	62	9.44 (.000)	7.24 (.000)
1993	51	69	10.83 (.000)	8.27 (.000)
1994	53	73	11.10 (.000)	8.34 (.000)

Panel B: Testing for a Difference Between Each Diversified Mutual Fund and Each Undiversified Mutual Fund for All Years Combined from 1990 through 1994

	Balanced (N=38)		Flexible (N=27)		Growth (N=105)		Growth and Income (N=59)	
	Parametric Test	Nonparametric Test	Parametric Test	Nonparametric Test	Parametric Test	Nonparametric Test	Parametric Test	Nonparametric Test
Environment (N=8)	5.36 (.000)	3.58 (.000)	4.06 (.002)	3.01 (.003)	6.18 (.000)	3.98 (.000)	6.39 (.000)	4.03 (.000)
Financial Services (N=12)	5.61 (.000)	4.03 (.000)	3.99 (.001)	3.36 (.001)	6.84 (.000)	4.66 (.000)	6.89 (.000)	4.55 (.000)
Gold (N=59)	21.40 (.000)	8.28 (.000)	19.10 (.000)	7.41 (.000)	32.52 (.000)	10.61 (.000)	24.28 (.000)	9.37 (.000)
Health/Bio (N=33)	5.23 (.000)	4.47 (.000)	3.52 (.001)	3.15 (.002)	6.54 (.000)	5.51 (.000)	6.59 (.000)	5.48 (.000)
Natural Resources (N=66)	10.31 (.000)	7.24 (.000)	8.30 (.000)	6.03 (.000)	13.62 (.000)	9.54 (.000)	12.16 (.000)	8.59 (.000)
Real Estate (N=9)	10.19 (.000)	4.34 (.000)	8.30 (.000)	4.27 (.000)	12.98 (.000)	4.79 (.000)	11.89 (.000)	4.65 (.000)
Science/Tech (N=44)	5.25 (.000)	4.57 (.000)	3.17 (.003)	2.93 (.003)	7.33 (.000)	6.16 (.000)	6.97 (.000)	6.07 (.000)
Specialty (N=52)	5.07 (.000)	4.56 (.000)	3.20 (.002)	2.80 (.005)	6.62 (.000)	6.00 (.000)	6.57 (.000)	5.81 (.000)
UTILITY (N=25)	6.19 (.000)	4.92 (.000)	4.58 (.000)	3.68 (.000)	7.51 (.000)	5.99 (.000)	7.50 (.000)	5.98 (.000)

Table 5 (cont.)—Comparing the Coefficients of Determination of Diversified Mutual Funds to Undiversified Mutual Funds Using Barron's as the Source of the Investment Objective

Panel C: Testing for a Difference Between Each Diversified Mutual Fund and Each Undiversified Mutual Fund for Each Year from 1990 through 1994 for Subsamples with at Least Seven Observations

	Parametric Test	Nonparametric Test	Parametric Test	Nonparametric Test	Parametric Test	Nonparametric Test
1990	Balanced (N=7)		Growth (N=18)		Growth and Income (N=8)	
Gold (N=10)	11.20 (.000)	3.37 (.001)	16.02 (.000)	4.29 (.000)	10.63 (.000)	3.51 (.000)
Natural Resources (N=11)	4.25 (.001)	2.72 (.007)	5.95 (.000)	3.89 (.000)	4.12 (.001)	2.85 (.004)
Science/Tech (N=8)	1.23 (.244)	1.22 (.224)	3.29 (.003)	2.64 (.008)	1.14 (.279)	1.21 (.227)
Specialty (N=9)	1.14 (.273)	0.64 (.525)	2.46 (.027)	2.24 (.025)	1.08 (.297)	0.43 (.665)
1991	Balanced (N=7)		Growth (N=18)		Growth and Income (N=10)	
Gold (N=11)	12.24 (.000)	3.44 (.001)	14.60 (.000)	4.43 (.000)	9.16 (.000)	3.84 (.000)
Natural Resources (N=12)	4.63 (.000)	3.08 (.002)	5.23 (.000)	4.00 (.000)	3.99 (.001)	3.20 (.001)
Science/Tech (N=8)	2.97 (.013)	2.26 (.024)	3.59 (.002)	2.81 (.005)	2.49 (.027)	2.00 (.046)
Specialty (N=10)	2.67 (.018)	2.49 (.013)	3.08 (.006)	2.85 (.004)	2.39 (.029)	1.93 (.054)
1992	Balanced (N=8)		Growth (N=21)		Growth and Income (N=13)	
Gold (N=12)	8.27 (.000)	3.66 (.000)	14.37 (.000)	4.70 (.000)	10.69 (.000)	4.22 (.000)
Natural Resources (N=13)	4.24 (.001)	3.30 (.001)	6.42 (.000)	4.29 (.000)	5.55 (.000)	3.95 (.000)
Science/Tech (N=8)	2.40 (.039)	1.52 (.128)	3.99 (.001)	3.05 (.002)	3.53 (.003)	2.21 (.027)
Specialty (N=11)	2.44 (.030)	1.94 (.052)	3.58 (.002)	3.29 (.001)	3.39 (.003)	2.72 (.007)

Table 5 (cont.)—Comparing the Coefficients of Determination of Diversified Mutual Funds to Undiversified Mutual Funds Using Barron's as the Source of the Investment Objective

Panel C: Testing for a Difference Between Each Diversified Mutual Fund and Each Undiversified Mutual Fund for Each Year from 1990 through 1994 for Subsamples with at Least Seven Observations

	Parametric Test	Nonparametric Test	Parametric Test	Nonparametric Test	Parametric Test	Nonparametric Test
1993	Balanced (N=8)		Growth (N=23)		Growth and Income (N=14)	
Gold (N=13)	6.94 (.000)	3.73 (.000)	15.65 (.000)	4.91 (.000)	8.40 (.000)	4.39 (.000)
Health/Bio (N=8)	4.54 (.002)	2.57 (.010)	8.88 (.000)	3.91 (.000)	5.88 (.000)	3.72 (.000)
Natural Resources (N=15)	5.37 (.000)	3.45 (.001)	9.35 (.000)	5.02 (.000)	6.66 (.000)	4.52 (.000)
Science/Tech (N=9)	3.28 (.009)	2.45 (.014)	5.29 (.000)	3.48 (.001)	4.51 (.000)	3.50 (.001)
Specialty (N=11)	2.76 (.018)	2.44 (.015)	3.73 (.001)	3.13 (.002)	3.88 (.001)	3.48 (.001)
1994	Balanced (N=8)		Growth (N=25)		Growth and Income (N=14)	
Gold (N=13)	12.39 (.000)	3.73 (.000)	24.04 (.000)	4.98 (.000)	22.52 (.000)	4.39 (.000)
Health/Bio (N=8)	3.86 (.002)	2.68 (.007)	5.70 (.000)	3.76 (.000)	7.00 (.000)	3.65 (.000)
Natural Resources (N=15)	5.13 (.000)	3.65 (.000)	8.44 (.000)	5.03 (.000)	9.60 (.000)	4.43 (.000)
Science/Tech (N=11)	2.96 (.013)	2.60 (.009)	4.83 (.000)	3.95 (.000)	6.32 (.000)	3.80 (.000)
Specialty (N=11)	2.60 (.019)	2.35 (.019)	3.52 (.003)	3.61 (.000)	4.72 (.000)	3.80 (.000)
Utility (N=8)	3.27 (.006)	2.68 (.007)	4.38 (.001)	3.68 (.000)	5.57 (.001)	3.58 (.000)

This table presents the results of testing for a difference in R^2 between the diversified mutual funds and the undiversified mutual funds presented in Table 4. The results of parametric and nonparametric tests are presented. The parametric test is the difference of means test on NR and the nonparametric test is the Wilcoxon rank sum test. For each test, the test statistic is given, followed by the significance level in parentheses. N is the number of mutual funds

Panel A of Table 6 presents the mean and median R^2s of the diversified and undiversified mutual funds while Panel B of Table 6 presents the statistical tests to determine if there is a statistical difference between the diversified and undiversified mutual funds. From Panel A, the diversified mutual funds have a mean R^2 of 69.40 and a median R^2 of 72.29, while the undiversified mutual funds have a mean R^2 of 30.09 and a median R^2 of 32.70. From the parametric and nonparametric test statistics presented in Panel B, the diversified mutual funds have significantly higher R^2s than the undiversified mutual funds. The parametric (difference of means) test statistic is 25.87 (p-value of .000) and the nonparametric (Wilcoxon rank sum) test statistic is 17.42 (p-value of .000).

The individual mutual funds in the diversified sample (the balanced, growth, and growth and income funds) have mean R^2s that range from 64.47 to 77.56 and median R^2s that range from 66.50 to 81.88. The individual mutual funds in the undiversified sample have mean R^2s that range from 1.17 to 43.60 and median R^2s that range from .85 to 47.12. Panel B individually compares the balanced, growth, and growth and income funds to each of the sector funds. For every parametric and nonparametric test, the balanced, growth, and growth and income funds all have significantly higher R^2s than any of the specialty funds. The p-values are all .001 or less.

Morningstar also furnishes the total net assets of each mutual fund and the average market capitalization of the companies in each fund. The net asset value measures a fund's size, while the average market capitalization reveals the average size of the firms in the fund. Although I do not present the results here due to space constraints, I find that when controlling for size, as measured by net asset value or average market capitalization, the above conclusions are not affected. In other words, when controlling for mutual fund size, the diversified mutual funds still have significantly higher R^2s than the undiversified specialty mutual funds.[19]

Fidelity Investments

Last, I analyze the R^2s of both undiversified and diversified mutual funds using data provided by an individual mutual fund family, *Fidelity Investments*. The data source is the January 1995 issue of the *Fidelity Investments Mutual Fund Guide*. The diversified mutual fund sample comprises funds that *Fidelity* classifies as growth or growth & income funds. The undiversified mutual fund sample consists of *Fidelity's* select funds. These specialty funds concentrate on particular areas of the market, such as air transportation, automotive, biotechnology, chemicals, computers, construction, defense, energy, financial services, health care, leisure, retailing, and technology. *Fidelity* calculates R^2 by regressing the mutual fund monthly returns on

[19] I discover that the size of a mutual fund does not influence the mutual fund's $R^{2.}$ Likewise, Roll (1988), when examining R^2 for individual firms, does not find evidence that the size of a firm influences the firm's $R^{2.}$ He finds no significant relationship between firm size and R^2.

Table 6—Mean and Median Coefficients of Determination of Diversified and Undiversified Mutual Funds Using Morningstar as the Data Source

Panel A: Descriptive Statistics			
Investment Objective	N	Mean	Median
The Whole Sample of Diversified and Undiversified Funds			
Diversified	737	69.40	72.29
Undiversified	153	30.09	32.70
The Individual Diversified Funds Based on Investment Objectives According to Morningstar			
Balanced	116	71.26	73.05
Growth	396	64.47	66.50
Growth and Income	225	77.56	81.88
The Individual Undiversified Funds Based on Investment Objectives According to Morningstar			
Communications	7	43.60	47.12
Financial	13	39.78	38.91
Health	12	28.07	25.97
Precious Metals	29	1.71	0.85
Natural Resources	22	28.91	29.32
Real Estate	6	13.96	11.60
Technology	15	33.89	36.39
Utilities	33	39.32	41.22
All Others	16	42.02	42.59

Table 6 (cont.)—Mean and Median Coefficients of Determination of Diversified and Undiversified Mutual Funds Using Morningstar as the Data Source

Panel B: Testing for a Difference Between Diversified Mutual Funds and Undiversified Mutual Funds Based on Investment Objectives According to Morningstar

The Whole Sample of Diversified and Undiversified Funds

	Parametric Test	Nonparametric Test
Diversified vs. Undiversified	25.87 (.000)	17.42 (.000)

Testing for a Difference between Each Diversified Mutual Fund and Each Undiversified Mutual Fund

	Balanced (N=116)		Growth (N=396)		Growth and Income (N= 225)	
	Parametric Test	Nonparametric Test	Parametric Test	Nonparametric Test	Parametric Test	Nonparametric Test
Communications (N=7)	7.56 (.000)	3.93 (.000)	5.90 (.001)	3.21 (.001)	10.51 (.000)	4.08 (.000)
Financial (N=13)	12.13 (.000)	5.44 (.000)	10.42 (.000)	4.91 (.000)	16.40 (.000)	5.56 (.000)
Health (N=12)	15.34 (.000)	5.56 (.000)	14.00 (.000)	5.52 (.000)	19.47 (.000)	5.61 (.000)
Precious Metals (N=29)	38.39 (.000)	8.31 (.000)	45.08 (.000)	8.95 (.000)	44.23 (.000)	8.76 (.000)
Natural Resources (N=22)	16.50 (.000)	7.22 (.000)	15.43 (.000)	7.27 (.000)	21.04 (.000)	7.42 (.000)
Real Estate (N=6)	11.43 (.000)	4.10 (.000)	10.18 (.000)	4.13 (.000)	13.80 (.000)	4.12 (.000)
Technology (N=15)	11.97 (.000)	5.96 (.000)	10.35 (.000)	5.65 (.000)	15.62 (.000)	6.06 (.000)
Utilities (N=33)	12.83 (.000)	7.92 (.000)	11.19 (.000)	7.22 (.000)	17.25 (.000)	8.49 (.000)
All Others (N=16)	8.40 (.000)	5.46 (.000)	6.69 (.000)	4.67 (.000)	11.57 (.000)	5.91 (.000)

This table presents the mean and median R^2 of diversified and undiversified mutual funds. The investment objectives and R^2 are supplied by Morningstar. Diversified mutual funds are those funds that have one of the following investment objectives: balanced, growth, or growth and income. Undiversified mutual funds are sector funds that concentrate their investments in a single economic sector. They are communication funds, financial funds, health funds, precious metal funds, natural resources funds, real estate funds, technology funds, utility funds, and all other specialty funds. Morningstar calculates R^2 regressing mutual fund monthly returns on S&P 500 monthly returns over a 36 month period. R^2 supplied by Morningstar is on a scale from 0 to 100. The descriptive statistics are presented in Panel A and the tests statistics are in Panel B. The parametric test is the difference of means test on NR and the nonparametric test is the Wilcoxon rank sum test. For each test, the test statistic is given, followed by the significance level in parentheses. N is the number of mutual funds the S&P 500 index monthly returns over the 36-month period from January 1, 1992 through December 30, 1994.

The 22 mutual funds in the diversified sample have a mean R^2 of .6095 and a median R^2 of .6550, while the 34 mutual funds in the undiversified sample have a mean R^2 of .3321 and a median R^2 of .3100. When testing for a significant difference between the diversified mutual fund sample and the undiversified mutual fund sample, the difference of means test statistic is 5.71 (p-value of .000) and the Wilcoxon rank sum test statistic is 4.70 (p-value of .000). Therefore, the diversified mutual funds have significantly higher R^2s than the undiversified mutual funds.

Conclusions

The ability to diversify a portfolio across a broad range of stocks leads to efficient risk-sharing, but how do investors measure diversification in order to know if they are diversified? There are many commonly accepted measures of corporate diversification, but measures of portfolio and mutual fund diversification are lacking. Hirshleifer and Riley (1992) note that there is no handy rule to determine if a portfolio is diversified. Barnea and Logue (1973) did introduce an unambiguous, objective, easily calculated measure of diversification more than thirty years ago. They argue that the coefficient of determination, R^2, from the market model regression is a measure of diversification because as it increases, the more closely a portfolio's returns move with the market's returns. In this study, I evaluate Barnea and Logue's argument that R^2 is a measure of diversification. I first examine R^2 as a measure of portfolio diversification. Instead of just adding securities to a portfolio similar to Wagner and Lau (1971), I analyze a more direct measure of portfolio diversification. Controlling for the number of firms in a portfolio, I provide evidence that the diversified portfolios have significantly higher R^2s than the undiversified portfolios. I also test if Barnea and Logue's theory can be extended to publicly quoted mutual funds by analyzing the R^2s of mutual funds. R^2 already appears to be a measure of importance in the mutual fund industry because industry players such as *Morningstar* and *Fidelity Investments* provide the R^2s of the mutual funds that they monitor. Neither defines R^2 as a measure of diversification or in terms of diversification. Using the investment objective of a mutual fund supplied by *Barron's, Morningstar*, and *Fidelity Investments*, I find that diversified mutual funds have significantly higher R^2s than less-diversified specialty or sector funds. These findings support Barnea and Logue's belief that the coefficient of determination is a valid measure of portfolio and mutual fund diversification and present another way to interpret R^2 of a mutual fund.

According to the NYSE, more than one-third of the shareowners have no more than a high school education. According to Rode, portfolio diversification rarely occurs as suggested by portfolio theory because portfolio theory is too difficult for the average investor to understand. With the complexities of portfolio theory and the varied educational backgrounds of stockholders, a simple measure of diversification such as R^2 is of great value. The great appeal of R^2 is its simplicity. It is unambiguous, objective, easily calculated, and intuitively appealing.

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