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"Estimation Risk in Morningstar Fund Ratings," H.D. Vinod; Mathew R. Morey, ***Journal of Investing*** Vol. 11 (4), 2002, 67-75.

This is a replication of the original work.

EmpR number	EmpR Description	Where to find EmpR	Where to find Replicated Result (filename, etc)	Comment on success in replication.
1	Exhibit 1: Understanding Morningstar Risk	Exhibit 1, page 70	Exhibits.xls, worksheet 'Exhibit1'	See Exhibit 1 below.
2	Exhibit 2: Characteristics of International Fund Sample	Exhibit 2, page 71	Exhibits.xls, worksheet 'Exhibit2'	See Exhibit 2 below.
3 & 4	Exhibit 3 & 4: Weighted Confidence Interval Widths Organized by Age: A Dummy Variable Analysis	Exhibit 3 & Exhibit 4, page 73-74	Exhibits.xls, worksheet 'Exhibit3and4'	See Exhibit 3 and 4 below.

PROGRAMS and Code:

EmpR number	Replication date	Replicator's Computer processor speed, operating system	Replicator's Software name (vendor) version number	Program file names
1	4/7/2005	AMD Athlon Processor 1.15 GHz 1.00 GB RAM Windows XP Professional Version 2002 Service Pack 2	Microsoft Excel 2002	Calc for Return.xls
2	4/8/2005			AssignStars.xls
3	4/12/05			Confidence Intervals.xls
4	4/12/05		R 1.9.1	See code below.

The GAUSS Light Version 3.2.40 (student version) is very limited in its procedural capabilities, so I used Excel for my initial findings and then used R for the regression analysis. Where I used Excel for the initial findings, the originators wrote procedures in GAUSS. The originators used GAUSS for the regressions also, whereas I used R.

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Article Description:

Investors often base mutual fund selection on Morningstar ratings. The very nature of using discrete star ratings, as opposed to using a continuous numerical value, will cause estimation error. In addition, in calculating Morningstar ratings for mutual funds, Morningstar uses a weighting system which requires younger funds to be rated on less information than older funds. This causes estimation risk, as we can expect younger funds' estimates to be less accurate (contain more estimation risk). In using this weighting system, time frames overlap and this too causes estimation risk.

This paper attempts to determine the estimation risk of the Morningstar ratings by determining the estimation risk in the underlying estimates used to calculate the star ratings. In the following replication paper I attempt to replicate the findings using Microsoft Excel and R.

I begin by explaining how Morningstar calculates the star ratings. Then I use the original 2001 data for the 1281 International Equity funds to recalculate the risk-adjusted return measure for each of the funds within the sample. Next I convert these risk-adjusted return measures to star ratings following Morningstar's logic.

I then employ two different methods to generate the confidence intervals. I first attempt to find average confidence intervals (unweighted and weighted) using Excel. My calculations do not match the original work. However they do depict increased estimation risk for young funds as opposed to seasoned funds. Next I run three regressions in R and depict the results.

My results are depicted in the replicated exhibits toward the end of this paper.

Explanation of Morningstar Calculations for Overall Star Rating
In order to calculate the overall Morningstar Rating, Morningstar first classifies funds into one of four categories: domestic equity, international equity, municipal bond, or taxable bond.

1. **Morningstar Calculates the Risk-Adjusted Return:**
Morningstar calculates an expense and load adjusted return by adjusting for expenses such as 12b-1 fees, management fees. Next it divides this adjusted return by the higher of:

The excess return of the fund category minus the 90-day US Treasury Bill rate
Or
The average 90-day US Treasury Bill rate

The higher of those measures is used to prevent distortions caused by very low or negative average excess returns.

2. **Morningstar Calculates a Risk Measure:**
Morningstar's risk measure differs from beta or standard deviation (which measures volatility). Instead Morningstar focuses only on downside risk by plotting monthly returns in relation to T-bill returns.

The amount by which the fund trails the T-bill returns each month are summed and then divided by the total number of months in the time horizon. This average monthly underperformance statistic is compared to other funds in the same category to express the fund's riskiness compared to the average in the category.

3. **Morningstar Calculates Time-Specific Return Scores:**
Morningstar subtracts the risk from the return for the corresponding time horizons (three years, five years, and ten years). These time horizon scores are compared to the time horizon scores of the other funds in the same fund category.

4. **Morningstar Assigns Star Ratings:**
If the fund's return score lands in the top 10%, it receives a time-specific rating of five stars. The next 22.5% receive a time-specific rating of four stars. The middle 35% receive three stars. The next 22.5% receive two stars, and the bottom 10% receive one star. All funds have at least three years worth of returns data in order to be included in this Morningstar evaluation.

5. **Morningstar's Weighting System**
Depending upon the age of the fund, Morningstar averages the past star ratings and rounds the result up. For funds with ten years or more worth of returns data, Morningstar weights the three-year star rating by 20%, the five year star rating by 30%, and the ten year star rating by 50%. For funds with five years to under ten years worth of returns data, Morningstar weights the three-year star rating by 40%, and the five year star rating by 60%. For funds with three years to under five years worth of returns data, Morningstar weights the three-year star rating by 100%.

My Calculation of the Morningstar Risk-Adjusted Return Number (using Microsoft Excel)

Given the data (2001, International Fund category) taken from the Morningstar CD, I found the risk adjusted return number using the following steps:

Copied and Pasted the 90-day T-Bill rates for the corresponding months onto a new worksheet (labeled TBill).

On Monthly Returns Worksheet:

- Created an IF statement to determine which funds are young, middle-aged, and seasoned.
- Used Excel's Vector Lookup function to transpose the data for the corresponding months (cell headings labeled: Tbill and numerical month value).
- Took an Average of the monthly returns (non-load adjusted as given) for the time frames (young funds were averaged over 3 years only, middle-aged funds were averaged over three years and five years, seasoned funds were averaged over three years, five years, and ten years).

On Risk-Adjusted Return Worksheet:

- Created an IF statement to determine and output whichever was greater: the monthly return minus the T-bill rate or simply the monthly T-bill rate. (Cell headings labeled: Higher of Rtn-Tbill or Tbill and numerical month value).
- Found the Average of the higher of the Excess Return or the Tbill for the three time frames.

On Results Worksheet:

- Copied and Pasted (as values to remove formulas) my Average Returns for the three time frames – highlighted in yellow.
- Copied and Pasted (as values) my Average of the higher of the Excess Return or the Tbill for the three time frames.
- Divided the Average Returns by the higher of the Excess Return or the Tbill (cells labeled 3YR, 5 YR, 10YR, RA RTN) – highlighted in green.

This can be found on the Calc for Return.xls file.

My Calculation of the Star Ratings (using Microsoft Excel)

Now that the Risk-Adjusted Return has been estimated for each of the three time horizons, I assign star ratings to the funds for each of the time horizons. Following Morningstar's logic, I assigned one star to the bottom 10% and five stars to the top 10% of the funds in each of the three time horizons. A two star rating went to the next 22.5% from the bottom and a four star rating went to the next 22.5% from the top. Finally, the middle 35% received three stars. This can be found on the AssignStars.xls file.

I simply copied and pasted the values that I had attained from the risk-adjusted returns calculations and then assigned the star ratings first by sorting the data and separating it out to separate worksheets, and then applying the logic noted above. Finally, I sorted the 3YR worksheet by Fund Number and then used a Vector Lookup function to combine those findings back onto a single worksheet (the Results worksheet) (sorting in ascending order is required of the lookup vector before using the Vector Lookup function).

In order to get the Vector Lookup to work properly for the 5YR and 10YR worksheets, I had to copy and paste all of the funds (just the youg, middle, seasoned, and Fund Numbers column from the ALL worksheet) back into the 5 yr and 10 year horizon sheets (placing them in new worksheets labeled '5yr ready for vlookup' and '10yr ready for vlookup'). Then I sorted these first in ascending by Fund Number and second by STAR in descending order. This essentially tricked the Vector Lookup function into recognizing that if the fund did not have a star rating for the time horizon, it should output "NA".

Lastly, I use Morningstar's weighting system to assign an overall star rating to each fund. To compute this, I created an IF statement which checks for fund age and then weights it accordingly (seasoned funds weigh the three-year star rating by 20%, five-year rating by 30% and the ten-year rating by 50%; middle-aged funds weigh the three-year star rating by 40%, and the five-year rating by 60%; young funds weigh the three-year rating by 100%). Results of the calculation are rounded up to the nearest whole number.

Again, this is all depicted on the Results worksheet.

My Calculations for the Weighted Confidence Intervals (using Microsoft Excel)

I transposed the data in column A through EA from the 'Calc for Return' Excel file. I pasted this into the 'Confidence Intervals' Excel file, separating the data into six worksheets and then combining the result onto the Summary worksheet. The reason for separating the data is that Excel has a limited number of columns and when transposing the data, the number of funds exceeds the number of columns allowed.

I then used Excel functions to calculate a count of the number of months which contain returns for each fund (using the COUNT function), the mean of those returns (using the AVERAGE function), the standard deviation (using the STDEV function), and the 95% confidence interval width (using Excel's CONFIDENCE function). I could then calculate C(3), C(5), and C(10) by multiplying the dummy variable by the confidence interval width and then taking an average for each of the types of funds (young, middle-aged, and seasoned). The weighed average is simply the average confidence interval weighted accordingly (seasoned funds weigh C(3) by 20%, C(5) by 30% and C(10) by 50%; middle-aged funds weigh C(3) by 40%, and C(5) by 60%; young funds weigh C(3) by 100%).

Results are depicted in Exhibit 3 and 4 (Excel Calculation). While the results do not appear consistent with the original findings, they are consistent with the theory that young fund ratings contain more estimation risk than middle-aged and/or seasoned funds.

My Regression Calculations for the Weighted Confidence Intervals (Using R)

To estimate the model for C(3):
3 year Risk-Adjusted Return = β_0 + β_1(3 year Star Rating) + β_2(5 year Star Rating) + β_3(10 year Star Rating) + μ

```
ratings = read.table ("C:/ratings3.prn", header=TRUE)
ratingsreg = lm(X3YRRARTN~X3YRStarRating+X5YRStarRating+X10YRStarRating,
data = ratings) #run regression
summary(ratingsreg)

> ratings = read.table ("C:/ratings3.prn", header=TRUE)
> ratingsreg =
lm(X3YRRARTN~X3YRStarRating+X5YRStarRating+X10YRStarRating, data =
ratings) #run regression
> summary(ratingsreg)

Call:
lm(formula = X3YRRARTN ~ X3YRStarRating + X5YRStarRating +
X10YRStarRating,
   data = ratings)

Residuals:
    Min      1Q   Median      3Q     Max
-0.80215 -0.04506  0.02644  0.08516  0.19284

Coefficients:
                      Estimate    Std. Error   t value     Pr(>|t|)
(Intercept)           -0.56118    0.03147      -17.834     < 2e-16 ***
X3YRStarRating        0.11131     0.02398      4.642       7.47e-06 ***
X5YRStarRating        0.06916     0.02619      2.641       0.00914 **
X10YRStarRating       0.05537     0.02173      2.548       0.01183 *
---
Signif. codes:  0 `***' 0.001 `**' 0.01 `*' 0.05 `.' 0.1 ` ' 1

Residual standard error: 0.1365 on 150 degrees of freedom
Multiple R-Squared: 0.8038,     Adjusted R-squared: 0.7999
F-statistic: 204.9 on 3 and 150 DF,  p-value: < 2.2e-16
```

To estimate the model for C(5):
5 year Risk-Adjusted Return = β_0 + β_1(3 year Star Rating) + β_2(5 year Star Rating) + β_3(10 year Star Rating) + μ

```
ratings = read.table ("C:/ratings5.prn", header=TRUE)
ratingsreg = lm(X5YRRARTN~X3YRStarRating+X5YRStarRating+X10YRStarRating,
data = ratings) #run regression
summary(ratingsreg)

> ratings = read.table ("C:/ratings5.prn", header=TRUE)
> ratingsreg =
lm(X5YRRARTN~X3YRStarRating+X5YRStarRating+X10YRStarRating, data =
ratings) #run regression
> summary(ratingsreg)

Call:
lm(formula = X5YRRARTN ~ X3YRStarRating + X5YRStarRating +
X10YRStarRating,
   data = ratings)

Residuals:
    Min      1Q   Median      3Q     Max
-0.69158 -0.05177  0.02091  0.08624  0.19108

Coefficients:
                     Estimate    Std. Error   t value     Pr(>|t|)
(Intercept)          -0.48290    0.03158      -15.293     < 2e-16 ***
X3YRStarRating       0.02496     0.02406      1.037       0.301332
X5YRStarRating       0.14918     0.02628      5.677       6.87e-08 ***
X10YRStarRating      0.07695     0.02181      3.529       0.000555 ***
---
Signif. codes:  0 `***' 0.001 `**' 0.01 `*' 0.05 `.' 0.1 ` ' 1

Residual standard error: 0.137 on 150 degrees of freedom
Multiple R-Squared: 0.821,      Adjusted R-squared: 0.8174
F-statistic: 229.3 on 3 and 150 DF,  p-value: < 2.2e-16
```

To estimate the model for C(10):
10 year Risk-Adjusted Return = β_0 + β_1(3 year Star Rating) + β_2(5 year Star Rating) + β_3(10 year Star Rating) + μ

```
ratings = read.table ("C:/ratings5.prn", header=TRUE)
ratingsreg =
lm(X10YRRARTN~X3YRStarRating+X5YRStarRating+X10YRStarRating, data =
ratings) #run regression
summary(ratingsreg)
```

```
> ratings = read.table ("C:/ratings5.prn", header=TRUE)
> ratingsreg =
lm(X10YRRARTN~X3YRStarRating+X5YRStarRating+X10YRStarRating, data =
ratings) #run regression
> summary(ratingsreg)

Call:
lm(formula = X10YRRARTN ~ X3YRStarRating + X5YRStarRating +
X10YRStarRating,
   data = ratings)

Residuals:
     Min       1Q    Median       3Q       Max
-0.519526 -0.038154  0.005348  0.050395  0.170484

Coefficients:
                      Estimate      Std. Error     t value       Pr(>|t|)
(Intercept)           -0.202860     0.019877       -10.206       < 2e-16 ***
X3YRStarRating        -0.009063     0.015146       -0.598        0.55
X5YRStarRating        0.070495      0.016540       4.262         3.57e-05 ***
X10YRStarRating       0.124108      0.013726       9.042         7.32e-16 ***
---
Signif. codes:  0 `***' 0.001 `**' 0.01 `*' 0.05 `.' 0.1 ` ' 1

Residual standard error: 0.08622 on 150 degrees of freedom
Multiple R-Squared: 0.8576,     Adjusted R-squared: 0.8547
F-statistic: 301.1 on 3 and 150 DF,  p-value: < 2.2e-16
```

Summary of Regression Results

C3

	Estimate	Std. Error	t value	Pr(>|t|)	Low Intercept-Tvalue	High Intercept+Tvalue	**CI Width**	**Weighted CI**
(Intercept)	-0.56118	0.03147	-17.834	< 2e-16 ***				
X3YRStarRating	0.11131	0.02398	4.642	7.47e-06 ***	-5.20318	4.08082	9.284	**9.284**
X5YRStarRating	0.06916	0.02619	2.641	0.00914 **	-3.20218	2.07982	5.282	
X10YRStarRating	0.05537	0.02173	2.548	0.01183 *	-3.10918	1.98682	5.096	

C5

	Estimate	Std. Error	t value	Pr(>|t|)				
(Intercept)	-0.4829	0.03158	-15.293	< 2e-16 ***				
X3YRStarRating	0.02496	0.02406	1.037	0.301332	-1.5199	0.5541	2.074	
X5YRStarRating	0.14918	0.02628	5.677	6.87e-08 ***	-6.1599	5.1941	11.354	**7.642**
X10YRStarRating	0.07695	0.02181	3.529	0.000555 ***	-4.0119	3.0461	7.058	

C10

	Estimate	Std. Error	t value	Pr(>|t|)				
(Intercept)	-0.20286	0.019877	-10.206	< 2e-16 ***				
X3YRStarRating	-0.009063	0.015146	-0.598	0.55	0.39514	-0.80086	-1.196	
X5YRStarRating	0.070495	0.01654	4.262	3.57e-05 ***	-4.46486	4.05914	8.524	
X10YRStarRating	0.124108	0.013726	9.042	7.32e-16 ***	-9.24486	8.83914	18.084	**11.36**

Replication of Exhibit 1

Exhibit 1 depicts a sample calculation for Morningstar Risk. It simply shows that in order to find the monthly underperformance measure, we have to check to see if The T-Bill is greater than the Fund Return. If the T-Bill is higher, we take the T-Bill minus the Fund Return. Otherwise, we will simply say "NA". The results of these calculations are later used in generating the Risk-Adjusted Return.

In replicating this exhibit, I found an error in the paper. The Total Underperformance should be 12.4 (not 13.2) by simple arithmetic.

Exhibit 1:

Month	Fund Return (%)	T-Bill Return		Underperformance
1	2.0	0.5		NA
2	-1.5	0.5		2.0
3	3.2	0.5		NA
4	1.2	0.4		NA
5	-4.0	0.6		4.6
6	2.1	0.5		NA
7	0.7	0.5		NA
8	2.3	0.5		NA
9	-1.7	0.5		2.2
10	2.4	0.4		NA
11	1.2	0.6		NA
12	-3.1	0.5		3.6
			Total Underperformance	12.4

$$\frac{\text{Total Underperformance}}{\text{Number of Months}} = \frac{12.4}{12}$$

1.03

Avg Monthly Underperformance

$$\frac{\text{Average Monthly Underperformance}}{\text{Avg Monthly Performance of Investment Category}} = \text{1-year Morningstar Risk}$$

Replication of Exhibit 2

Exhibit 2 depicts a summary of the characteristics of the data used in this analysis. It provides a count of the number of funds that fit each of the star categories as well as the number of young, middle-aged, and seasoned funds.

To replicate this exhibit, I simply copied and pasted my values from the Results worksheet within the AssignStar.xls file and then used a PivotTable report to summarize the results in a similar manner to the way the data is presented in Exhibit 2.

Where 1 = yes and 0 = no

Count of 3YR Star Rating	Seasoned		
3YR Star Rating	0	1	Grand Total
1	109	20	129
2	257	31	288
3	392	56	448
4	165	23	188
5	204	24	228
Grand Total	1127	154	1281

Count of 5YR Star Rating	Middle		
5YR Star Rating	0	1	Grand Total
1	25	53	78
2	23	151	174
3	52	218	270
4	37	137	174
5	17	60	77
NA	508		508
Grand Total	662	619	1281

Count of 10YR Star Rating	Young		
10YR Star Rating	0	1	Grand Total
1	16		16
2	35		35
3	53		53
4	35		35
5	15		15
NA	619	508	1127
Grand Total	773	508	1281

Replication of Exhibit 3 and 4

Excel Calculation

Age of Fund	Number of Funds	Weighted CI
Young	508	1.89
Middle-Aged	619	1.52
Seasoned	154	1.22

R Calculation

Age of Fund	Number of Funds	Weighted CI
Young	508	9.284
Middle-Aged	619	7.642
Seasoned	154	11.36