The Effect of Capital Wealth on Optimal Allocation and Diversification

Abstract

It is well known that the wealthier the household, the larger tends to be the proportion of its total capital portfolio allocated to publicly traded stock, and the larger tends to be the number of individual stock issues included in its portfolio. Using the "homogeneous securities" case of a model proposed by Michael Brennan (1975), explicit functional forms are obtained for both the optimal proportion of the portfolio allocated to stocks, and the optimal number of individual stock issues in the portfolio. An empirical evaluation of these theoretical results, using a dataset derived from the 2004 Survey of Consumer Finances, lends substantial support to the Brennan model.

Journal of Economic Literature Classifications:
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The Effect of Capital Wealth on Optimal Allocation and Diversification

1. Introduction

It is well known that wealthier investors tend to hold a larger proportion of their assets in common stocks than do less wealthy investors, and that they diversify their stock portfolios to a greater extent. Since the widely proclaimed diversification prescription implies that every investor in common stock, whatever his or her total wealth level, should hold a substantial number of different stocks, the fact that smaller investors tend to hold a relatively limited number of stocks suggests that they are influenced, to a larger extent than wealthier investors, by the transactions costs involved in purchasing different stocks. In a word, wealthier investors can better afford the higher transactions costs involved in holding highly diversified portfolios.

This seems straightforward enough in an intuitive sense, but portfolio choice theory has paid rather little attention to this particular question. The seminal contributions of Markowitz (1952, 1959) focused on how a given level of capital wealth should be allocated over a range of assets with different characteristics; they do not consider how different amounts of wealth might affect the allocation process. The substantial theoretical and empirical portfolio choice literature has considered, and continues to consider, a very large number of factors that influence household investment patterns.

However, to the authors' knowledge, only a 1975 contribution by Michael J. Brennan directly and formally addresses the potential effect of variations in total capital wealth on the two key diversification questions: the proportion of total financial capital assets to be invested in stock issues, and the optimal amount of diversification in stock issues. Although Brennan did not develop explicit mathematical formulae for the optimal values, it is straightforward to obtain these from the "homogeneous securities" variant of his model. The purpose of this paper is to test these explicit theoretical predictions of Brennan's model using data from the 2004 Survey of Consumer Finances. The empirical analysis is supportive.

The remainder of this article is organized as follows. Section 2 sets forth the model. Section 3 describes the 2004 Survey of Consumer Finances and enumerates the variables utilized in this research. Section 4 presents the empirical results. Section 5 concludes.

2. Optimal Diversification with Homogeneous Securities

Let the capital wealth of an individual be denoted assets a. The proportion of a held in stocks is ρ, and the proportion held in bonds is $1 - \rho$. The wealth constraint is:

$$s + b = \rho a + (1-\rho)a = a \tag{1}$$

where s and b denote the holdings of stocks and bonds respectively. To simplify the analysis the variance of bond returns is set to zero. The rate of return on bonds, r_b, is then the risk-free rate of interest.

Using the capital asset pricing model, the rate of return on stock issue i, denoted $r_{s,i}$, is:

$$r_{s,i} = r_b + \beta_i (r_m - r_b) + \varepsilon_{s,i} \tag{2}$$

where β_i is the beta coefficient of stock issue i, r_m is the value-weighted market return, and $\varepsilon_{s,i}$ is the residual disturbance for stock issue i, with expected value zero and variance $\sigma^2_{s,i}$. Under the "homogeneous securities" assumption, $\beta_i = 1$ for all securities, and the mean and variance of the residual disturbance $\varepsilon_{s,i}$ for each stock issue are the same: $\varepsilon_{s,i} = \varepsilon_s = 0$ and $\sigma^2_{s,i} = \sigma^2_s$. Thus for all i, the random variable $r_{s,i} = r_m + \varepsilon_s$ has expected value $\overline{r}_s = \overline{r}_m$ and variance $\sigma^2_m + \sigma^2_s$. Since s is a high return asset, we assume $\overline{r}_s > r_b$.

The first diversification decision variable of the capital owner is ρ, the proportion of total capital assets to be held in the form of stock issues. The capital owner then sub-divides the stock portfolio equally over n different stocks. The number of stocks held is the second decision variable. For analytical purposes, it will be taken to be a continuous variable, although in practice, of course, it must be a discrete variable taking only integer values. The model specifies that an equal amount is held in each stock. This is not efficient according to most portfolio choice models, but it is apparently descriptive of real-world practices among many investors, as discussed by Benartzi and Thaler (2001), Stevenson (2001), Windcliff and Boyle (2004) and McClatchey and Vandenhul (2005). Also, this specification is consistent with the model assumption that all stocks are alike.

The cost of transacting in each security is assumed to be a fixed amount c. Then the rate of return on investment, net of the fixed costs of transacting, nc, is:

$$r = \sum_{i=1}^{n} r_{s,i} \frac{\rho}{n} + r_b(1-\rho) - n(c/a)(1+r_b) \tag{3}$$

The expected value and variance of return are:

$$\mathrm{E}(r) = \overline{r}_s \rho + r_b (1-\rho) - n(c/a)(1+r_b) \tag{4}$$

$$\mathrm{V}(r) = \rho^2 \left(\sigma_m^2 + \frac{\sigma_s^2}{n} \right) \tag{5}$$

Following Brennan, the criterion function to be maximized is:

$$L = \mathrm{E}(r) - \lambda \mathrm{V}(r) = \overline{r}_s \rho + r_b (1-\rho) - n(c/a)(1+r_b) - \lambda \left(\rho^2 (\sigma_m^2 + (\sigma_s^2 / n)) \right) \tag{6}$$

This is a mean-variance formulation where λ represents the marginal rate of transformation of risk for return. First-order conditions for the maximization of L are:

$$\frac{\partial L}{\partial \rho} = (\overline{r}_s - r_b) - 2\lambda\rho \left(\sigma_m^2 + \frac{\sigma_s^2}{n} \right) = 0 \tag{7}$$

$$\frac{\partial L}{\partial n} = -(c/a)(1+r_b) + \lambda\rho^2 \left(\frac{\sigma_s^2}{n^2} \right) = 0 \tag{8}$$

Solving (7) for n and (8) for n^2, we have respectively:

$$n = \frac{2\lambda\rho\sigma_s^2}{(\overline{r}_s - r_b) - 2\lambda\rho\sigma_m^2} \tag{9}$$

$$n^2 = \frac{\lambda\rho^2\sigma_s^2}{(c/a)(1+r_b)} \tag{10}$$

Eliminating n between (9) and (10):

$$4\lambda^2\sigma_m^4\rho^2 - 4\lambda\sigma_m^2(\overline{r}_s - r_b)\rho + (\overline{r}_s - r_b)^2 - 4\lambda\sigma_s^2(c/a)(1+r_b) = 0 \tag{10}$$

This is a quadratic equation in ρ with two roots. Evaluation of the expression under the radical sign in the quadratic formula establishes that the expression is always positive, indicating that the two roots of this quadratic equation are always real numbers. Further, evaluation of the second-order condition for a maximum establishes that it is the smaller of the two real roots (corresponding to the minus on the radical in the quadratic formula) that produces a maximum in L. Upon simplification of the quadratic formula expression for the smaller root, we obtain the optimal ρ, denoted by ρ*:

$$\rho^* = \frac{.5(\overline{r}_s - r_b)}{\lambda\sigma_m^2} - \frac{\sqrt{\sigma_s^2 c(1+r_b)}}{\sigma_m^2\sqrt{\lambda a}} \tag{11}$$

Substitution of ρ^* into (10) above determines the optimal n, denoted by n^*:

$$n^* = \frac{.5\sigma_s(\overline{r}_s - r_b)}{\sigma_m^2\sqrt{\lambda(c/a)(1+r_b)}} - \frac{\sigma_s^2}{\sigma_m^2} \tag{12}$$

As these are explicit formulae for optimal ρ^* and n^*, the comparative statics effects of the parameters on optimal diversification may be ascertained directly by inspection. Our particular interest is in the effect of total capital wealth a on optimal diversification. Isolating the a parameter, we have:

$$\rho^* = \phi_1 - \phi_2\frac{1}{\sqrt{a}} \text{ where } \phi_1 = \frac{.5(\overline{r}_s - r_b)}{\lambda\sigma_m^2};\ \phi_2 = \frac{\sqrt{\sigma_s^2 c(1+r_b)}}{\sigma_m^2\sqrt{\lambda}}\text{; and} \tag{13}$$

$$n^* = \psi_1\sqrt{a} - \psi_2 \text{ where } \psi_1 = \frac{.5\sigma_s(\overline{r}_s - r_b)}{\sigma_m^2\sqrt{\lambda c(1+r_b)}};\ \psi_2 = \frac{\sigma_s^2}{\sigma_m^2}\text{; and} \tag{14}$$

where the ϕ and ψ parameters are all positive. It is apparent that both ρ^* and n^* are concave increasing functions of total capital wealth a. Furthermore, whereas n^* increases indefinitely with a, there is an asymptotic upper limit on ρ^* at $\phi_1 = .5(\overline{r}_s - r_b)/\lambda\sigma_m^2$.

Note that expressions (11) and (12) are valid only for n^* and $\rho^* \geq 0$, since negative transactions costs are not allowed. It is useful to consider the marginal participation level of wealth at which n^* and $\rho^* = 0$. Equations (11)-(12) or (13)-(14) may be solved for the marginal participation level of wealth a^o:

$$a^o = \frac{\phi_2^2}{\phi_1^2} = \frac{\psi_2^2}{\psi_1^2} = \frac{\lambda c(1+r_b)}{.25(\overline{r}_s - r_b)^2}\sigma_s^2 \tag{15}$$

The other parameters have the intuitively expected effects. For optimal ρ^*: (1) $d\rho^*/d\overline{r}_s > 0$; (2) $d\rho^*/d\sigma_s^2 < 0$ and $d\rho^*/d\sigma_m^2 < 0$; (3) $d\rho^*/dr_b < 0$; (4) $d\rho^*/d\lambda < 0$; and (5) $d\rho^*/dc < 0$. These are intuitively expected results because, respectively: (1) a higher expected rate of return on stocks makes them more attractive; (2) higher variance on stock return makes stocks riskier and hence less attractive; (3) a higher rate of return on bonds make stocks relatively less attractive; (4) a higher level of risk aversion on the part of the capital owner, as reflected in a larger value of λ, makes risky stocks less attractive; and (5) higher transactions costs on stocks makes them less attractive. Because ρ^* and n^* are proportional to one another, the signs of the comparative statics derivatives for n^* are the same as those for ρ^*.

3. Survey of Consumer Finances Dataset

Although it is common knowledge that wealthier investors keep a larger proportion of their capital wealth in the form of common stock, formal statistical evidence of this fact is not overly abundant. Perhaps the most definitive early piece of evidence to this effect is reported in Table A 10 ("Composition of Portfolio of Liquid and Investment Assets, December 31, 1962") in the 1966 Projector-Weiss report on the Survey of Financial Characteristics of Consumers (SFCC) sponsored by the Federal Reserve Board. On the fifth page of this eight-page table (on p. 118 in the report), there is a size distribution by "size of portfolio" containing "mean investment assets" and "mean assets of publicly traded stock." For the low-wealth bracket of $500-$1,000, stock assets are 26.90 percent of total investment assets; for the medium wealth bracket of $50,000-$99,999, stock assets are 52.98 percent of total investment assets; while for the highest wealth bracket of $500,000 and over, stock assets are 71.30 percent of total investment assets.

There are only nine wealth brackets in the 1966 SFCC report. This high level of aggregation is repeated in other published sources of empirical information on capital wealth distribution. For example, the various articles documenting increasing financial inequality in the United States by Edward Wolff (1987, 1992, 1994) present size distributions containing five quintiles. The statistical results reported below are based on the entire dataset of 4,519 households contained in the 2004 Survey of Consumer Finances (SCF), and also on two aggregated datasets: the first consisting of 100 brackets each containing 45 households, and the second consisting of 25 brackets each containing 180 households. Descriptive statistics on the second of these are shown in Table 2 below. To the authors' knowledge, comparable information to that contained in this table has not heretofore appeared in any published source.

The Survey of Consumer Finances (SCF), described by the Federal Reserve Board as "a triennial survey of the balance sheet, pension, income, and other demographic characteristics of U.S. families," had its origins in the above-mentioned 1962 Survey of Financial Characteristics of Consumers and the 1963 Survey of Changes in Family Finances. The current triennial pattern was commenced in 1983. The SCF is remarkably comprehensive. The 2004 survey contains 2,834 data items (variables), and the full public dataset contains 4,519 households. Data obtained from the Survey of Consumer Finances have been utilized in numerous published studies on a wide variety of topics. A few illustrative recent examples include Castronova and Hagstrom (2004) on the demand for and usage of credit cards, Ben-Gad (2004) on the welfare effects of the Reagan era deficits, Baek and Hong (2004) on the determinants of consumer indebtedness, Aizcorbe et al

(2004) on household vehicle acquisition patterns, Bergstrasser and Poterba (2004) on household portfolio decisions, and Wu (2005) on the determinants of household saving behavior.

Table 1 lists the variables taken from the 2004 SCF dataset, as well as all constructed variables utilized in the research. The SCF variable X3914 is used directly as n (the number of stocks in the portfolio). Total capital wealth, the sum of variables 1 (X3721) through 11 (X3915), is the empirical analogue of wealth assets a. The proportion of capital wealth assets allocated to stock, ρ, is value of stock funds (X3822) plus value of stocks (X3915), divided by total capital wealth. Variable X3913 is a binary variable indicating whether or not the household owns some publicly traded stock. This variable is not used anywhere in the statistical analysis, but descriptive information on it is provided in Table 2, by way of general interest.

Variables 14 (X14) through 21 (X5901) are potential control variables for refining the estimated relationships between stock proportion and the capital wealth variable, and between number of stocks and the capital wealth variable. Certain of these variables are coded in a way inconsistent with the standard binary variable. For example, the variable X301 (expectations concerning the performance of the U.S. economy over the next five years relative to the last five years) are coded 1 for "better," 2 for "worse" and 3 for "about the same." These were re-coded to 1 for "better" and 0 for "otherwise." This adjustment was also made for the two other analogous variables: X302 and X304.

The researchers' expectation was that the large amount of random variation typically to be found in survey data would result in very low explanatory power of regressions of stock proportion and number of stocks on capital wealth, when the regressions are based on the entire dataset of 4,519 households. Not only is there considerable inaccuracy in responses, unintentional or otherwise, there will also be considerable unmeasured variation over households in the parameters of the Brennan model. For example, the parameter λ (marginal rate of substitution between risk and return), the indicator of household risk aversion, no doubt varies considerably over households, and there is no attempt to measure risk aversion in the SCF. The researchers' expectation in this regard was indeed fulfilled. In order to cope with the random variation problem, the full-set regressions were supplemented by regressions using two additional datasets composed of aggregated data. The entire dataset was sorted firstly in descending order on wealth, and secondly in descending order on wage and salary income. Two aggregated datasets of smaller size were then computed.

First, a dataset of 100 observations was constructed from the sorted data consisting of the mean values of the variables over 100 brackets, each containing 45 households. This method deletes the last 19 observations from the dataset, but this represents very little data loss from the full set of 4,519 observations. The deleted observations are at the bottom of the ranking, such that both capital wealth and wage and salary income for these 19 households are zero. Second, a dataset of 25 observations was constructed from the sorted data consisting of the mean values of the variables over 25 brackets, each containing 180 households. Again, this loses data from the last 19 observations. As the statistical results shown below manifest, by suppressing random variation within brackets, the relationships between the variables of primary interest to this research become much stronger.

Sorting the full dataset of 4,519 households on capital wealth reveals that 2,424 households report positive capital wealth; the other 2,076 households, approximately 46 percent of the total, report zero capital wealth. The 100-bracket dataset shows the first 54 brackets having positive mean capital wealth, while the 25-bracket dataset shows the first 14 brackets having positive mean capital wealth. Table 2 shows bracket means for the 25-bracket dataset for the capital wealth-related variables. For bracket 1 (the wealthiest bracket), the top line of data shows that for the 180 households in this bracket, mean capital wealth is $44,080,431, the proportion of households reporting ownership of stock securities is .9444, the mean number of stock securities owned by the household is 48.27, mean stock wealth is $30,124,101, and mean stock wealth as a proportion of mean capital wealth is .6834.

4. Empirical Results

Table 3 is based on the full SCF dataset of 4,519 households. Regression results for ρ (proportion of stock in portfolio) are on the left; those for n (number of stocks in portfolio) are on the right. In both cases there is a “sparse” formulation which omits the eight control variables and an “augmented” formulation which includes them. Note that for the ρ equation the number of observations is 2,424: the number of households with positive capital wealth. For the remaining households with zero capital wealth, both the ρ dependent variable and the $1/\sqrt{a}$ independent variable are undefined because of division by zero. This problem does not apply to the n equations, therefore they are based on all 4,519 observations.

Looking first at the ρ equations, the t-statistic on the $1/\sqrt{a}$ independent variable is –15.70 for the sparse formulation and –13.93 for the augmented formulation, both of which indicate the statistical significance of this variable at higher than the 99 percent confidence level. As for the control variables in the augmented formulation, some are significant and some are not, but as these variables are not of special concern to this research, interpretation of these results is left to the interested reader. The overall R-squared goodness-of-fit statistic, despite the high t-statistic of the $1/\sqrt{a}$ independent variable, is rather disappointing: 0.09 for the sparse formulation, rising only to 0.13 for the augmented formulation. Results for the n equation are basically analogous, except that the t-statistics on the $\sqrt{a}$ independent variable are unusually high, and as a result the R-squared statistics are reasonably high (for cross-section data).

As expected, owing to the large amount of random variation in data obtained from a survey, the regression equations shown in Table 3 do not have a great deal of explanatory power, even for the n equation. Therefore regressions were also run on the aggregated datasets described above; results are presented in Table 4. The Table 4 regressions all pertain to sparse formulations that omit the eight control variables. One reason for this is to put less “strain” on the much smaller number of observations. Also there may be problems in interpreting the estimated regression coefficients of the control variables because the entire dataset was sorted on total capital wealth. Unless there are very strong correlations between total capital wealth and the various control variables, the within-bracket means of the control variables may be unrepresentative. Finally, from the results in Table 3, the control variables apparently do not have a significant qualitative impact on the relationships of principal interest here: those between total capital wealth and stock proportion, and between total capital wealth and number of stock issues.

The left side of Table 4 pertains to dependent variable ρ and the right side to dependent variable n. For each dependent variable, results are shown for the 100-bracket dataset and the 25-bracket dataset. The ρ regressions are based on 54 observations from the 100-bracket dataset, and 14 observations from the 25-bracket dataset, because the remaining observations in these datasets are undefined in ρ and $1/\sqrt{a}$ (the observations for which a is zero). The n regressions are based on all observations: 100 from the 100-bracket dataset, and 25 from the 25-bracket dataset, since in this case all variables are defined for all observations. As expected, the explanatory power of the regressions are greater for the smaller datasets owing to the suppression of random variation within brackets. For example, the ρ regression equation has an R-squared of 0.80 for the 25-bracket dataset and 0.69 for the 100-bracket data, relative to 0.09 for the full dataset (sparse formulation).

Figures 1 and 2, based on the 100-bracket aggregated SCF dataset, are provided to illustrate visually the relatively good fit of the estimated equations to the SCF data. In these figures the horizontal axis represents not total capital wealth but rather the log of total capital wealth. If total capital wealth were used, the observations would be compressed too close to the left-hand vertical axis for the graph to be readable. Figure 1 pertains to ρ (proportion of stock in portfolio) and Figure 2 to n (number of stocks in portfolio). In both cases, a curve representing the estimated values of the dependent variables (respectively ρ and n), derived from the estimated equations, is superimposed over a scatter diagram of the actual values of these variables. Considering that these figures are based on notoriously variable survey data, the fits are fairly respectable.

5. Conclusion

By most accounts it is "common knowledge" that wealthier households hold a larger percentage of their total capital assets in the form of publicly traded stock, and that their stock capital portfolios are more diversified, than is the case with less wealthy households. Nevertheless, the effect of total capital wealth on optimal diversification has received rather little attention in portfolio theory. However, an important contribution on this subject was made in a 1975 article by Michael J. Brennan. On the basis of some strong assumptions, especially "homogeneous securities," the model enables mathematically explicit solutions for the optimal values of stock proportion ρ and number of stocks n. Direct inspection of these solutions indicates that the optimal stock proportion is a linear function of the reciprocal of the square root of total capital wealth, while the optimal number of stock issues is a linear function of the square root of total capital wealth. Data from the 2004 Survey of Consumer Finances (SCF) has been utilized in this research to evaluate these results.

The statistical analysis is supportive: the t-statistic of the $1/\sqrt{a}$ independent variable in the ρ equation (proportion of total portfolio allocated to stock) is strongly significant, both for the full SCF dataset and for the aggregated SCF datasets. While the R-squared goodness-of-fit statistic for the full SCF dataset is quite low, this statistic becomes respectably large for the aggregated SCF datasets. Results for the $\sqrt{a}$ variable in the n equation (number of stocks in the portfolio) are similar, except that even for the full SCF dataset, the R-squared goodness-of-fit statistic is fairly respectable given that the data is cross-sectional.

It goes without saying that some strong assumptions are necessary to obtain the mathematically explicit solutions and unambiguous comparative statics results forthcoming from the "homogeneous securities" variant of the Brennan model of optimal diversification. But it has been the universal experience of economic theoreticians that without strong assumptions, rather little of practical interest can be deduced. And strong assumptions are not necessarily invalid assumptions. The fact that reasonably good fits to notoriously variable survey data are obtained using regression specifications indicated by the Brennan model, is strong evidence that this model may in fact be a reasonable approximation to reality.

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Table 1
Variables Utilized in the Research

Survey of Consumer Finance (SCF) Variables:			
#	Name	Explanation	Usage
1	X3721	TOTAL VALUE OF CDS	*a* component
2	X3822	TOTAL MKT VAL STOCK FUNDS	*a* component
3	X3824	TOT MKT VAL TAX FREE BONDS	*a* component
4	X3826	TOT MKT VAL GVMT BACK BOND	*a* component
5	X3828	TOTAL MKT VAL OTHER BONDS	*a* component
6	X3830	TOTAL MKT VAL COMBO FUNDS	*a* component
7	X3902	VALUE OF SAVINGS BONDS	*a* component
8	X3906	MORT_BONDS:FACE VALUE	*a* component
9	X3908	TREAS_BONDS:FACE VALUE	*a* component
10	X3910	MUNI/STATE_BONDS:FACE VALUE	*a* component
11	X3915	TOTAL MARKET VALUE OF STOCKS	*a* component
12	X3913	HAVE ANY PUBLIC TRADED STOCK?	1 = yes; 0 = no
13	X3914	NUMBER OF DIFFERENT STOCKS	*n*
14	X14	RESPONDENT'S RECONCILED AGE	Control variable
15	X101	NUM PEOPLE IN HH ACCORD TO HHL	Control variable
16	X301	EXPECTATIONS FOR ECONOMY	Control variable
17	X302	INTEREST RATES HGHR, LWR, SAME?	Control variable
18	X304	PAST 5 YEARS INC HGHR, LWR, SAME?	Control variable
19	X3103	OWN/SHARE OWNERSHIP ANY BUS?	Control variable
20	X5702	AMOUNT OF WAGE-SALARY INCOME	Control variable
21	X5901	RESPONDENT GRADE COMPLETED	Control variable

Constructed Variables:	
a	= X3721 + X3822 + 3824 + X3826 + X3828 + X3830 + X3902 + X3906 + X3908 + X3910 + X3915
ρ	= (X3822 + X3915) / a
$1/\sqrt{a}$	reciprocal of square root of a
$\sqrt{a}$	square root of a
Log(a)	logarithm of a

Table 2
Bracket Means for the 25-Observation Dataset

Bracket	Value of Total Capital Wealth (a)	Proportion of Households Owning Some Stock (X3913)	Number of Stocks in Portfolio (n = X3914)	Value of Stocks in Portfolio (X3822 + X3915)	Value of Stocks as a Proportion of Value of Total Capital Wealth (ρ)
1	44,080,341	0.9444	48.27	30,124,101	0.6834
2	6,304,269	0.8389	25.44	3,817,593	0.6055
3	1,990,672	0.8722	20.61	1,338,079	0.6722
4	833,996	0.7889	12.91	556,062	0.6667
5	409,059	0.6667	9.49	270,766	0.6619
6	204,833	0.7111	5.59	144,152	0.7037
7	104,094	0.6222	3.56	66,863	0.6423
8	52,401	0.5167	2.84	32,138	0.6133
9	26,065	0.5611	2.12	15,467	0.5934
10	13,275	0.5000	1.58	7,229	0.5446
11	6,401	0.5278	1.15	3,681	0.5751
12	2,533	0.4056	0.71	1,306	0.5156
13	688	0.2056	0.31	186	0.2697
14	38	0.0278	0.04	4	0.1088
15	0	0	0	0	—
16	0	0	0	0	—
17	0	0	0	0	—
18	0	0	0	0	—
19	0	0	0	0	—
20	0	0	0	0	—
21	0	0	0	0	—
22	0	0	0	0	—
23	0	0	0	0	—
24	0	0	0	0	—
25	0	0	0	0	—

Table 3
Regression Equations for ρ (Proportion of Stock in Portfolio)
and n (Number of Stocks Held in Portfolio)
Full Survey of Consumer Finances (SCF) Dataset

Independent Variables	Estimated Regression Coefficients of Independent Variables (t-statistics in parentheses)			
	Dependent Variable ρ		Dependent Variable n	
	sparse	augmented	sparse	augmented
intercept	0.6356 (71.28)	0.3338 (4.41)	1.4808 (6.96)	–5.4915 (–3.85)
$1/\sqrt{a}$	–5.1055 (–15.70)	–4.8075 (–13.93)	—	—
$\sqrt{a}$	—	—	0.007556 (52.12)	0.006929 (42.70)
age of respondent	—	–0.0006 (–4.16)	—	0.0414 (2.99)
number in household	—	–0.0065 (–1.02)	—	–0.0864 (-0.57)
expect. better econ. perform.	—	0.0213 (1.34)	—	–0.4580 (–1.17)
expect. higher int. rates	—	0.0303 (1.24)	—	0.5006 (0.94)
higher income past 5 yrs	—	0.0466 (2.67)	—	0.7060 (1.51)
business ownership share	—	0.0162 (0.94)	—	2.4251 (4.98)
wage-salary income	—	–3.07E-10 (–0.07)	—	1.19E-07 (0.76)
years of education	—	0.0258 (6.62)	—	0.3049 (4.03)
R-squared	0.09	0.13	0.38	0.39
F-statistic	246.58	39.73	2716.62	316.03
observations	2424	2424	4519	4519

Table 4
Sparse Regression Equations for ρ and n
Using Aggregated SCF Datasets

Independent Variables	Regression Coefficients of Independent Variables (t-statistics in parentheses)			
	Dependent Variable ρ		Dependent Variable n	
	100 brackets	25 brackets	100 brackets	25 brackets
intercept	0.6364 (47.41)	0.6277 (27.21)	1.4057 (3.16)	1.1642 (2.00)
$1/\sqrt{a}$	–5.1607 (–10.85)	–3.5784 (–6.96)	—	—
$\sqrt{a}$	—	—	0.0077 (25.31)	0.0078 (19.71)
R-squared	0.69	0.80	0.87	0.94
F-statistic	117.77	48.46	641.08	388.61
observations	54	14	100	25

Figure 1
Actual and Estimated ρ (Proportion of Stocks in Portfolio)
54 Observations from 100-Household Aggregated SCF Dataset

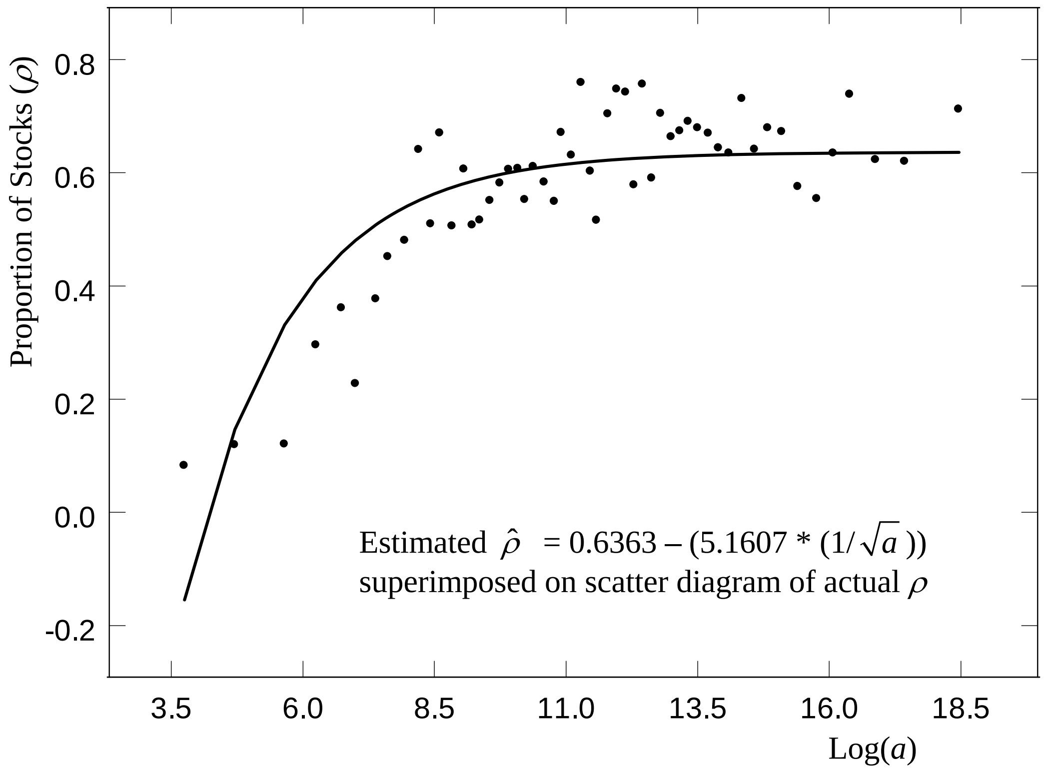

Figure 2
Actual and Estimated n (Number of Stocks in Portfolio)
100 Observations from 100-Household Aggregated SCF Dataset