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Household ratio guidelines for the amount of investments

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Abstract

Some textbooks suggest using financial ratios to provide simple indicators of whether households are making appropriate financial decisions. We investigate three investment ratios mentioned in textbooks: investments to net worth, investments to annual income, and investments to total assets. We conduct regressions on respondent evaluation of the adequacy of retirement income, among households with a non-retired head in the 2013 Survey of Consumer Finances. The investments to total assets ratio has the strongest relationship to adequacy, controlling for selected household characteristics. The investments to net worth ratio (Capital Accumulation ratio) is inferior to the other two ratios. © 2016 Academy of Financial Services. All rights reserved.

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1. Introduction

1.1. Background

Household financial ratios are used to help provide simple rules for financial decisions, because many households have trouble with more complex analyses (Greninger, Hampton, Kitt, and Achacoso, 1996; Harness, Chatterjee, and Finke, 2008). Financial ratio guidelines are intended to provide easily understandable rules, without necessarily allowing for indi-

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vidual circumstances. For instance, the guideline of saving 10% of income is widely accepted by financial experts (Greninger et al., 1996), and may provide a starting point for discussion between financial advisers and clients, but it is clearly not justified in terms of the normative life cycle model (Hanna, Fan, and Chang, 1995), as most households should not save in years when income is far below normal, and perhaps should save much more than 10% in some situations. However, as a simple educational device, financial ratio guidelines may be useful for educators and advisers.

One topic covered by a few proposed ratio guidelines is the appropriate amount of investments that should be held by households. The investment ratios we examine are related to retirement adequacy. A complete assessment of retirement adequacy is complex, and involves many assumptions (Greninger, Hampton, Kitt, and Achacoso, 2000). Survey analyses of retirement adequacy involve careful identification of the size and composition of retirement investments, expected retirement age, and projection of the levels of Social Security and any other pensions (Kim and Hanna, 2015; Yuh, Hanna, and Montalto, 1998). For many households, having multiple retirement income stages can further complicate the analysis of retirement adequacy (Kim, Hanna, and Chen, 2014).

Investment ratios can potentially provide a quick assessment of whether a household is on track to an adequate retirement. Guidelines related to the amount of investments ignore the role of home equity in the overall household portfolio (Cheung and Miu, 2015) and make many other simplistic assumptions. The most frequently mentioned investment ratio is the Capital Accumulation Ratio, which has been analyzed in a number of empirical analyses (Harness, Finke, Chatterjee, 2009; Letkiewicz and Hanna, 2013; Moon, Yuh, and Hanna, 2002; Yao, Hanna, and Montalto, 2002, 2003). The Capital Accumulation Ratio, defined as the proportion of net worth held in investment assets, was proposed by Lytton, Garman, and Porter (1991). It has been used in two personal finance textbooks, in editions of the Garman and Forgue (2003) from about 2000 to 2010, and in DeVaney (1997). These authors propose that having a Capital Accumulation Ratio of at least 25% is a good indicator of the ability to accumulate capital for future goals, as it shows that net worth is not being devoted to vehicles and one's personal residence. In the Greninger et al. (1996) article reporting a Delphi survey of financial planners and educators, a level of 50% for the ratio is suggested.

However, as Letkiewicz and Hanna (2013) note, the Capital Accumulation Ratio guideline advocated by Garman and Forgue (2003) in previous versions of their textbook before 2012 is not commonly suggested in financial planning textbooks. Garman and Forgue (2012, p. 78) suggest using the ratio of investments to total assets to answer the question of whether one is investing enough. They state guidelines of having the ratio be at least 10% for those in their 20's, 11% to 30% for those in their 30's, and over 30% for those aged 40 and over. Yao et al. (2002) mention the alternative of using the investments to assets ratio instead of the Capital Accumulation Ratio because of the problem of households having negative net worth.

Dalton, Dalton, Cangelosi, Guttery, and Wasserman (2005, p. 124) suggest using the ratio of investment assets to annual income, with a goal of having sufficient investments to generate the amount of income needed in retirement. They suggest having a ratio of 10 at retirement, with ratios of 3 to 4 about 10 years before retirement and a ratio of at least 1

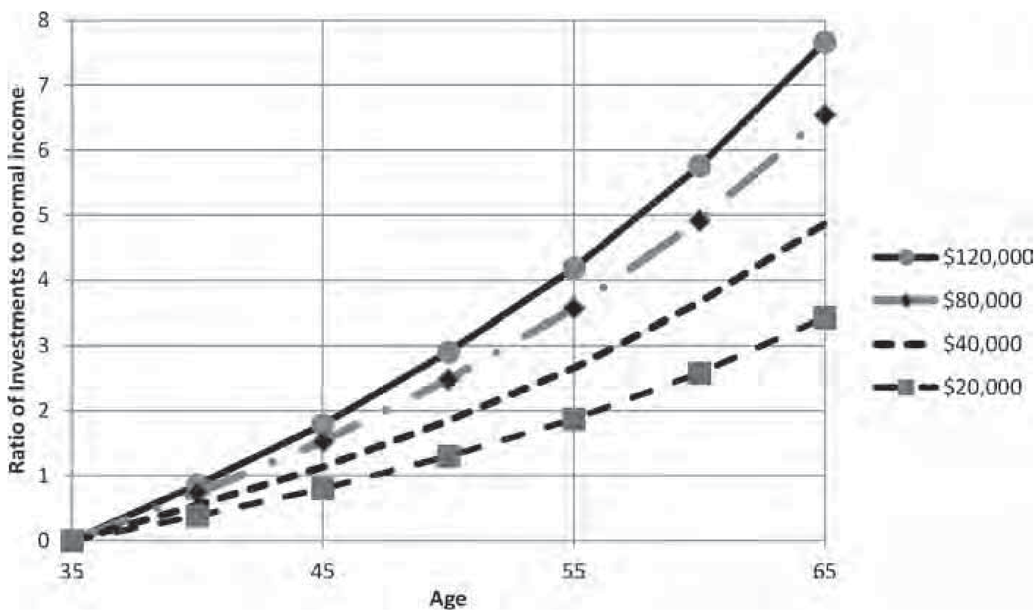

Fig. 1. Ratio of needed amount of retirement investments to income, Ibbotson analysis of amount to accumulate to replace 80% of net pre-retirement income, by age and income level. Calculations by author, based on table in Ibbotson (2008), p. 199.

about 20 years before retirement. This ratio is similar to the normative analysis presented in Ibbotson (2008, p. 199). Fig. 1 shows graphically the pattern implied by the results in Ibbotson. As shown, the needed ratio depends not only on age, but also on income, because of the progressive nature of Social Security pension benefits and taxes on current earnings.

While a number of empirical studies have been conducted using the Capital Accumulation Ratio (see review by Letkiewicz and Hanna, 2013), there are no empirical studies of one of the newer ratios, the ratio of investment assets to annual income (Dalton et al., 2005). There is one brief abstract related to the other newer ratio used by Garman and Forgue (2012), the ratio of investment assets to total assets. Yao and Hanna (2002) report comparisons how well the 25% Capital Accumulation Ratio guideline is related to retirement adequacy to how well the 25% investment to assets guideline is related to retirement adequacy, and note that neither guideline is a very good indicator of retirement adequacy. Many of the previous empirical studies on investment ratios focus on meeting simple thresholds, and therefore, have not provided much insight into what levels might be best for households. There have been no rigorous analyses of whether particular ratio levels are optimal (Moon, et al, 2002).

1.2. Objectives

Lytton et al. (1991) suggest that establishment of ratio guidelines "… would be dependent on … empirical research to determine appropriate empirical ranges." Harness et al. (2009) also suggest that ratio guidelines should be research based. They note that "A problem with using ratios as tools is that the extant literature testing their value is limited. For example, there is little evidence that a capital accumulation ratio of 0.7 is better than one of 0.3." The objective of this article is to provide insights into three household investment ratios, what value of each ratio is best, and whether one ratio is better than the others. We do not directly test whether guidelines proposed by textbook authors make sense, as there is no rigorous analysis presented by any of the authors. We present distributions of the two newer ratios, along with the Capital Accumulation Ratio, based on analyses of the 2013 Survey of Consumer Finances. Furthermore, for an exploratory attempt to derive normative results for levels of the three investment ratios, three Ordinary Least Squares (OLS) regressions are utilized, with respondent assessment of the adequacy of future retirement income, as a function of age, homeownership status, having a defined benefit plan, and employment status along with linear and quadratic variables for each investment ratio. Our conclusion on which ratio is the best is based on the explanatory power of each ratio regression, and also the plausibility of the effects of the ratio on the assessment of retirement adequacy, and the mathematical properties of each ratio.

2. Method

2.1. Mathematical considerations for financial ratios

Harness et al. (2009) note that many financial ratios have a non-normal distribution. The component variables of the three ratios related to investments are income, investments, net worth, and total assets. All have skewed distributions, especially the asset and net worth variables, with very long tails of the distribution. Further, many households have zero or negative net worth, making interpretation of the Capital Accumulation Ratio problematic, because net worth is in the denominator of the ratio.

2.2. Data and sample

In this study, the 2013 Survey of Consumer Finances (SCF) released by Federal Reserve Board (Bricker et al., 2014) is used. The total sample size of the 2013 SCF is 6,015 and for our main analyses, households with non-retired heads ($N = 5{,}665$) are analyzed.

2.3. Dependent variable

If an investment ratio is to provide some guidance for financial planning, presumably the level of the ratio should be related to projected retirement adequacy. This is the approach used by Yao et al. (2003), although they use arbitrary levels of the Capital Accumulation Ratio and analyze the effect on an objective measure of retirement adequacy. In this exploratory study, we use the household’s subjective assessment of retirement adequacy as a dependent variable. The SCF variable (X3023) has five levels:

> X3023 Using any number from one to five, where one equals totally inadequate and five equals very satisfactory, how would you rate the retirement income you receive (or expect to

receive) from Social Security and job pensions? Include 401(k) accounts and all other types of pensions.

1. *TOTALLY INADEQUATE
2.
3. *ENOUGH TO MAINTAIN LIVING STANDARDS
4.
5. *VERY SATISFACTORY

Kim and Hanna (2015) show that this variable is related to an objective estimate of retirement adequacy, although not perfectly. If we want to include households of all ages, and not make arbitrary assumptions about the retirement ages of those who did not list a specific retirement age, the subjective measure of retirement adequacy has advantages over the objective measure. Three OLS regressions on subjective retirement adequacy are run, controlling for age of head, age squared, homeownership status, having a defined benefit pension, employment status and one of the ratio variables. To allow for nonlinear effects of the ratios on subjective retirement adequacy, a quadratic term for the ratio is also included.

We include linear and quadratic terms for both age and for each ratio. Appendix A shows how to obtain the optimum level (extreme point) for age and for each ratio using basic principles from calculus.

2.4. Independent variables

2.4.1. Key variables: three investment ratios

Each of the ratios has the value of investments in the numerator. Investment assets consist of all financial assets other than monetary assets such as checking and saving accounts, plus nonfinancial assets such as art work, antiques, net business assets, and real estate other than the personal residence. Monetary (liquid) assets include checking, savings, money market, and call accounts, and are not counted as part of investment assets, although certificates of deposit are included as investment assets. Net worth is the sum of monetary assets, investment assets, and non-financial assets minus consumer debt and property debt. As shown in the descriptive results below, there are some extreme values of the ratio, so some adjustments are made for the regression analysis. In our analytic sample, 71% of households have positive amounts of investments.

The Capital Accumulation Ratio is defined as investment assets-to-net worth and is calculated from information on investment assets and net worth. If net worth is zero or negative, then the ratio is defined as equal to the value of investments, in other words, the denominator will be assumed to be equal to one (cf., Letkiewicz and Hanna, 2013). Table 1 illustrates the rationale for recoding the ratio for values of net worth less than or equal to zero. Assume that the value of investment assets equals $10,000. For a household with net worth of $100,000, the ratio is 0.1, and for a household with $10,000 of net worth, the ratio is 1.0. However, as net worth approaches zero, the ratio increases, for example, it is 10,000 for net worth of $1, and the ratio is not defined for net worth of zero. Conceptually, as net worth decreases in the positive range, the increase in the ratio values represents increased leverage. However, as net worth decreases from zero in the negative range, the ratios are

Table 1 Illustration of distribution of investments to net worth ratio, assuming investments = $10,000

Net worth ($)	Ratio
100,000	0.1
10,000	1
5,000	2
1,000	10
100	100
10	1,000
1	10,000
0.1	100,000
0.01	1,000,000
−0.01	−1,000,000
−0.1	−100,000
−1	−10,000
−100	−100
−1,000	−10
−10,000	−1
−100,000	−0.1

Note: Table created by authors.

negative. For net worth of $1, the ratio is 10,000, but for a net worth of −$1, the ratio is −10,000. This switch does not make sense in terms of our objective of relating values of the ratio to retirement adequacy. In both cases the household is highly leveraged. Consider somebody who just graduated from college with $110,000 of debt and no assets other than an IRA worth $10,000. Even though the situation is different from somebody with net worth of $1 and an IRA worth $10,000, it seems reasonable to assign a value of the ratio of 10,000 to both cases, rather than a ratio of −0.1 to the person with $110,000 of debt. Therefore, we follow the example of Yao et al. (2002) and Yao et al. (2003) and calculate the ratio as investments divided by 1.0 if net worth is non-positive. In our analytic sample, there are 579 households with zero or negative net worth (11.7% of the sample based on a weighted analysis.).

The ratio of investments to annual income (Dalton et al., 2005) is calculated as the ratio of investments to annual household income. Dalton et al. (2005) do not specify whether income should be measured as current or normal income, but we use respondent estimates of normal income. If the denominator is zero, the ratio is defined at the value of investments. As with the Capital Accumulation Ratio, there are some extreme values of the ratio, so adjustments are made for the regression analysis. Dalton, Dalton, and Oakley (2014) discuss the ratio of investments plus monetary assets to gross earnings, although this ratio does not address the idea of needing investments that will grow. However, as a worker approaches retirement, it is plausible that those that are risk averse will shift some investments to monetary assets such as money market accounts. In our analytic sample, there are eight households reporting zero normal income (0.08% of the sample based on a weighted analysis).

The ratio of investments to total assets (Garman and Forgue, 2012) is calculated as the ratio of investment assets to total assets. Total assets include both financial assets and non-financial assets. For the 82 households with zero assets (1.56% of the sample based on a weighted analysis.), the ratio is defined as the value of investments, which in all cases is equal to zero.

2.4.2. Control variables

In each regression, in addition to the ratio and the square of the ratio, a few household characteristic variables directly related to retirement adequacy are included as control variables. The age of the household head and the square of the age (divided by 10,000 to scale the estimated coefficients) were included. To test for whether optimal ratio levels depend on age, interaction variables are created between age and the ratio and the square of the ratio. One disadvantage of adding interaction terms is that there is multicollinearity because of the interaction terms, resulting in some effects not being significantly different from zero, so for comparison, we also present regressions without interaction terms (Appendix B). Dummy variables for whether the household owns its home, and whether the head has a defined benefit pension are included. Furthermore, dummy variables for whether the head works part-time, and whether the head is not working but not retired are included (both relative to the head working full-time).

2.5. Descriptive and multivariate analyses

For descriptive analyses, quantiles, means, and skewness of the ratios are obtained with weighted analyses, both for the entire 2013 SCF sample and for the analytic sample of households with a non-retired head. In addition, the means and medians of the ratios for age groups are obtained with weighted analyses. OLS regressions are utilized to estimate the effect of ratio levels on respondent assessment of the adequacy of retirement income. The suggestions in Lindamood, Hanna, and Bi (2007) are followed in analyzing the data, including use of unweighted regressions.

3. Results

3.1. Descriptive results

For all 6,015 households in the 2013 SCF, the maximum level of net worth in the 2013 SCF is $1,324,417,600, with 11.59% of households having negative net worth, and 1.33% of households having zero net worth. (The SCF includes vehicles, housing, and financial assets, but does not include the value of personal possessions such as furniture.) The maximum value of investment assets is over one billion dollars, $1,320,813,200. However, 30.57% of households have zero investment assets, and one household is coded as having negative investments, presumably because of debt not recorded elsewhere. The maximum value of assets is $1,324,540,600, and there is also a case with a negative value for total assets.

Table 2 shows the distribution of the three ratios for all households and for households with non-retired heads. For all households, the maximum value of the investments to net worth ratio is almost 59,000,000, partly because of the almost 13% of households with zero or negative net worth. For instance, a young recent college graduate with $1,000 in a mutual

Table 2 Distribution of three investment ratios, all households (untrimmed) and households with non-retired head, trimmed ratios

Distribution	Investment/net worth		Investment/normal income		Investment/total assets	
	All households	All non-retired*	All households	All non-retired**	All households	All non-retired
Mean	1026.43	6.98	383.17	2.32	0.28	0.29
Maximum	58,580,000	130.00	125,340,000	30.00	1.00	1.00
99th percentile	20,000	130.00	30.35	30.00	0.98	0.98
95th percentile	130.00	100.00	11.43	11.74	0.76	0.88
75th percentile	0.76	0.77	2.12	2.25	0.52	0.53
Median	0.35	0.37	0.31	0.38	0.17	0.19
25 percentile	0.00	0.00	0.00	0.00	0.00	0.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00
Skewness	74.35	4.57	55.80	3.10	0.70	0.65

Note: Analysis by authors of 2013 Survey of Consumer Finances, weighted. Ratios defined as value of investments if denominator ≤0. Recoded to 0 if investments <0.

*Values above 130 recoded to 130.

**Values above 30 recoded to 30.

fund and $30,000 in student debt would have an investments to net worth ratio of 1,000. The maximum value of the investments to annual income ratio is over 125,000,000, whereas the maximum value of the investments to total assets ratio is only 1.00. For all households, the median level of the investments to net worth ratio is 0.35, the median for the investments to normal income ratio is 0.31, and the median for the investments to total assets ratio is 0.17. For all households, the skewness of the investments to net worth and the investments to normal income ratios are very high (74 and 56, respectively), but the skewness of the investments to total assets ratio is only 0.7.

The columns for the ratio with non-retired heads correspond to the sample used for the regression analyses. In addition, for these columns and for the regression, extreme values of the investments to net worth ratio and of the investments to normal income ratio are recoded. For all households, the 95th percentile of the investments to net worth ratio is 130, so for households with values of the ratio above 130, the ratio is recoded to 130 to avoid having overly influential values in the regression analysis. The 95th percentile of the investments to normal income ratio is 11.43 for all households. That level is not extreme in terms of the Ibbotson (2008) normative analysis (see Fig. 1), so we instead use the approximate level of the 99th percentile in the full sample, 30, as the point of recoding for our analytic sample of non-retired households. Values of the investments to normal income ratio above 30 are recoded to 30. The rationale for both of these recoding rules is to limit the effect of a few extreme values on the dependent variable.

Table 3 shows mean and median values of the three ratios by age ranges. The mean values of the investments to net worth ratio decrease by age, contrary to textbook discussions of the desirable patterns of the ratio by age (DeVaney, 1997; Garman and Forgue, 2003). The median value of the investments to net worth ratio increases by age up to the 55 to 64 age range. The mean value of the investments to normal income ratio increases by age, from 0.50 for those under 25 to 3.99 for those 65 and over. The median value of the investments to

Table 3 Mean and median of ratios by age groups

Age range	Investments/net worth*	Investments/normal income**	Investments/assets
Mean			
<25	18.30	0.50	0.13
25–34	16.13	0.64	0.20
35–44	8.92	1.20	0.27
45–54	5.80	2.03	0.32
55–64	4.13	3.15	0.36
65 and over	1.25	3.99	0.32
Median			
<25	0.00	0.00	0.00
25–34	0.27	0.08	0.07
35–44	0.40	0.29	0.18
45–54	0.46	0.63	0.25
55–64	0.49	0.95	0.33
65 and over	0.29	1.02	0.24

Note: Analysis by authors of households with non-retired heads of 2013 Survey of Consumer Finances, weighted. Ratios defined as value of investments if denominator ≤0. Recoded to 0 if investments <0.

*Values above 130 recoded to 130.

**Values above 30 recoded to 30.

normal income ratio increases by age, from 0.00 for those under 25 to 1.02 for those 65 and over. The mean value of the investments to assets ratio increases by age up to the 55 to 64 range, from 0.13 for those under 25 to 0.36 for those in the 55 to 64 range. The median value of the investments to assets ratio increases by age up to the 55 to 64 range, from 0.00 for those under 25 to 0.33 for those in the 55 to 64 range.

3.2. Regression results

Table 4 shows the results for three OLS regressions, with the dependent variable being the respondent's subjective assessment of the adequacy of retirement income, including interaction terms between age of the head and the ratio and the square of the ratio. (Appendix B has the same regressions without the interaction terms.) The effects of the ratio of investments to net worth and the square of that ratio, as well as the interactions of age with the ratio and with the ratio squared, are not significant. Age and age squared are significant, and the combined effect implies that at a value of the ratio equal to zero, subjective assessment of retirement adequacy decreases with age up to age 40, then increases as age increases above age 40. Homeowners have a higher level of perceived retirement adequacy than otherwise similar renters. Those with a defined benefit pension have significantly higher assessments of adequacy than those without one. Households with a head employed part-time, and those with a head not working but not retired, have higher assessments of adequacy than those with a head employed full-time. The adjusted R^2 for the regression is 0.044.

For the second OLS regression shown in Table 4, the effects of the ratio of investments to normal income and the square of that ratio, as well as the interactions of age with the ratio and with the ratio squared, are not significant. In a version of the regression without interaction terms (Appendix B), the effects of the ratio and the ratio squared are significant,

Table 4 Regressions on subjective assessment of retirement adequacy, among households with non-retired head, by investment ratios, controlling for age, homeownership, having defined benefit plan, working part-time, and not working

Variable	Investment/net worth		Investment/normal income		Investment/assets	
	Coefficient	*p*-value	coefficient	*p*-value	coefficient	*p*-value
Ratio	−0.0446	0.2071	−0.0227	0.4699	0.2566	0.6800
Ratio Squared	0.0003	0.2054	−0.0002	0.8594	−0.5280	0.4593
Age * Ratio	0.0014	0.1295	0.0009	0.0767	0.0266	0.0182
Age * Ratio Squared	−0.00001	0.1231	−0.00002	0.3338	−0.0205	0.1064
Age of head	−0.0261	<.0001	−0.0225	<.0001	−0.0301	<.0001
Age of head/10000	3.2870	<.0001	2.7423	<.0001	3.2392	<.0001
Homeowner	0.1565	0.0001	0.1399	0.0007	0.0693	0.0930
Have defined benefit pension	0.3922	<.0001	0.3893	<.0001	0.3682	<.0001
Employment status of head (reference category: full-time)						
Head working part-time	0.1344	.0204	0.1387	0.0172	0.1504	.0095
Head not working but not retired	0.1700	.0009	0.1933	0.0002	0.2331	<.0001
Intercept	2.6254	<.0001	2.5700	<.0001	2.6884	<.0001
Adjusted R^2		0.0444		0.0500		0.0577

Note: Analysis by authors of 2013 SCF, households with non-retired heads. Extreme values of ratios recoded. Unweighted analyses. RII technique used.

and the combined effect of the ratio and ratio squared are positive up to a level of 14. Age and age squared are significant, and the combined effect implies that at a value of the ratio equal to zero, subjective assessment of retirement adequacy decreases with age up to age 41, then increases as age increases above age 41. Homeowners have a higher level of perceived retirement adequacy than otherwise similar renters. Those with a defined benefit pension have significantly higher assessments of adequacy than those without one. Households with a head employed part-time, and those with a head not working but not retired, have higher assessments of adequacy than those with a head employed full-time. The adjusted R^2 for the regression is 0.050.

For the third OLS regression shown in Table 4, the effects of the ratio of investments to assets and the square of that ratio do not have significant effects on retirement adequacy, but the interaction of age and the ratio is significant and positive. In a version of the regression without interaction terms (Appendix B), the effects of the ratio and the ratio squared are significant, and the combined effect of the ratio and the ratio squared are positive up to a level of 0.52. Age and age squared are significant, and the combined effect implies that at a value of the ratio equal to zero, subjective assessment of retirement adequacy decreases with age up to age 46, then increases as age increases above age 46. Those with a defined benefit pension have significantly higher assessments of adequacy than those without one. Households with a head employed part-time, and those with a head not working but not retired, have higher assessments of adequacy than those with a head employed full-time. The adjusted R^2 for the regression is 0.058.

Table 5 shows the levels of each ratio for which there is an extreme point in terms of the combined effects of the ratio and ratio squared and the interaction terms in each regression, based on the formula shown in Appendix A. All of the numbers shown in Table 5 represent maximum points, for example, for a household head age 25, the level of the investments to assets ratio that maximizes the assessment of retirement income is 0.44. There is no

Table 5 Optimum values of ratios by age, based on regressions

Age	Investments/net worth	Investments/normal income	Investments/assets
25	68.28	−0.07	0.44
35	56.01	6.06	0.48
45	61.70	10.01	0.50
55	62.58	12.77	0.52
65	62.94	14.80	0.53

Note: Based on regressions in Table 4.

monotonic pattern between age and the level of the investments to net worth ratio. For the investments to normal income ratio, for all ages above 25, the optimal level of the ratio increases with age, from 6.06 at age 35 to 14.80 at age 65. For the investments to assets ratio, the optimal level of the ratio increases slightly with age, from 0.44 at age 25 to 0.53 at age 65.

4. Summary and implications

4.1. Summary

The investments to net worth ratio (also known as the Capital Accumulation Ratio) is the only household financial ratio related to the amounts of investments for which there has been empirical research, and it is discussed in two personal finance textbooks (DeVaney, 1997; Garman and Forgue, 2003). However, it has some problematic mathematical properties (Harness, et al., 2008), as it cannot be directly calculated for almost 13% of the households in the 2013 SCF. The ratio is not related to subjective assessment of retirement adequacy among households with non-retired heads. Another financial ratio, the investments to annual income ratio, is also discussed in a textbook (Dalton et al., 2005). However, it has extreme values for a small proportion of households. It is not as strongly related to subjective assessment of retirement adequacy as the ratio of investment assets to total assets.

The investments to assets ratio is discussed in a textbook (Garman and Forgue, 2012). The investments to total assets ratio has advantages in terms of some of the mathematical issues discussed by Harness et al. (2008). Even though it has a skewed distribution, it is not as skewed as the other two ratios. Furthermore, it is almost always possible to calculate the investments to total assets ratio, as long as the household does not have zero assets. The regression with the investments to assets ratio has a higher adjusted R^2 than the regressions with the other two ratios.

Further, the investments to total assets ratio has a positive effect on subjective retirement adequacy for most households, even though in the OLS regression we might interpret a small decrease in subjective adequacy as the ratio increases above a level of 0.6. By contrast, the investments to net worth ratio does not have a statistically significant effect on subjective retirement adequacy. The investments to normal income ratio does have a significant positive effect on subjective retirement adequacy, though it has some very extreme values, unlike the investments to assets ratio.

4.2. Implications

As with any household financial ratio above, the investments to asset ratio can at best be a simplistic guide to initial thinking about financial decisions. Further, the OLS regression with subjective retirement adequacy also has significant effects for homeownership, age, and having a defined benefit pension. Therefore, for instance, if two households are similar in terms of age and homeownership status, and have the same value of the investments to asset ratio, but one has a defined benefit pension but the other has nothing but Social Security, it makes sense that they would have different assessments of retirement adequacy.

If an author or educator wants to use a financial ratio guideline related to the amount of investments in terms of two of three criteria stated in Section 1.2, the investments to assets ratio is superior to other ratio guidelines that have been proposed. For the regressions of ratios on perceived retirement adequacy, the investments to assets ratio has the highest R^2 and has the best mathematical properties. The relationship between ratio levels and retirement adequacy are plausible for both the investments to assets ratio and the investments to normal income ratio, though in the regressions with interaction terms with age (Table 4), none of the terms involving the investments to normal income ratio are significantly different from zero, while for the investments to assets ratio, one term is significant. In the regressions with no age interaction terms (Appendix B), the ratio and the square of the ratio have highly significant effects for both the investments to normal income ratio and the investments to assets ratio.

For the investments to assets ratio, a ratio guideline of 0.5 might be plausible, based on our regression results. As with any financial ratio guideline, one should be cautious in applying such guidelines, as a more complex analysis of a household's situation is always desirable.

Even though the investments to assets ratio is best in terms of mathematical properties and explanatory power, the investments to normal income ratio has some plausibility in terms of financial planning models (e.g., Fig. 1). Both the median and mean levels of both the investments to normal income ratio and the investments to assets ratio by age group (Table 3) are far below the optimal levels of these two ratios based on the regressions (Table 5). This divergence between the optimal patterns and actual patterns is consistent with most research on retirement adequacy (Hanna, Kim, and Chen, 2016).

The investments to net worth ratio, also known as the Capital Accumulation Ratio, has poor mathematical properties, and has limited explanatory power in terms of the regression on perceived retirement adequacy. Even though this ratio is the only investment ratio with an extensive amount of empirical research, it should not be used in financial education or advising in the future.

Appendix: a finding maximum levels for age and for each ratio from regression results.

If Y is the assessment of retirement adequacy, and X is either age or the ratio, the relevant results from each regression without interaction terms between age and the ratio can be expressed as:

Table B1
Regressions on subjective assessment of retirement adequacy, among households with non-retired head, by investment ratios, controlling for age, homeownership, having defined benefit plan, working part-time, and not working

Variable	Investment/net worth		Investment/normal income		Investment/assets	
	coefficient	*p*-value	coefficient	*p*-value	coefficient	*p*-value
Ratio	0.0062	.6627	0.0340	<.0001	1.6088	<.0001
Ratio squared	−5.4E-05	.6220	−0.0012	<.0001	−1.5457	<.0001
Age of head	−0.0255	<.0001	−0.0274	<.0001	−0.0301	<.0001
Age of head/10,000	3.3069	<.0001	3.4001	<.0001	3.3601	<.0001
Homeowner	0.1574	<.0001	0.1307	.0003	0.0776	.0591
Have defined benefit pension	0.3915	<.0001	0.3905	<.0001	0.3678	<.0001
Employment status of head (reference category: full-time)						
Head working part-time	0.1345	.0204	0.1405	.0151	0.1693	.0034
Head not working but not retired	0.1616	.0015	0.1863	.0003	0.2242	<.0001
Intercept	2.6063	<.0001	2.6401	<.0001	2.5785	<.0001
Adjusted R^2		0.0444		0.0503		0.0578

Note: Analysis by authors of 2013 SCF, households with non-retired heads. Extreme values of ratios recoded. Unweighted analyses. RII technique used.

$$Y = aX + bX^2. \quad (1)$$

$$dY/dX = a + 2bX. \quad (2)$$

At extreme point, slope =0.

$$\text{So, } X_e = -a/2b. \quad (3)$$

If a > 0, X_e is a maximum.
If a < 0, X_e is a minimum.

The calculus is more complicated with the interaction terms.
With X = ratio, G = age, coefficients = a, b, c, d

$$Y = aX + bX^2 + cGX + dGX^2. \quad (4)$$

$$dY/dX = a + 2bX + cG + 2dGX. \quad (5)$$

$$\text{at slop} = 0, X = -(a + cG)/(2b + 2dG). \quad (6)$$

Appendix B

Table B1 shows regressions of the ratios and the square of the ratios, without interaction terms between age and the ratio and ratio squared variables. (The regressions with interaction terms for age, shown in Table 4, have very high Variance Inflation Factors for the interaction terms, indicating multicollinearity, which resulted in all but one of the interaction terms not being statistically significant.) For the investments to net worth ratio regression, the ratio and its square are not significant, and the combined effect implies that perceived retirement adequacy is maximized at a level of the ratio of almost 57, an extreme level of household leverage. For the investments to normal income ratio regression, both the ratio and its square have significant effects, and the combined effect implies that perceived retirement adequacy is maximized at a level of the ratio of almost 14. For the investments to asset ratio regression, both the ratio and its square have significant effects, and the combined effect implies that perceived retirement adequacy is maximized at a level of the ratio of 0.5.

As with the regressions with interaction terms between age and ratio and ratio squared (Table 4), the adjusted R^2 is highest for the investments to assets ratio regression, and lowest for the investments to net worth ratio regression.

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