Performance analysis based on adequate risk-adjusted measures

by

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A thesis submitted in partial fulfillment of the requirements for the degree of

Master of Science

in

Mathematical Finance

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Abstract

The main purpose of this thesis is to explore different risk-adjusted ratios, add correlation into account and see which one of them accommodates for risk the best way. In finance it is well-known that investors can not rely on pure return. Some fund managers can produce high return but at the same time they can be exposed to a very high risk. Therefore, it is important to adjust for risk and compare fund/managers based on a risk-adjusted return.

Also, this thesis applies popular risk-adjusted measures to mergers and acquisitions(M&A). In order to deal with correlation in M&A, we use Dowd's (2000) approach and calculate the same measures for the acquiring company before the acquisition and assuming that the company acquired the target few years ago. Therefore, we include correlation in all measures and we can compare the same measures for the company and see if it increased or decreased. Detailed calculations will be presented in this thesis.

There are many risk-adjusted measures because investors can not agree how we need to define risk. In this thesis we will give different definitions of risk and demonstrate the advantages and disadvantages of each. Our methods of study and outcomes are illustrated by numerical examples on the real financial data.

Acknowledgment

Firstly, I would like to thank my supervisor Dr. Melnikov his guidance and his encouragement throughout my studies. Without his help, this thesis would not come to fruition.

Secondly, I would like to express my deepest gratitude to Dr. Kuttler, Dr. Frei, Dr. Kong, and Dr. Yaskin for being a part of my thesis examining committee and for going over my thesis.

Thirdly, I would like to thank the Department of Mathematical and Statistical Sciences at University of Alberta for providing me with financial support throughout my program.

Special thanks go out to my family for their unconditional love and support, and for always being so dependable. To my friends who helped me enjoy my graduate school and go through all difficult times.

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1 Introduction

This thesis is devoted to a comprehensive performance analysis in Corporate Finance. We review several risk-adjusted performance measures discussing their advantages and disadvantages and apply these measures to rank mutual fund/managers and to estimate the effectiveness of Mergers and Acquisitions(M&A).

In addition to standard risk-adjusted measures, this thesis adds correlation to them and provide guidance on how to account for correlation when investor's portfolio is built.

Correlation is an important parameter when one wants to create a portfolio rather than investing in a single stock. If we define risk as a standard deviation of stock returns (as most investors do) or some sort of standard deviation, then if we have a portfolio of two or more stocks then the combined standard deviation is not a sum of single standard deviations. Instead, we have a correlation term and a portfolio standard deviation looks like this:

$$\sigma^2_{Portfolio} = \sigma^2_A\omega^2_A + \sigma^2_B\omega^2_B + 2\rho_{A,B}\omega_A\omega_B\sigma_A\sigma_B$$

where σ_A and σ_B are standard deviations of stocks A and B respectively

ω_A and ω_B are weights invested in stocks A and B respectively

$\rho_{A,B}$ is a correlation between stocks A and B.

Therefore, it is clear from this equation that investors should seek negative or small correlation to decrease the overall portfolio risk. That is why it is important to be able to select new investments including adjustments for correlation.

The method that was described in a Dowd's (2000) paper shows the idea of how to adjust for correlation using the most popular and widely used risk-adjusted measure - Sharpe ratio. Dowd's basic idea is the following: calculate the Sharpe ratio before the deal and calculate on if the deal went through, then we can compare these two ratios and if it increased then

we would proceed with the deal. In this case, we account for correlation when we calculate the new Sharpe Ratio.

In this thesis, we extend Dowd's (2000) idea not only to the Sharpe ratio but to all ratios that are described in this thesis. This method was applied only for M&A, but investors are encouraged to apply the same procedure as in M&A to their own portfolios to account for correlation.

In literature authors often exploit Mergers and Acquisitions. Some are interested in reasons behind the Mergers waves. For example, Jarrad Harford (2005) tried to distinguish between two merger waves model neoclassical (industries create clusters of mergers as a response to industry shocks) and behavioral (managers take advantages of market overpricing some assets and underpricing the other). His research compares the two models and supported the "neoclassical model, as modified to include a role for capital liquidity" (Harford (2005), p. 559).

Baker and Savasoglu (2002) in their paper answered the question why merger arbitrage returns are not arbitraged away. They developed a model where some investors that do not hold a diversified portfolio sell stocks to avoid completion risk.

Wang and Moini (2012) provided in their paper different ways to define M&A performance. They showed accounting, financial, operational, and perceptual metrics. However, as was mention in their paper there is no united definition of M&A performance is and M&A is complex in its nature.

In order to adjust for correlation in ranking managers, this thesis also presents calculations for M3 measure which was proposed by Muralidhar (2000). He accounts not only for the correlation but also provides guidance on how to build a portfolio with the highest risk-adjusted return using a benchmark, risk-free asset, and a fund or stock we are interested in.

In this thesis we are interested in a risk-adjusted measures that are based on stock returns

rather than accounting-based measures. We do it because first, there is more information on stocks rather than financial statements that are presented quarterly. Second, in this thesis we assume that the price of the company is what you can sell it for in the market rather than selling the company by parts. Finally, many measures refer to benchmarks and for all funds and acquisitions S&P 500 was used as a benchmark. It is impossible to get financial statements for this Index. Even if we could get financial statements for Indexes it would be hard to compare them because companies can have different policies and different accounting preferences. Therefore, market data was used to obtain all measures.

In addition, throughout this paper we assume that investors are risk averse. Which means that if an investor has a choice between two investments with the same expected return then investor will choose the one with the lower risk. Here, we do not make any assumptions about the definition of the risk.

For M&A we do not have a goal to compare different acquisitions possibilities rather we want to evaluate the existent acquisitions based on the past performance of both companies. We look at this problem from the prospective of an acquiring company. There are two different approaches to this problem: 1) short-term performance before and after the announcement, 2) long-term performance. If investor believes that market reacts to the information immediately we should look at the return of approximately 20 days before and after the announcement of acquisition. However, in this thesis we have a different goal. It will be useful to check what market thinks of the acquisition, but we are interested in a prospective that the acquiring company will keep target company forever. Therefore, we are more interested in a long-term performance, rather than short-term. In addition, there are many evidences that the market can not reflect information immediately.

One of the examples that market can not reflect the information immediately could be post-earnings announcement drift which was presented by Bernard and Thomas (1989) they showed that if the company was doing good before the earnings release and earnings were

better than investors anticipated then this company's stock will keep increasing for a long time. If the market could reflect information immediately we would have a jump at 0 and that's all. We would not have a long time increase in stock's price. The same applies for the companies that are doing bad and their earnings are worse than investors anticipated.

In addition, in a recent research done by Ornelas, Silva Jnior, and Fernandes (2010) shows that performance ratios matter. Previously, Eling (2008) showed that some measures have a very high correlation in ranking with the Sharpe ratio and it might be enough just to look at Sharpe Ratio. However, Ornelas, Silva Jnior, and Fernandes (2010) exploited other measures in their research and agreed with Eling to some degree but not all measures produced a high correlation. Therefore, we should look and compare measures and we can not use only Sharpe Ratio.

Therefore, it is interesting and might be useful to check what market thinks in short run about the acquisition, but it should not be the only reference point. Also, investors do not have as much information as managers do. That is why, we are interested in a log-time performance rather than 20 days before and after the announcement.

The structure of this paper is the following. Section 2 describes the risk-adjusted performance measures that can be applied for both ranking funds/managers and M&A also describing advantages, disadvantages, and additions from different researches to the measures. Section 3 provides real-world examples and description on how to apply these measures to the 8 biggest funds in the United States. Section 3 provides real-world examples of Acquisitions and procedure on how to apply risk-adjusted measure in this case and the most importantly how to account for correlation. Section 4 provides conclusions. All data can be found in Bloomberg and YAHOO!Finance.

2 Risk-adjusted performance measures

The following risk-adjusted performance measure are considered to be applicable for ranking managers and evaluating the profitability of Mergers and Acquisitions.

2.1 Sharpe Ratio

Let's start describing risk-adjusted performance measure from one of the most widely used and often studied measures Sharpe Ratio. Sharpe Ratio was first proposed by Sharpe in 1966. Which is defined as an excess expected return of investment to its standard deviation. Mathematical definition of the Sharpe Ratio is the following:

$$SR = \frac{\mu - R_f}{\sigma},$$

where R_t – one-period return between dates $t-1$ and t, $\mu = E(R_t)$ - an expected return of investment, $\sigma^2 = Var(R_t)$ - variance of the investment's returns, R_f - risk free rate.

As we can see the Sharpe Ratio denominator is a standard deviation of the investment's return. Therefore, we assume that risk of the investment is its deviation from the mean return. That is why we can represent the Sharpe Ratio graphically as

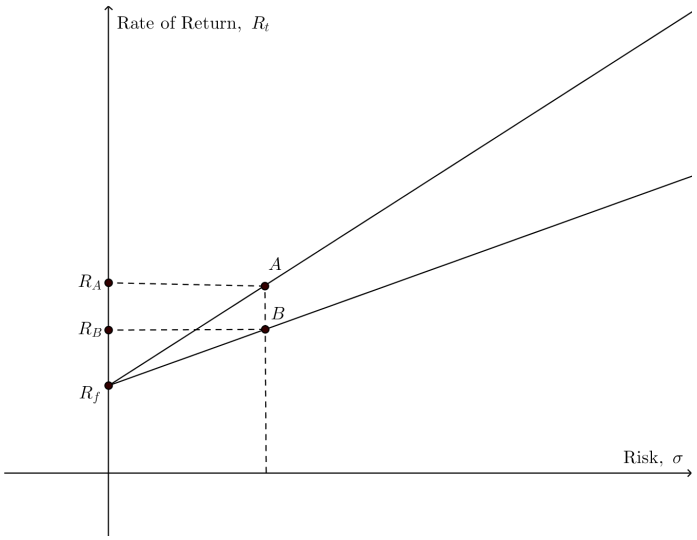

Figure 1: Graphic Representation of the Sharpe Ratio

as can be seen from the Figure 2 that if an investor has to make a choice between two investments A and B he/she should choose investment A. Since A and B have the same risk (standard deviation) but an investment A has a higher return for the same risk.

In real life we don't know the actual mean and standard deviation of returns. Hence, we need to use historical or estimations of the mean and standard deviation. If historical returns on period $[1, T]$ are known then we can calculate mean and standard deviation the following way:

$$\mu_{est} = \frac{1}{T}\sum_{t=1}^{T} R_t$$
$$\sigma^2_{est} = \frac{1}{T}\sum_{t=1}^{T}(R_t - \mu_{est})^2.$$

Therefore, estimated Sharpe Ratio can be calculated using estimated mean and standard deviation as:

$$SR_{est} = \frac{\mu_{est} - R_f}{\sigma_{est}}.$$

In addition, to estimation of mean return and standard deviation investors need to make a decision about risk free rate.

Risk free rate of return is defined as the rate of return investor can expect from a theoretically risk free investment. In practice there is no real risk-free rate. We can approximate it but even government bonds contain some risk because government entities can default as well as companies do. Therefore, every investor needs to make a choice about risk free rate of return. There are multiple possibilities for risk free rate and they include:

1. *Short-term interest rates.* Usually T-Bills rates are used. T-bills are bonds that are issued by the US government and mature within a year.
2. *Long-term interest rates.* Usually Treasure notes or Treasury bonds rates are used. They are also issued by the US government and mature less than 10 years and more than 10 years respectively.
3. *Real risk free rates adjusted for inflation.* Real $R_f = \frac{1+\text{nominal risk-free rate}}{1+\text{inflation rate}}$.

The choice of risk free rate is not as crucial as one can think. Even though it is not crucial which risk-free rate investor chooses, it is still important to be consistent and choose the same rate for all investment options otherwise comparison will be impossible.

Since investors seek higher return with lower risk then they need to select an investment opportunity with a higher Sharpe Ratio. If returns are negative, then Sharpe Ratio will be negative as well. Therefore, investors should be looking for a higher volatility to have better chances to get positive returns. Hence, we are looking for a higher Sharpe ratio not in an absolute value sense but in a value. In addition, to ease criteria which investment opportunity is better Sharpe ratio has other advantages and disadvantages

First, it is easy to calculate based on past performance. Every investor has access to stock's prices for publicly traded companies. Therefore, one can calculate returns based on past performance in addition to the standard deviation and obtain the Sharpe Ratio.

Second, Sharpe Ratio allows to compare and rank portfolios and funds if consistent

parameters are chosen.

Finally, being one the of the most common and widely cited statistics Sharpe Ratio has been studied and most of it advantages and disadvantages are known.

Now, let's discuss disadvantages of the Sharpe Ratio.

First, standard deviation is not always an appropriate risk measure. If returns are not normally distributed, then the standard deviation will give a wrong estimate of the risk. Also, investors do not want to penalize companies for the deviation above the mean.

Second, standard deviation as a risk measure punishes companies for an upward momentum. Which means that if company has a great increase in stock prices will imply that it also has a high standard deviation but as an investor we would like to have a great increase, but Sharpe Ratio will tell us different.

Third, since it is a backwards looking measure it does not provide us useful information about the future.

Forth, as was noted in Modigliani and Modigliani(1997) Sharpe ratio produces a number that is hard to interpret. There is no meaning to the Sharpe Ratio. Investors can only compare ratios on the same time period and for the same risk-free rate.

Fifth, it does not provide a guidance on how to build portfolio.

Finally, it is not a reliable measure if correlation is present between one or more assets within a portfolio. For example, if investment A has a higher Sharpe Ratio than investment B then using Sharpe Ratio approach we should choose A instead of B. However, if B has a negative correlation with a portfolio we might choose B in order to reduce the overall risk. Therefore, Sharpe Ratio will lead to a wrong decision.

Since Sharpe Ratio is a widely used risk-adjusted measure throughout these years were offered many **modifications**. There are few of them:

2.1.1 Alternative Sharpe Ratio

This alternative was offered by Bacon (2013) in his book Practical Risk-Adjusted Performance Measurement

$$SR_{Alternative} = \frac{\mu - R_f}{\sigma - \sigma_f}$$

where σ_f is a standard deviation of risk free rate of return. However, there is almost no variability in risk free rate that is why this modification is almost never used.

2.1.2 Revised Sharpe Ratio

In 1994 Sharpe revised his ratio and wrote that Sharpe Ratio does not "incorporate information about the correlation of a fund or strategy with other assets, liabilities, or previous realizations of its own return. For this reason, the ratio may need to be supplemented in certain applications" (Sharpe 1994). However, he did not provide the guidance on how to implement this idea of correlation.

2.1.3 A generalized Sharpe Ratio approach

On a Sharpe ratio we can look from a different angle. Dowd (2000) introduced a slightly different approach to applying Sharpe Ratio. He suggested not only taking the highest Sharpe Ratio but calculate two Sharpe Ratios. First one of the current portfolio and second of the new portfolio (if investment opportunity was accepted). In this case the decision rule can be presented as:

$$\text{Accept the investment if } SR^{new} \geq SR^{old}.$$

This approach helps to avoid the correlation problem and we will apply and extend his method to other measures. Since correlation is already incorporated in the denominator of new Sharpe Ratio. Unfortunately, this approach does not provide guidance if returns do not

follow a Gaussian distribution.

2.1.4 Andrew Lo additions

In 2002 Lo offered few additional remarks to the Sharpe Ratio.

1. When annual Sharpe Ratio is calculated investors multiply monthly returns by $\sqrt{12}$ but this method does not account for serial correlation of the portfolio's returns. Therefore, one can calculate the Sharpe ratio only for the same investment's style "with which a portfolio's returns have been generated"(Lo 2002).

2. Investment style of a fund manager should be considered because it affects the statistical properties of the returns.

3. In addition, market environment also affects the ratio. For example, Russian government default in 1998 would dramatically change the Sharpe ratio and assumptions investors make on the statistical properties of returns.

4. Under the assumptions that returns are independent and identically distributed (IID) the standard error of the Sharpe Ratio (SR) can be calculated the following way:

$$\mathrm{SE(SR)} = \sqrt{\frac{1 + \frac{\mathrm{SR}^2}{2}}{T}}$$

in addition, 95% confidence interval can be calculated as follows:

$$\mathrm{SR} \pm 1.96\sqrt{\frac{1 + \frac{1}{2}\mathrm{SR}^2}{T}}$$

As we can see from these equations if funds have higher Sharpe ratio their estimates are less precise due to increased standard error.

5. In addition, under the assumption of *stationary* returns ("joint probability distribution of an arbitrary collection of returns does not change if all the dates are incremented by the

same number of periods" (Lo 2002)) it is possible to calculate new standard error.

6. Finally, Lo showed the way how time aggregation can be incorporated into the calculations of SR. There are two different ways depending if we assume IID or NON-IID returns.

i. If we assume IID returns and have q-periods, then the Sharpe ratio is

$$\mathrm{SR}(q) = \sqrt{q}\mathrm{SR}$$

ii. If we assume NON-IID (stationary) returns and have q-periods, then

$$\mathrm{SR}(q) = \frac{q}{\sqrt{q + 2\sum_{k=1}^{q-1}(q-k)\rho_k}}\mathrm{SR}$$

where $\rho_k = Cov(R_t, R_{t-k})/Var(R_t)$ is the kth order autocorrelation of R_t.

iii. If we assume first order autoregressive returns with the formula

$$R_T = \mu + \rho(R_{t-1} - \mu) + \varepsilon_t, -1 < \rho < 1$$

where ε_t is IDD with mean 0 and standard deviation σ_ε. Then the autocorrelation coefficient is ρ^k and the scale factor is

$$\eta(q) = \sqrt{q}\left[1 + \frac{2\rho}{1-\rho}\left(1 - \frac{1-\rho^q}{q(1-\rho)}\right)\right]^{-\frac{1}{2}}$$

and graphically it can be represented as

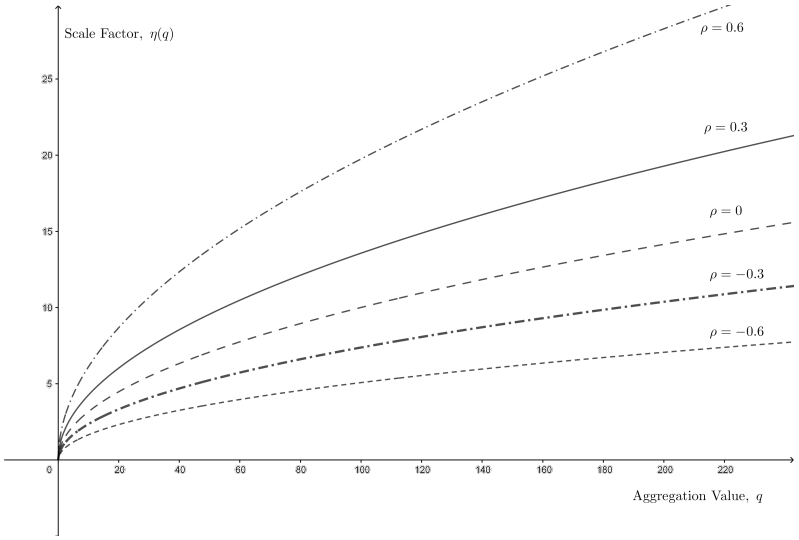

Figure 2: Correlation Impact on the Scale Factor

As we can see correlation plays a great role in the scale factor for the Sharpe ratio.

2.2 Information Ratio

"The information ratio is a measure that seeks to summarize in a single number the mean-variance properties of an active portfolio" (Goodwin 1998). Information Ratio (IR) is another modification of the Sharpe Ratio. The difference between Sharpe Ratio and Information Ratio is that usually SR is calculated using the risk-free rate and Information Ratio is calculated using benchmark not necessary riskless asset. As a Sharpe Ratio IR measures excess return over a given period adjusted to risk. However, IR measure consistency of manager's performance when Sharpe ratio measures whether a manager outperforms the risk-free rate or not. Similarly to the Sharpe Ratio, Information Ratio reward higher variability if returns (or ratios) are negative. It makes intuitive sense since it is better to underperform inconsistently than underperform consistently. Because in case of inconsistent underperformance there is a higher chance to outperform.

Now, let's define the Information Ratio.

$$\text{Information Ratio } = \frac{\text{Annualized Excess Return}}{\text{Annualized Tracking Error}}$$

Similarly to the Sharpe Ratio, no one can know the exact Excess Return and tracking error. Therefore, we can provide the method that allows us to calculate it. If R_{P_t} is the return on an active portfolio in period t and R_{B_t} is the return on a benchmark portfolio or security in the same period t then we can define excess return as

$$ER_t = R_{P_t} - R_{B_t}$$

if $\overline{ER_t}$ is an arithmetic average then

$$\overline{ER} = \frac{1}{T}\sum_{t=1}^{T} ER_t$$

and if $\hat{\sigma}$ is the standard deviation of excess returns from the benchmark, or tracking error, for the same period the formula is:

$$\hat{\sigma} = \sqrt{\frac{1}{T-1}\sum_{t=1}^{T}(ER_t - \overline{ER})^2}$$

Now, we are ready to define the Information Ratio:

$$IR = \frac{\overline{ER}}{\hat{\sigma}},$$

It measures the ability of a manager to generate an excess return over a benchmark (most of the time it is S&P500 is assumed to be a benchmark). The higher the information ratio,

the better manager's performance over a given period.

Graphically it can be represented as:

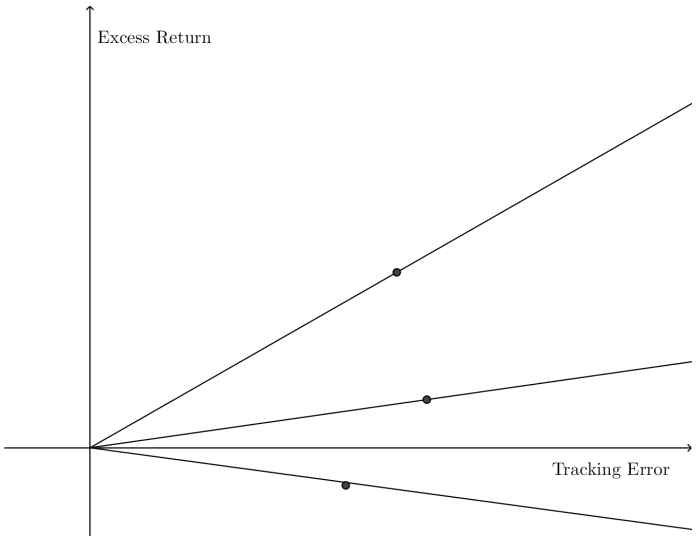

Figure 3: Graphic Representation of the Information Ratio

Nowadays, many practitioners are focused on maximizing information ratio in order to prove higher skills. As suggested in Grinold and Khan (1999) book that higher information ratio is better than lower, the notion of success is captured and quantified by the information ratio, and every investor seeks the strategy or manager with the highest information ratio. However, Muralidhar showed in his paper that it is not always the case. Which leads us to the advantages and disadvantages of using IR.

The first advantage is that it is easy to calculate based on past performance. All investors have access to stocks prices for publicly traded companies and if the benchmark is chosen to be publicly traded then calculations are easy.

Second, IR is a useful measure when the benchmark has been carefully chosen to match the manager's style.

Third, information ratio has a better number representation than the Sharpe Ratio. As mentioned in a book by Bacon "Thomas Goodwin quotes Grinold and Kahn stating that an

information ratio of 0.5 is good, 0.75 is very good and 1.0 is exceptional". Also, everything that above 1.0 is "unsustainable or fraudulent". However, these numbers came from Jacobs and Levy (1996) and it is not clear how they came up with these numbers.

Now let's discuss the disadvantages of the information ratio.

First, it is not a complete statistics and investors can not rely only on the information ratio in order to make their decisions.

Second, only maximizing information ratio can lead to wrong conclusions because it captures only active portfolio but investing in risk-free assets can increase the risk-adjusted performance of the whole portfolio rather than increasing the information ratio.

Third, measure says nothing about performance and provides no guidance as to how portfolios should be constructed.

Finally, information ratio does not have any information about correlation between asset classes.

The same as for the Sharpe ratio for the information ratio there were a lot of **modifications** offered throughout these years. Here are some of them:

2.2.1 Geometric Information Ratio

As mentioned in a book by Bacon (2013) it is possible to create geometric information ratio if geometric excess return is used instead of standard excess return:

$$\text{Information Ratio } IR_G = \frac{g}{\sigma_G}$$

where:

g = annualized geometric excess return

σ_G = annualized tracking error of geometric excess return with the following formulas:

$$g = \left(\frac{1 + R_{P_i}}{1 + R_{B_i}}\right) - 1$$

$$\sigma_G = \sqrt{\frac{\sum_{i=1}^{n}(g - \overline{g})^2}{n}},$$

where $\overline{g}$ - mean geometric excess return. Geometric information ratio and standard information ratio can give different results, but investors should be consistent in their calculations.

2.2.2 Thomas H. Goodwin additions

There are some suggestions and comments were made by Goodwin (1998):

1. T-statistics calculations.

It is possible to calculate the statistical significance of an information ratio for given null and alternative hypothesis. Formula for t-statistics is the following:

$$t_{IR} = \frac{\overline{ER}}{\frac{\hat{\sigma}}{\sqrt{T}}}$$

which follows a t-distribution with $T-1$ degrees of freedom and after that standard statistical techniques can be used in order to determine the outcome of hypothesis test. Also, it can be shown that information ratio has a direct connection with its t-statistics by the following equation:

$$t_{IR} = \mathrm{IR}\sqrt{T}$$

In order to finalize the discussion about t-statistics it can be shown that if some investors have their own desired t-statistics for fund manager T_{Hurdle} then corresponding t-stats can be calculated:

$$t_{IR} = \sqrt{T}(IR - T_{Hurdle})$$

which still follows a T-distribution with $T - 1$ degrees of freedom.

2. Annualization methods.

a) *Arithmetic Mean Excess Return.*

It is when, for example, the monthly mean will be multiplied by 12 and monthly tracking error will be multiplied by $\sqrt{12}$. This method is widely used in practice and has a direct connection with t-statistics which other methods don't have.

b) *Geometric Mean Excess Return.*

It is theoretically better than average mean returns because it takes compounding into account. If we want to change from quarterly data to yearly using geometric approach we need to do the following:

$$\overline{AER_1} = \left[\prod_{t=1}^{T}\left(\frac{1+R_{P_t}}{1+R_{B_t}}\right)\right]^{\frac{4}{T}} - 1$$

tracking error will be adjusted the same way as in arithmetic annualization method. Even though this method is theoretically better than arithmetic mean returns it is not clear how standard deviation should be calculated. Either using arithmetic mean approach or geometric approach.

c) *Continuously Compounded Mean Excess Return.*

In this case if we want to change again from quarterly to yearly rates we will use the following formula:

$$\begin{aligned}\overline{AER_2} &= \ln(1+\overline{AER_1}) \\ &= \frac{4}{T}\left[\sum_{t=1}^{T}\ln(1+R_{P_t} - \sum_{t=1}^{T}\ln(1+R_{B_t}))\right].\end{aligned}$$

This method has the same advantages and disadvantages as geometric mean approach.

d) *Frequency-Converted Data.*

If j is the year index, then frequency-converted annualized excess return is

$$\begin{aligned} AER_j &= AR_{P_j} - AR_{B_j} \\ &= \left(\prod_{t=4(j-1)+1}^{4(j-1)+4} (1 + R_{P_t}) \right) - \left(\prod_{t=4(j-1)+1}^{4(j-1)+4} (1 + R_{B_t}) \right). \end{aligned}$$

Theoretically the frequency-conversion method is the best because it provides returns as they were observed only annually. However, the practical approach is a little bit complicated because if you want to update Information Ratio when quarter earnings were released then you have no easy way to do so.

3. Manager's style affects the choice of a benchmark.

Also, Goodwin showed in his article that managers with different styles should be compared to different benchmarks and it is very important to make the right choice of a benchmark. As it was shown by Frank Russel there are six style categories: market-oreinted large-capitalization U.S. equities, large-cap value U.S. equities, large-cap growth U.S. equities, small-cap U.S. equities, international EAFE (MSCI's Europe/Australia/Far East Index) equities, and sector-rotation U.S. bonds. Different benchmarks should be used for different manager styles as shown in Table 1.

Style Category	**Benchmark**
Market-oriented large-capitalization U.S. equity	Russell 1000
Large-cap value U.S. equity	Russell 1000 Value
Large-cap growth U.S. equity	Russell 1000 Growth
Small-cap U.S. equity	Russell 2000
International EAFE equity	MSCI EAFE
Sector-rotation bonds	Lehman Brothers Aggregate

Table 1: Style Depended Benchmarks

As he showed in one of the examples if we compare market-oriented managers (First

Quarter 1986 - Fourth Quarter 1995) with S&P500 and Russell 1000 they will perform worse against S&P00. Therefore, it is important to be consistent with benchmark and choose it carefully.

2.2.3 Arun S. Muralidhar additions

There are three major points that were made my Muralidhar:

1. Information Ratio is incomplete statistics.

As one of the simplest examples if portfolio has information ratio 1 but takes only 0.1 risk it produces 0.1 or return. In addition, this measure does not say anything about performance and gives no guidance in how to construct the portfolio. And he showed measure M^2 in comparison to the information ratio. This measure leverage or delaverage the portfolio in order for portfolio to have the same standard deviation.

$$\text{r(RAP)} = \frac{\sigma_B}{\sigma_1}\ \text{r(Actual Portfolio)} + (1 - \frac{\sigma_B}{\sigma_1})\ \text{r(F)}$$

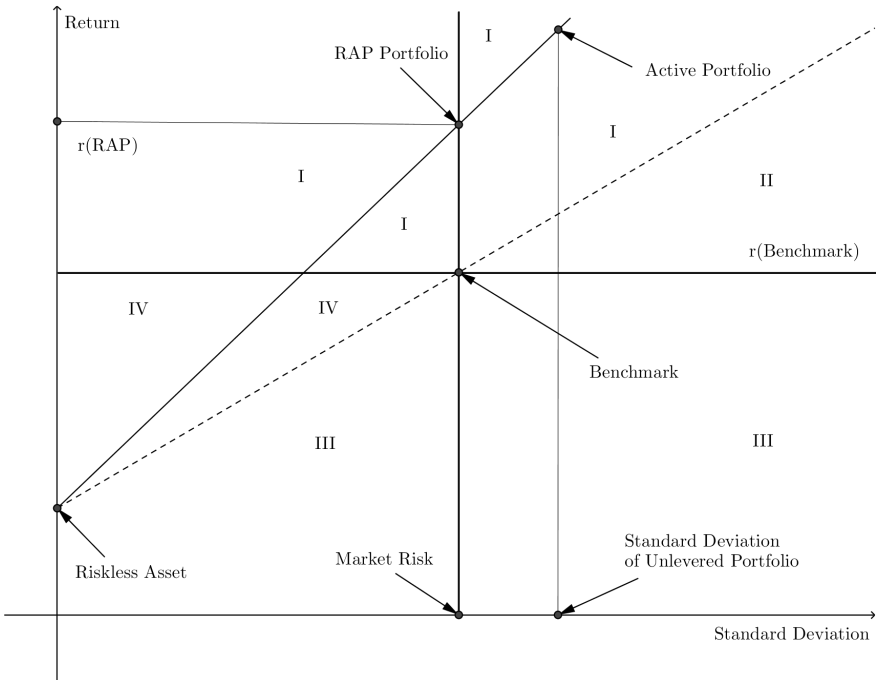

Figure 4: Risk Adjusting Using the M-2 Measure

As shown in Figure 3, M-2 measure produces 4 regions:

I - portfolios that outperform on both risk-adjusted and absolute basis,

II - portfolios that outperform on an absolute basis but underperform on risk-adjusted basis,

III - portfolios that underperform on both absolute and risk-adjusted basis,

IV - portfolios that underperform on absolute basis but outperform on risk-adjusted basis.

Therefore, M-2 allows to compare portfolios with the same standard deviation. However, M-2 doesn't capture the correlation risk and managers can outperform the benchmark only by taking a correlation risk.

2. Luck versus Skill.

As shown by Siegel and Ambarish the time horizon needed in order to distinguish between

noise and skills can be calculated as:

$$T > \frac{K^2[TE(1)]^2}{\left[\left(r(1) - \frac{\sigma_1^2}{2}\right) - \left(r(B) - \frac{\sigma_B^2}{2}\right)\right]^2}$$

where K - the number of standard deviations for a given confidence interval, $TE(1) = \sqrt{\sigma_1^2 - 2\rho_{1,B}\sigma_1\sigma_B + \sigma_B^2}$.

It brings us to the conclusion that "higher tracking error will either lower the confidence in the skill of the fund manager or extend the time period needed for evaluation". Therefore, Muralidhar proposed the M-3 measure.

3. M-3 measure and how to allocate investments.

$$r(CAP) = a * r(MutualFund) + b * r(B) + (1 - a - b)r(F)$$

where $a -$ proportion invested in a mutual fund

$b -$ proportion invested in the benchmark

$(1 - a - b) -$ proportion invested in the riskless asset

$CAP -$ correlation-adjusted portfolio.

Therefore, if investor has a desirable tracking error then the target correlation between benchmark and the portfolio is:

$$\rho_{T,B} = 1 - \frac{TE(Target)^2}{2\sigma_B^2}$$

and desirable allocation can be calculated as

$$\begin{aligned} a &= \sqrt{\frac{\sigma_B^2(1 - \rho_{T,B}^2)}{\sigma_1^2(1 - \rho_{1,B}^2)}} \\ &= \frac{\sigma_B}{\sigma_1}\sqrt{\frac{(1 - \rho_{T,B}^2)}{(1 - \rho_{1,B}^2)}} \end{aligned}$$

and

$$b = \rho_{T,B} - a * \frac{\sigma_1}{\sigma_B}\rho_{1,B}$$

Therefore, M-3 measure gives a guidelines in order how to construct an active and passive portfolio if desirable tracking error is known.

2.3 Sortino Ratio

Sortino ratio is another modification of Sharpe ratio that uses downside deviation rather than standard deviation as a measure of risk and was proposed by Sortino and van der Meer in (1991). As was written by Rollinger and Hoffman (2015) Harry Markowitz who developed Modern Portfolio Theory in 1959, noted that since downside deviation is relevant to investors it is more appropriate to use downside deviation as a measure of risk and not standard deviation. Sortino ratio is defines as:

$$S = \frac{R - T}{DR}$$

Where:

$R =$ the average period return

$T =$ the target or required rate of return

$DR =$ downside risk and calculated as follows by Sortino:

$$DR = \sqrt{\int_{-\infty}^{T} (T - r)^2 f(r) dr}$$

where r is the return on some asset, and $f(r)$ is a distribution of returns r.

However, Harlow (1991) offered a different formula for DR when discrete distribution of returns is present using "lower partial moments" (LPMs) with $n = 2$ and we will call it a

target downside deviation (TDD) as in Rollinger and Hoffman (2015)

$$TDD = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(Min(0, X_i - T))^2}$$

Where:

$X_i = i^{th}$ return

$N =$ total number of returns.

It has a similar formula to standard deviation:

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(X_i - \mu)^2}$$

where $\mu =$ average over all X_i returns.

As Rollinger and Hoffman (2015) noticed there are two main differences between standard deviation and TDD. The first one is that in TDD the *target return* is used and in standard deviation it is the average of returns. Second, in TDD zero excess return is still included and the minimum value of all summation but in standard deviation there is no minimum. To summarize, standard deviation is a measure of dispersion around the mean value, *both above and below* when TDD is a measure of dispersion below some desirable target return.

Graphically Sortino Ratio can be represented as:

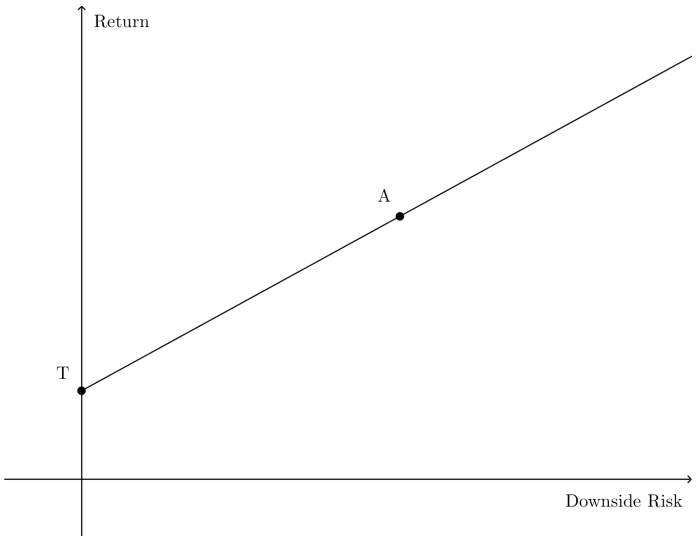

Figure 5: Sortino Ratio

Also, it is clear that the minimum rate of return investors should be seeking is the risk free return. Therefore, target return should always be greater than or equal to the risk free rate.

There as some advantages for the Sortino ratio.

First, it is easy to calculate based on past performance if target return is chosen.

Second, it takes into account only downside risk. Therefore, managers are not penalized for upside deviation.

Finally, as Papageorgiou (2005) mentioned it accounts better if distribution is not symmetric. If two managers have the same mean and the same standard deviation it doesn't mean they have the same distribution. If manager A has a normally distributed returns and manager B has the same mean and the same standard deviation but returns are left skewed then Sharpe ratio won't show the difference. However, with Sortino ratio preference will be given to the manager A.

The disadvantages of the Sortino ratio are very similar to the previous measure.

First, it is a backwards looking measure and does not provide any useful information

about the future.

Second, it does not provide any guidance on how to build a portfolio.

Finally, it does not account for correlation between assets.

2.4 Calmar Ratio

Calmar Ratio (short for **CAL**ifornia **M**anaged **A**ccounts **R**eports) was introduced by Young (1991). It is similar to the Sharpe ratio because is a a ratio of return over risk measure. However, in Calmar Ratio doesn't consider excess return and instead of taking standard deviation as a measure of risk in Calmar Ratio *maximum drawdown* (MDD) is a risk measure. MDD is "the maximum cumulative loss from a market peak to the following trough" (Magdon-Ismail, 2004) it measures how sustained losses can be. Therefore, we can define the ratio now:

$$\text{Calmar Ratio} = \frac{\text{Return over period [0, T]}}{\text{MDD over period [0, T]}} \text{ or}$$
$$\text{Calmar Ratio} = \frac{\text{Return over period [0, T]} - \text{Risk Free Rate}}{\text{MDD over period [0, T]}}$$

where usually return takes as annualized return of the company and MDD over period $[0, T]$ can be calculated (in percentage) as:

$$\text{MDD} = \frac{\text{Through Value - Peak Value}}{\text{Peak Value}}$$

Similar to the Sharpe Ratio, Calmar Ratio gives a possibility for investors to rank hedge funds or commodity trading advisors. The higher Calmar Ratio the better performance of a given fund or manager.

Let's start with the advantages of Calmar ratio.

First, it helps to show a long term prospectives instead of Sharpe Ratio which is too

sensitive to momentum changes. Usually investors calculate Calmar ratio over the period of three years.

Second, it shows the cumulative loss investors can have if he/she invest in the fund or hire a specific manager.

Now, let's discuss the disadvantages of the Calmar ratio.

First, there is no way to change return from one frequency to another similar to $\sqrt{T}$ for Sharpe ratio. Therefore, it is necessary to compare Calmar Ratio over the same period of time (typically three years).

Second, there is no guidance on how to create a portfolio and no common portfolio optimization approach similar to Sharpe Ratio due to the lack of understanding how the MDD of a portfolio relates to the performance.

Finally, a lot of time needed in order to reflect momentum changes.

There are some possible **modifications** can be made to the Calmar ratio.

2.4.1 Sterling Ratio

Sterling Ratio is similar to Calmar Ratio, however, it replaces maximum drawdown by average drawdown. When this ratio was first introduced to the public by Deane Sterling Jones, a company no longer exists, it looked like:

$$\text{Sterling Ratio} = \frac{R \text{ on [0, T]}}{\overline{D} + 10\%}$$

where $\overline{D}$ is the average largest drawdown. Sterling ratio contains arbitrary choice of +10% because it is necessary to compensate for average drawdown since this value usually very

small. However, Bacon (2013) offered different modification of this ratio:

$$\text{Sterling Ratio}_{\text{Bacon}} = \frac{R - R_F}{\left| \sum_{i=1}^{i=d} \frac{D_i}{d} \right|}$$

where d fixed to the investor's preference. If $d = 1$ then it is a maximum drwadown but typically it is 3 years. Usually, when this ratio is used only a fixed number of largest drawdowns are averaged For example, the largest individual drawdowns over three years.

2.4.2 Burke Ratio

This ratio suggests to use a concept of taking square root of the sum of squares in order penalize for large drawdowns and not small. Therefore, the ratio is:

$$\text{Burke Ratio} = \frac{R - R_F}{\sqrt{\sum_{i=1}^{i=d} D_i^2}}$$

the number of drawdowns used can be a fixed number of largest drawdowns.

2.5 Risk-Adjusted Return on Capital

As mentioned in Prokopczuk, Rachev, and Truck (2004) in late 1970s Banker Trust developed Risk-Adjusted Return on Capital (RAROC). It was defined as:

$$RAROC_{BankersTrust} = \frac{\text{Risk-Adjusted Return}}{\text{Equity Capital}}$$

However, the word "Risk-Adjusted Return" is misleading. Since it was used to represent the difference between deterministic return and expected loss i.e. possibility that debtor defaults. Since expected loss is known than there is no risk involved. That is why it is better

to use Expected Return. In addition, nowadays Economic Capital is used not Equity Capital. Thus, we can define RAROC as follows:

$$RAROC = \frac{\text{Expected Return}}{\text{Economic Capital}}$$

where Economic Capital is the amount of money which is needed to secure bank from default in the worst case scenario. In addition, it has to capture all risk (market, credit, and operational).

For now it sounds abstract and we need to find estimations on how to calculate RAROC. In addition, we are interesting in financial definition of this measure and not accounting definition. Therefore, in reality, Value at Risk (VaR) is used instead of Economic Capital since VaR represent the maximum amount of money for a given confidence level and in a specific time period. It can be calculated:

$$P(X < -VaR) = \alpha \text{ or } \int_{-\infty}^{-VaR} f(x)dx = \alpha$$

where X is a random variable that represents the profit and the loss of the business and $f(x)$ is the density function of profit and loss distribution.

Even with this expression it seems a little bit abstract how to calculate VaR. In practice there are 6 methods used (Methodologies are provided by Bacon(2013)):

Methodology	**Ex-post**	**Ex-ante**
Parametric	Parametric	Analytical (or variance-covariance)
Historical	Non-parametric	Historical simulation
Monte Carlo	Ex-post Monte Carlo	Monte Carlo Simulations

Table 2: VaR Methodologies

1. Parametric VaR.

This method assumes that return has normal distribution. Therefore, the 95% and 99%

confidence VaR can be calculated as follows:

$$\text{VaR}_{95\%} = \mu - 1.65 * \sigma$$

$$\text{VaR}_{99\%} = \mu - 2.33 * \sigma$$

2. Historical VaR.

For historical approach it is necessary to reorganize return from the best to the worst and find 95th percentile with 95% confidence. There are five main methods how to calculate the percentile:

$$\text{Method 1} = \frac{n}{N}$$
$$\text{Method 2} = \frac{n-1}{N}$$
$$\text{Method 3} = \frac{n-1}{N-1}$$
$$\text{Mathod 4} = \frac{n-0.5}{N}$$
$$\text{Mathod 5} = \frac{n}{N+1}$$

where: n = rank of the observations (in case if ranked best to worst)

N = total number of observations.

In a small sample size the difference in methods is usually significant. As explained in Carl Bacon book method 3 is better from the performance measurer's perspective when sample size is 100, method 2 is better from a risk perspective to determine 95th percentile for value at risk.

3. Monte Carlo simulation.

Monte Carlo is similar to historical approach but usually random number generator is used in order to calculate hypothetical returns for the future and after that 95th percentile is taken.

We know that RAROC allows managers and investors to compare two different investment opportunities, i.e. it allows us to say if the investment A is better than the investment B. However, not always either one of these investments brings profit (in case if both investment has negative rate of return). Therefore, we need to find a way to use RAROC in order to determine if it is a profitable investment or not. The following explanation is based on the idea that priority of the investment is to maximize the Shareholders value. The basic idea of making a decision in this case is:

$$\text{Increase Shareholders Value} \Leftrightarrow \text{RAROC} > \text{Cost of Equity Capital Rate}$$

We compare RAROC to Cost of Equity Capital because it is important to consider the opportunity cost of the investment. Therefore, in many books it is possible ro find RAROC ratio being presented as:

$$\text{RAROC} = \frac{\text{Expected Return - Cost of Capital Rate * VaR}}{\text{VaR}}$$

If we represent RAROC ratio this way then we can write decision condition in the following way:

$$\text{Increase of Shareholders Value} \Leftrightarrow \text{RAROC} > 0$$

Another question arises: How do we determine Cost of Capital Rate?

There can be different answers to this question:

1. It can be an internal rate which is determined within a company and is used by its managers and executive team.

2. Use the rate that shareholders expect from their investment.

None of these answers are scientifically significant. However, they are widely used in

practice. If you are looking for more scientific answer there are different models that allow to calculate the Cost of Equity Capital:

1. CAPM.

2. Option Pricing Theory (if Equity Capital can be interpreted as a call option on the total firm capital).

3. The model of Froot and Stein.

The some advantages for RAROC.

First, it allows to compare businesses with different sources of risk.

Second, it is a powerful tool for capital allocation and risk control.

However, as any measure RAROC has its own disadvantages.

First, it is hard to determine Cost of Capital Rate.

Second, it is a more accounting based ratio rather than financial measure.

Finally, if a small number of returns are present then it can be either hard or impossible to calculate VaR.

3 Ranking managers with the help of performance measures

Now, when we know the theory behind few risk-adjusted measures let's look at some real financial examples. In section we will be looking at the 8 larges funds of the United States, we will apply risk-adjusted measures to them and rank funds. Each subsection will provide detailed instructions on how the selection process was made and the procedure of calculating given measures.

3.1 Fund Case-Studies

There are thousands of funds and to select some the choice was made towards the biggest funds in the United States because average investor would go to the internet and find some article about funds where he/she can invest. Article by Bill Harris "The 10 Biggest Mutual Funds: Are They Really Worth Your Money?" in Forbs brought our attention and 8 out of 10 funds presented were chosen for the illustration. Two funds from this article were eliminated because they are fixed income funds. In order to be able to compare apples to apples they were not selected because comparison wouldn't be fair when we have to select a benchmark.

Monthly data was taken for the 11 years from 1/1/2006 up to 1/1/2017 for all 8 fund. First ten years were used to analyze the risk-adjusted performance of all funds when the last year was used to compare the results for the previous 10 years and the following year. The data was obtained for all funds and for the benchmark which was chosen to be S&P500 because funds are different by their nature and we need a common benchmark.

One should note that American Financial Crisis in 2008-2010 is also included in the time frame, therefore, returns are lower for those years and in many cases they are negative but it is a part of the risk when investors put their money in the market that is why there is no justification to consider them as outliers and remove them from the set.

After monthly data was obtained it was converted to the annual returns by the following function:

$$R_{annual} = \prod_{i=1}^{12}(R_i + 1) - 1$$

then the mean return was used as a return for the funds and the benchmark and standard deviation was calculated over the 10 years for annual returns.

3.1.1 Sharpe Ratio Case-Studies

First, let's show how Sharpe Ratio can be applied to the 8 selected funds.

As we know from the definition of the Sharpe ratio we need an appropriate risk-free rate. In this examples US 10 years T-Bond rate as of 12/31/2005 was chosen and equal to 4.39%. 10 years T-Bonds were chosen because we want to make sure we would make more on our investments rather than investing in a risk-free rate and leaving money there for 10 years.

In the Table 3 we Sharpe ratio and all information needed for all 8 funds:

Fund	Return	Standard Deviation	Sharpe Ratio	Rank
F	4.39%	0		
1	6.56%	14.15%	0.15313	VI
2	6.33%	21.33%	0.09116	VII
3	10.00%	18.77%	0.29881	I
4	9.29%	19.83%	0.24690	IV
5	5.13%	4.54%	0.16248	V
6	5.51%	22.05%	0.05064	VIII
7	9.13%	18.38%	0.25801	III
8	9.60%	18.53%	0.28103	II

Table 3: Sharpe Ratio

As we can see from the Table 3 all funds produce positive returns and greater than the risk-free rate. Therefore, it would be more beneficial for investors in a long run to invest in any of these funds rather than risk-free rate even though financial crisis of 2008-2010 is included in this dataset.

Table 3 allows us to make the following conclusions:

- If we compared pure return without adjusting for risk, then the fund 3 would be the most attractive. Actually, fund 3 was the best even after adjusting for the risk (standard deviation) because its return to risk had the best ratio.

- Fund 6 produced quite small annual return over the last 10 years comparing to the risk they take. They produce only 5.13% return per year, but they take 22.05% of risk, which is the highest risk among all 8 funds.

- In addition, maybe fund 5 didn't produce the highest return but its risk was relatively small keeping in mind that Financial Crisis period was included and fund 5 got the 5th rank.

As we can see Sharpe ratio gives different ranking rather than a pure return. In addition, it allows easy calculations and comparison between fund's return and risk.

3.1.2 Information Ratio Case-Studies

First, let's discuss how the benchmark was selected and the details of these calculations.

Since funds that were selected have different nature then it would be beneficial for all of them to select a benchmark which is a whole market or S&P500 since some of these funds are stock market indexes, some are growth funds. Therefore, in order to be consistent, S&P500 was selected as a benchmark.

As we know from the definition of the Information ratio we need to have an average annual excess return and standard deviation of the excess return. Therefore, in order to obtain these values annual returns for each fund were used then S&P500 annual returns were subtracted from the fund's return. Then average was taken and the standard deviation for each fund. Then this is the result of the calculations in a Table 4.

Fund	Return/Excess Return	Standard Deviation	Information Ratio	Rank
B	7.25%	18.74%		
1	-0.69%	8.85%	-0.0781	VI
2	-0.91%	12.17%	-0.0750	V
3	2.75%	10.18%	0.2702	III
4	2.04%	8.50%	0.2399	IV
5	-2.12%	18.30%	-0.1158	VI
6	-1.74%	11.95%	-0.1456	VIII
7	1.88%	5.73%	0.3290	II
8	2.35%	5.53%	0.4251	I

Table 4: Information Ratio

As we can see from the Table 4 not many funds managed to produce positive excess return over the 10 years if market (S&P500) was selected as a benchmark.

Table 4 allows us to make the following conclusions:

- As in the Sharpe ratio fund 3 managed to produce the highest excess return. However, in the relationship to a benchmark this fund was exposed to one of highest risks among all 8 funds.

- Fund 8 produced almost the same excess return as fund 3. However, fund 8 did not take as much "extra" risk as fund 3. Therefore, now fund 8 has the highest Information ratio and the lowest tracking error among all funds. Which means that funds 8 is more attractive for the investor rather than funds 3 if we compare it to the Sharpe ratio.

- As we compare Information Ratio ranking with the Sharpe ratio overall there is a difference but most of the funds are changed places by one ranking. However, Information ratio allows us to compare returns not only with a risk-free rate but with a market and see how much "additional" risk each fund brings to the market risk.

- Finally, if we use Grinold And Khan (1999) approach and compare Information ratio with 0.5, 0.75, and 1.0 we can see that none of the funds produces even "good"

Information ratio over the 10 years period.

3.1.3 M2 (RAP) or Modigliani and Modigliani Ratio Case-Studies

As in Information ratio for RAP we have to select a benchmark and S&P500 was still used as a benchmark for all 8 funds. The following formula was used to calculate RAP that was offered by Modigliani and Modigliani (1997):

$$RAP = (1 + d)R_i - R_f d$$

where R_i average annual return of the fund, R_f is a risk-free rate, and $d = \frac{\sigma_B}{\sigma_i} - 1$.

Risk-free rate and the benchmark was chosen the same values as in Sharpe and Information ratios. Results of the calculations can be found in Table 5.

Fund	Return	Standard Deviation	$d = \frac{\sigma_B}{\sigma_i} - 1$	RAP	Rank
F	4.39%	0.00%			
B	7.25%	18.74%			
1	6.56%	14.15%	0.3247	7.26%	VI
2	6.33%	21.33%	-0.1214	6.10%	VII
3	10.00%	18.77%	-0.0015	9.99%	I
4	9.29%	19.83%	-0.0551	9.02%	IV
5	5.13%	4.54%	3.1264	7.43%	V
6	5.51%	22.05%	-0.1501	5.34%	VIII
7	9.13%	18.38%	0.0196	9.22%	III
8	9.60%	18.53%	0.0111	9.66%	II

Table 5: M2 or RAP

As we know from the nature of M2 measure it produces the same ranking as a Sharpe Ratio but instead of having a number which can be hard or impossible to interpret (Sharpe ratio), RAP gives investors a risk-adjusted return that was calculated based on the leverage/delaverage of the portfolio.

Table 5 allows us to make the following conclusions:

- Funds 1, 5, 7, and 8 produced higher risk-adjusted return rather than a pure return. However, funds 2, 3, 4, 6 produced lower risk-adjusted return.
- On a pure return fund 5 in particular doesn't look very attractive for the investors. However, it wasn't exposed to a lot of risk (just 4.54%) and after adjusting for risk fund 5 produces 7.43% of return.
- Fund 6 was exposed to the highest risk among all funds which brought this fund to the 8th place.

3.1.4 M3 or Muralidhar Ratio Case-Studies

As we established in the beginning it is important to adjust for the correlation between a benchmark and a fund's return. One of the measures that adjusts for the correlation is M3. It requires benchmark returns (S&P500), risk-free rate (US T-Bond) and a target tracking error. For the target tracking error was 7% selected. Which corresponds to 0.9302 of the target correlation ($1 - \frac{0.07^2}{2(0.1874)^2}$). The choice of the tracking error was made based on the risk-free return and the return of a benchmark. Investors always should seek a target return higher than a risk-free therefore it is higher that 4.4% but it is lower than the market because we want to be conservative and prepare for a lower return of the market then the last year. Investors can choose any target tracking error but calculations will be exactly the same.

In addition, M3 requires a correlation coefficient between fund's returns and a benchmark. Correlation was calculated for annual returns using the following formula:

$$\rho_{A,B} = \frac{\sum(A - \bar{A})(B - \bar{B})}{\sqrt{\sum(A - \bar{A})^2 \sum(B - \bar{B})^2}}$$

One should note that d here has slightly different definition than in M2. Muralidhar defined it as $d = \frac{\sigma_B}{\sigma_i}$. In the Table 6 calculations for M3 measure are presented:

Fund	Return	σ_i	$\rho_{T,B}$	d	TE	a	b	$1-a-b$	M3	Rank
F	4.39%	0.00%	0							
B	7.25%	18.74%	1	100%						
1	6.56%	14.15%	0.8921	132.47%	7.26%	1.0758	0.2057	-0.2815	7.31%	VI
2	6.33%	21.33%	0.8231	87.86%	6.10%	0.5678	0.3983	0.0339	6.63%	VII
3	10.00%	18.77%	0.8526	99.85%	9.99%	0.7014	0.3313	-0.0327	9.27%	III
4	9.29%	19.83%	0.9043	94.49%	9.02%	0.8125	0.1526	0.0349	8.80%	IV
5	5.13%	4.54%	0.2155	412.64%	7.43%	1.5509	0.8492	-1.4001	7.96%	V
6	5.51%	22.05%	0.8404	84.99%	5.34%	0.5755	0.3611	0.0634	6.06%	VIII
7	9.13%	18.38%	0.9525	101.96%	9.22%	1.2292	-0.2182	-0.0110	9.60%	II
8	9.60%	18.53%	0.9560	101.11%	9.66%	1.2653	-0.2661	0.0008	10.22%	I

Table 6: M3 Measure

Table 6 allows us to make the following conclusions:

- Correlation has an effect on ranking funds/managers. For example, Sharpe ratio suggested that the most attractive fund for investments is fund 3. However, if we adjust for the correlation the most attractive fund will be 8 the same as Information ratio suggested.

- M3 measure gives investors a guidance on how to build a portfolio out of risk-free rate, benchmark and a fund. For example, if we use the strategy that M3 suggests we will get 10.2% of risk-adjusted return on fund 8. When its pure return is only 9.6%.

- Some funds outperform on unadjusted basis but underperform on adjusted basis and vise versa. For example, fund 3 has 10% unadjusted return but only 9.3% adjusted return.

- Fund 5 has one of the least attractive pure returns for the investors. However, after adjusting for risk and correlation it has the highest change to M3 of 64.4%.

3.1.5 Sortino Ratio Case-Studies

Next ratio is a Sortino ratio that uses the Target Downside Deviation (TDD) as a risk measure. In the formula of the TDD we need to use the target required rate of return. As

a target rate risk-free rate was chosen because it is a minimum return that investors should require from funds.

In Table 7 calculations are presented for all 8 funds:

Fund	Return	TDD	Sortino	Rank
F	4.39%	0.00%		
1	6.56%	14.39%	0.1505	VI
2	6.33%	20.13%	0.0966	VII
3	10.00%	17.07%	0.3285	I
4	9.29%	18.14%	0.2699	III
5	5.13%	3.35%	0.2203	V
6	5.51%	21.84%	0.0511	VIII
7	9.13%	17.59%	0.2695	IV
8	9.60%	17.05%	0.3054	II

Table 7: Sortino Ratio

Table 7 allows us to make the following conclusions:

- Fund 6 as in most of previous measures is exposed to the highest risk among all 8 funds in addition to having very low return it brings it to the last place.
- Fund 5 as in most of previous measures has the lowest risk of only 3.35%. When the majority of funds have more than 15% of risk. However, having very low return gives fund 5 only the 5th place.
- Fund 3 having the highest return among all 8 fund get the first place because it has a relatively low risk comparing to the other funds.

3.1.6 Calmar Ratio Case-Studies

In the Calmar ratio Maximum Drawdown (MDD) is used as a risk measure. The basic idea of the MDD is a maximum cumulative loss over the entire period. Calculations are presented in a Table 8

Fund	Return	MDD	Calmar	Rank
F	4.39%	0.00%		
1	6.56%	10.99%	0.1971	V
2	6.33%	19.49%	0.0998	VI
3	10.00%	13.23%	0.4238	III
4	9.29%	20.29%	0.2413	IV
5	5.13%	9.43%	0.0782	VII
6	5.51%	23.21%	0.0481	VIII
7	9.13%	9.14%	0.5185	II
8	9.60%	10.02%	0.5199	I

Table 8: Calmar Ratio

The following conclusions can be made from the Table 8

- Fund 5 again has the lowest risk among all 8 funds. However, as we can see from the ranking the difference in risk is not significant enough because Calmar ratio gave it the 7th place.
- Fund 3 losses it's first place again because it has 13.23% of risk which is not too high, however, fund 8 has approximately the same return but lower risk which brings fund 8 to the first place and fund 3 to the 3rd.
- Fund 6 has the highest risk and one of the lowest returns among all 8 funds which brings it to the 8th place again.

3.1.7 RAROC Case-Studies

As was discussed previously RAROC uses VaR as a measure of risk. In order, to determine VaR historical approach and monthly data was used in order to obtain VaR because 10 years are not enough to calculate the percentile carefully. Also, 5th percentile was used to obtain VaR. Table 9 shows the calculations:

Fund	Return	VaR	RAROC	Rank
1	0.50%	-5.29%	0.0948	IV
2	0.46%	-9.04%	0.0505	VII
3	0.74%	-6.72%	0.1104	II
4	0.68%	-7.12%	0.0959	III
5	0.42%	-1.43%	0.2909	I
6	0.40%	-10.00%	0.0396	VIII
7	0.69%	-7.47%	0.0918	VI
8	0.73%	-7.94%	0.0918	V

Table 9: RAROC Measure

As we can see from the Table 9 it gives very different results comparing to other measures most likely because monthly data was used and not yearly. However, we still can make the following conclusions from the Table 9:

- All funds have negative VaR which means that none of the funds produced positive returns in the 5% of worst scenarios.
- Fund 6 has the highest risk among all funds. However, previously fund 6 had a lot higher risk than other but using RAROC fund 2 has a risk almost as high as fund's 6.
- Fund 5 produced the lowest risk again and a relatively high monthly return which brings fund 5 to the first place.

3.1.8 Putting all measures together

In this section we will see all measures together in order to make an easier comparison. Table 10 contains rankings for all measures for 8 funds:

Fund	Sharpe	Information	M2	M3	Sortino	Calmar	RAROC
1	VI	VI	VI	VI	VI	V	IV
2	VII	V	VII	VII	VII	VI	VII
3	I	III	I	III	I	III	II
4	IV	IV	IV	IV	III	IV	III
5	V	VI	V	V	V	VII	I
6	VIII	VIII	VIII	VIII	VIII	VIII	VIII
7	III	II	III	II	IV	II	VI
8	II	I	II	I	II	I	V

Table 10: Comparison between measures

As we can see from this table all measures have quite different results. However, RAROC has the most distinct ranking most likely because it used monthly data.

If we look at specific funds the following can be noted:

- All ratios ranked fund 6 as the least attractive fund for the investments including RAROC.
- All measures except RAROC put fund 5 on places 5-7 (most of them gave it 6th place). However, based on RAROC this fund got the first place.
- All measures agree that fund 3 has to be in the top of the list. However, only Sharpe, M2 and Sortino ratios put it on the first places. Others gave it either second or third places. Especially, if we look at M3 it gave it the third place and we know that fund 3 underperforms on risk-adjusted basis if we add correlation and benchmark into account and into the portfolio. Therefore, fund 3 shouldn't take the first place.
- An interesting observation is that all ratios except for RAROC agreed on which funds take places from 1-4, and 5-8. All ratios ranked funds 3, 4, 7, and 8 as the top 4 funds out of 8. Even though they had different rankings but they all shared the first half of the ranking.

In this section we looked at the past performance, we adjusted pure return for the risk but the purpose of this is to find the best fund/manager for the future. Therefore, it bring us to the next section where the same measure were calculated for the following year and we will compare past results with the following year.

3.2 Comparing the same ratios for the following year

In this section we will compare ratios that were calculated over the 10 years and the same measures for the following year.

The idea of this is to see which ratio was closer to prediction the next year's ranking. For this section risk-free rate was chosen a 1 year US T-Bill as of 1/03/2017 and benchmark was S&P500 for 2017.

3.2.1 Sharpe Ratio following year

Fund	Return	Standard Deviation	Sharpe	Previous Sharpe	Ranking	Previous Ranking	Increase/ Decrease
F	0.89%	0.00%					
1	8.99%	3.83%	2.12	0.1531	VI	VI	Increase
2	24.63%	7.17%	3.31	0.0912	IV	VII	Increase
3	24.39%	9.15%	2.57	0.2988	V	I	Increase
4	17.84%	8.94%	1.90	0.2469	VII	IV	Increase
5	2.39%	1.79%	0.84	0.1625	VIII	V	Increase
6	23.83%	4.42%	5.20	0.0506	I	VIII	Increase
7	19.48%	4.33%	4.30	0.2580	III	III	Increase
8	18.98%	4.18%	4.33	0.2810	II	II	Increase

Table 11: Comparing Sharpe Ratio

As we can see from the Table 11 that all Sharpe ratios increased because in the previous examples Financial Crisis was included. However, let's look at the annual return and the ranking of Sharpe Ratio.

Table 11 allows us to make the following conclusions:

- If we compare just pure annual returns, then fund 2 would have the first place but fund 2 has one of the highest risks among all 8 funds.
- All ratios ranked fund 6 as the least attractive fund. However, as we can see from its performance in the following year fund 6 got one of the highest returns and one of the lowest risks. That is why Sharpe ratio ranked fund 6 as the first one.
- Another big change was for fund 5. Even with Financial Crisis fund 5 had average annual return of 5.13%. However, for the 2017 it returns dropped to 2.4%. Which brought it to the last place even though it has the lowest risk among all 8 funds.

3.2.2 Information ratio following year

In the Table 12 we can find a comparison between previous 10 years and the following year.

Fund	Return/ Excess Return	Standard Deviation	Information Ratio	Previous IR	Ranking	Previous Ranking	Increase/ Decrease
B	17.32%	5.68%					
1	-12.64%	8.82%	-1.4333	-0.0781	VII	VI	Decrease
2	0.15%	10.65%	0.0137	-0.0750	I	V	Increase
3	-0.21%	13.23%	-0.0160	0.2702	II	III	Decrease
4	-5.54%	12.90%	-0.4294	0.2399	IV	IV	Decrease
5	-17.90%	6.04%	-2.9618	-0.1158	VIII	VI	Decrease
6	-0.39%	7.65%	-0.0515	-0.1456	III	VIII	Increase
7	-3.98%	8.09%	-0.4923	0.3290	V	II	Decrease
8	-4.39%	7.88%	-0.5569	0.4251	VI	I	Decrease

Table 12: Information Ratio Comparison

There are few things could be noted from the Table 12

- Almost all funds except for fund 2 have negative excess return which means that all of them did not manage to beat the benchmark for the following year.
- Fund 8 that was previously ranked the worst fund now got the third rank and it is one of two funds which information ratio increased even though it is still negative.
- Since almost all funds have negative information ratio then based on the information ratio investor shouldn't invest in any of the funds. Even fund 2 which have a positive information ratio have a ratio of 0.01.

3.2.3 M2 ratio for the following year

In the Table 13 we can find a comparison between previous 10 years and the following year.

Fund	Return	Standard Deviation	$d = \frac{\sigma_B}{\sigma_i} - 1$	RAP	Previous RAP	Ranking	Previous Ranking	Increase/ Decrease
F	0.89%	0.00%						
B	17.32%	5.68%						
1	8.99%	3.83%	0.4831	12.90%	7.26%	VI	VI	Increase
2	24.63%	7.17%	-0.2086	19.68%	6.10%	IV	VII	Increase
3	24.39%	9.15%	-0.3798	15.46%	9.99%	V	I	Increase
4	17.84%	8.94%	-0.3651	11.65%	9.02%	VII	IV	Increase
5	2.39%	1.79%	2.1761	5.66%	7.43%	VIII	V	Decrease
6	23.83%	4.42%	0.2854	30.38%	5.34%	I	VIII	Increase
7	19.48%	4.33%	0.3113	25.27%	9.22%	III	III	Increase
8	18.98%	4.18%	0.3591	25.48%	9.66%	II	II	Increase

Table 13: RAP or M2 comparison

There are few things could be noted from the Table 12

- Fund 6 has the highest risk-adjusted return of 30%.
- Fund 5 has the only RAP measure that decreased for the following year in comparison to the previous year. However, its risk-adjusted return is 5.6% when pure return is 2.4%.

- Fund 3 moved from the first place to the fifth having a risk-adjusted return of 15.46% when pure return is 24.4%.

3.2.4 M3 ratio for the following year

In the Table 14 we can find a comparison between previous 10 years and the following year including a, b, and $1-a-b$ calculations. Both target correlations are calculated based on 7% which gives us $\rho_{T,B}$ 93% and 23.9% for previous and following year correspondingly:

Fund	Return	Standard Deviation	$\rho_{1,B}$	d	M3	Previous M3	Rank	Previous Rank	Increase/ Decrease
F	0.89%	0.00%	0						
B	17.32%	5.68%	1	100%					
1	8.99%	3.83%	-71.22%	148.31%	37.62%	7.31%	I	VI	Increase
2	24.63%	7.17%	-36.59%	79.14%	30.69%	6.63%	VI	VII	Increase
3	24.39%	9.15%	-56.96%	62.02%	33.09%	9.27%	V	III	Increase
4	17.84%	8.94%	-53.50%	63.49%	27.30%	8.80%	VII	IV	Increase
5	2.39%	1.79%	-5.61%	317.61%	10.36%	7.96%	VIII	V	Increase
6	23.83%	4.42%	-13.54%	128.54%	35.90%	6.06%	II	VIII	Increase
7	19.48%	4.33%	-29.64%	131.13%	34.56%	9.60%	III	II	Increase
8	18.98%	4.18%	-26.33%	135.91%	33.92%	10.22%	IV	I	Increase

Fund	a	b	$1-a-b$	Previous a	Previous b	Previous $1-a-b$	TE	Previous TE
1	2.051	1.224	-2.276	1.076	0.206	-0.282	12.90%	7.26%
2	0.826	0.621	-0.447	0.568	0.398	0.034	19.68%	6.10%
3	0.733	0.912	-0.645	0.701	0.331	-0.033	15.46%	9.99%
4	0.730	0.854	-0.584	0.813	0.153	0.035	11.65%	9.02%
5	3.089	0.294	-2.382	1.551	0.849	-1.400	5.66%	7.43%
6	1.260	0.372	-0.632	0.576	0.361	0.063	30.38%	5.34%
7	1.333	0.541	-0.874	1.229	-0.218	-0.011	25.27%	9.22%
8	1.368	0.504	-0.872	1.265	-0.266	0.001	25.48%	9.66%

Table 14: M3 Comparison

Just a reminder that a is a portion invested in a mutual fund, b is a portion invested in the benchmark, and $1-a-b$ is a portion invested in a risk-free rate. As we can see from the Table 14 the following conclusions can be drawn:

- Fund 1 now has the first ranking most likely due to the fact that it has a very strong negative correlation with the benchmark for the following year.

- Fund 1 has one of the lowest pure returns, however, after the adjustment for correlation gives it 37.62% of return after the correct allocation of investments between fund, benchmark, and a risk-free rate.

- It makes sense that all ratio increased for the following year because for the previous years crisis of 2008-2010 was included. Therefore, return adjusted for correlation is greater for the following year.

3.2.5 Sortino Ratio for the following year

In the Table 15 we can find a comparison between previous 10 years and the following year

Fund	Return	TDD	Sortino	Previous Sortino	Ranking	Previous Ranking	Increase/ Decrease
F	0.89%	0.00%					
1	8.99%	1.60%	5.0665	0.1505	V	VI	Increase
2	24.63%	2.14%	11.1075	0.0912	IV	VII	Increase
3	24.39%	5.12%	4.5877	0.2988	VI	I	Increase
4	17.84%	5.56%	3.0471	0.2469	VII	III	Increase
5	2.39%	1.00%	1.5004	0.1625	VIII	V	Increase
6	23.83%	0.61%	37.5334	0.0506	III	VIII	Increase
7	19.48%	0.42%	44.5980	0.2580	I	IV	Increase
8	18.98%	0.43%	42.2068	0.2810	II	II	Increase

Table 15: Sortino ratio comparison

As we can see from this table that there is a big difference between previous Sortino ratio and a current one. This difference is because different annualization method was used. Since it was calculated only for a year monthly TDD was calculated and then multiplied by $\sqrt{12}$. Therefore, comparison between ratios is not possible. However, we can compare rankings.

From the Table 15 we can make the following conclusions:

- Most of the funds have TDD around or less than 1%. However, two funds 3 and 4 have

risk higher than 5% and as we can see that the previous Sortino ratio ranked them as top 3 funds.

- Funds 7 and 8 have large Sortino ratios because they have a high return comparing to a low risk which brings them to the top two places.
- Fund 6 which was the least attractive fund based on past performance has the third rank in the following year.

3.2.6 Calmar Ratio for the following year

In the Table 16 we can find a comparison between previous 10 years and the following year

Fund	Return	MDD	Calmar	Previous Calmar	Ranking	Previous Ranking	Increase/ Decrease
F	0.89%	0.00%					
1	8.99%	1.29%	6.2839	0.1971	V	V	Increase
2	24.63%	1.63%	14.5878	0.0998	IV	VI	Increase
3	24.39%	5.03%	4.6755	0.4238	VI	III	Increase
4	17.84%	5.48%	3.0953	0.2413	VII	IV	Increase
5	2.39%	1.35%	1.1132	0.0782	VIII	VII	Increase
6	23.83%	0.54%	42.7174	0.0481	III	VIII	Increase
7	19.48%	0.34%	54.2476	0.5185	I	II	Increase
8	18.98%	0.35%	51.0389	0.5199	II	I	Increase

Table 16: Calmar Ratio comparison

Like the Sortino ratio we can not compare previous and current Calmar ratio because previous Calmar was calculated over the last three years but the current one only over the last year. However, we can compare rankings which will give us an idea of how funds did in comparison to each other.

From the Table 16 the following conclusions can be drawn:

- Almost all funds have a risk around 1% when funds 3 and 4 have risk higher than 5% but in the previous Calmar ratio they were in the top 4 funds.
- Funds 6-8 have large Calmar ratio because they have a high return comparing to a very small risk which allows them to get the first three positions in the ranking. Also, if we compare their previous ranks we will see that finds 7 and 8 were in the top two, however, fund 6 was the last one.
- Fund 1 didn't change it's ranking in comparison to other and fund 5 moved from the 7th position to the last one.

3.2.7 RAROC for the following year

In the Table 17 we can find a comparison between previous 10 years and the following year

Fund	Monthly Return	VaR	RAROC	Previous RAROC	Rank	Previous Rank	Increase/ Decrease
1	0.75%	-1.00%	0.7502	0.0948	VI	IV	Increase
2	2.05%	-1.40%	1.4643	0.0505	IV	VII	Increase
3	2.03%	-2.48%	0.8188	0.1104	V	II	Increase
4	1.49%	-2.63%	0.5660	0.0959	VII	III	Increase
5	0.20%	-0.48%	0.4119	0.2909	VIII	I	Increase
6	1.99%	0.11%	18.1709	0.0396	III	VIII	Increase
7	1.62%	-0.05%	30.4743	0.0918	I	VI	Increase
8	1.58%	-0.08%	19.9601	0.0918	II	V	Increase

Table 17: RAROC Ratio Comparison

RAROC was calculated based on monthly basis because otherwise there is not enough data to calculated 5th percentile. From the Table 17 we can draw the following conclusions:

- Even though fund 6 has the third ranking but it is the only fund which VaR is positive meaning that even the lowest 5% of returns is positive. That is why it is supposed to be the most attractive fund based on RAROC.

- Fund 5 which had the first ranking before now has the lowest and it is the least attractive fund for investors.

- If we compare previous ranking and for the following year we can notice that it has very big difference. Previous ratios changed places for fund just a little bit but RAROC brought some funds from the top ranking to the lowest and vise versa.

3.2.8 Final comparison between all ratios and comments

There are two tables presented. Table 18 represents the ranking we had previously and Table 19 represents the ranking for the following year.

Fund	Sharpe	Information	M2	M3	Sortino	Calmar	RAROC
1	VI	VI	VI	VI	VI	V	IV
2	VII	V	VII	VII	VII	VI	VII
3	I	III	I	III	I	III	II
4	IV	IV	IV	IV	III	IV	III
5	V	VI	V	V	V	VII	I
6	VIII	VIII	VIII	VIII	VIII	VIII	VIII
7	III	II	III	II	IV	II	VI
8	II	I	II	I	II	I	V

Table 18: Comparison of all ratios for the previous 10 years

Fund	Sharpe	Information	M2	M3	Sortino	Calmar	RAROC
1	VI	VII	VI	I	V	V	VI
2	IV	I	IV	VI	IV	IV	IV
3	V	II	V	V	VI	VI	V
4	VII	IV	VII	VII	VII	VII	VII
5	VIII	VIII	VIII	VIII	VIII	VIII	VIII
6	I	III	I	II	III	III	III
7	III	V	III	III	I	I	I
8	II	VI	II	IV	II	II	II

Table 19: Comparison of all ratios for the following year

From these two tables the following conclusions can be made:

- As we can see from the Table 19 almost all ratios agree that fund 7 and 8 should be on the first 3-4 positions. It agrees with the ratios of the previous 10 years. Almost all ratios gave funds 7 and 8 the top rankings.

- The same as for the past 10 years all measures agree on the worst fund which this year it happed to be fund 5. Previously, all measures ranked fund 5 from 5-7th places except for RAROC which gave it the 1 place.

- Another interesting remark that all ratios except for M3 ranked fund 1 from 5-7th places. However, M3 gave it the first place which shows how mush correlation affect the ranking. If we go back and look at the Table 14 we will see that fund 1 had the lowest negative correlation with the benchmark. Which proves our previous assumptions about correlation: investors seek investments with the negative correlation and the lower correlation the better because it helps to diversify the risk.

- As we can see from the Figure 6 most of histograms show approximately normal distributions except for Fund 3 and 1. Also, we can see that all funds have long left tails because crisis of 2008-2010 was included in calculations and can be considered as outliers.

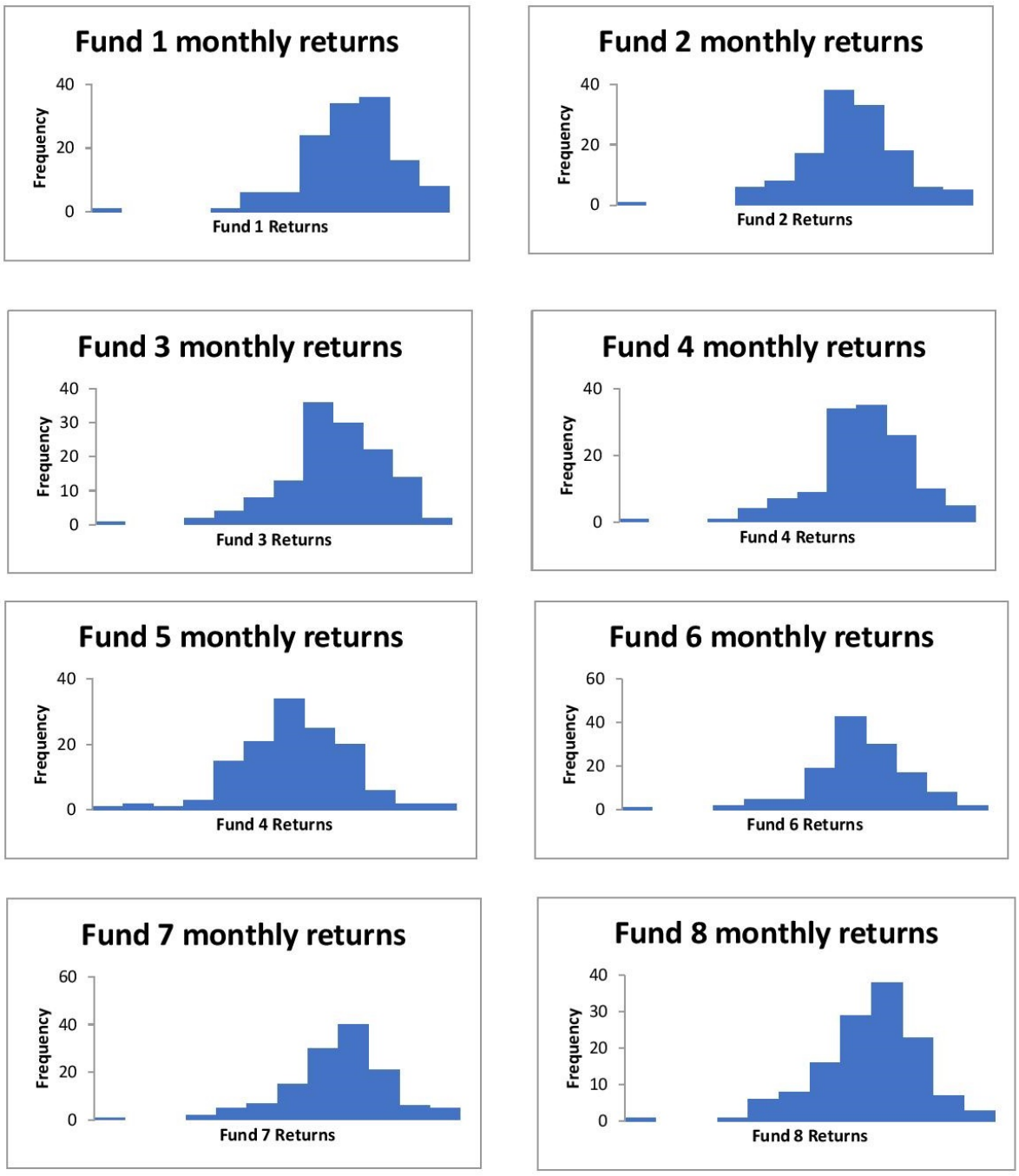

Figure 6: Histograms for all monthly returns

4 Comparing the effectiveness of M&A with the help of performance measures

In this section we will show how to apply the risk-adjusted measures described previously to measure Mergers and Acquisitions(M&A). There are few remarks before we go into the details:

1. We look at M&A from the prospective of a buyer. That is why we are not interested in a short-term performance of a target stock's returns. However, we will look at it and describe it.

2. In these examples all M&A were 100% acquisitions. Meaning that an acquire acquired 100% of the target company on the completion date.

3. The purpose of these examples not only to calculate the risk-adjusted measures but to incorporate correlation. We will adjust for the correlation using Dowd's (2000) approach and the procedure is the following:

a. Calculate all measures for the buyer before acquisition.

b. Assume that the acquire acquired the target company either 10 years ago or as long as we have data and calculate the same ratios under the assumption that acquisition happened 10 years ago or the max data we have.

c. Compare previous and the new ratio. If it increases then ratio suggests to proceed with the acquisitions.

therefore, using this process we account for the correlation as was explained in the previous chapters.

4. New ratios are calculated either using the price if it is provided or a target's market capital on the date of completion to calculate the weight of each stock. Also, acquire market capital was used for the weight on the date of completion.

5. Calmar ratio wasn't calculated for the M&A because for it we have to have combined

stock price of both companies and it is impossible to do because weight will change every day which each stock contributes to the total stock.

6. Since all acquisitions happen during different periods they will have different risk-free rate and benchmark returns. Therefore, comparison is impossible between acquisitions but it is not the goal of this paper. We are interested if acquisition was successful based on different risk-adjusted measures. The same technique can be applied if choice needs to be made between multiple target companies.

In addition, this chapter's structure is different from the previous one. Instead of reporting ratio by ratio we will report all ratios for the same Acquisition.

As in the previous chapter S&P500 was used as the benchmark. However, benchmark's return and standard deviation are different for each case because each acquisition was completed on different date. Also, all calculations for the long run are connected to the completion date and not the announcement date.

4.1 Brookfield Infrastructure Partners Case-Studies

Niska Gas Storage Partners (NKA) announced on 06/15/2016 that they agreed to be acquired by Brookfield Infrastructure Partners (BIP) and deal was completed on 07/19/2015. The price for this deal was set to be $4.225 per share. The day before the last day of NKA's stocks trade there were almost 38M shares outstanding. Therefore, the price of the NKA was calculated to be $160.5M. Hence, for all the calculations the weights of new company are 0.0164 for NKA and 0.9836 for BIP because BIP's market cap was $9646.22M.

	Sharpe Ratio	Information Ratio	M2	M3	Sortino	RAROC
BIP Alone	0.31206	0.19340	0.08743	0.08044	0.59592	-0.08894
Assuming Acquisition	0.48767	0.13579	0.06389	0.09671	∞	-0.21430
Following Year	0.86849	0.79804	0.11605	0.11608	5.36771	0.23863
Decision	Accept	Decline	Decline	Accept	Accept	Decline
Right/Wrong	Right	Wrong	Wrong	Right	Right	Wrong

Table 20: Brookfield Infrastructure Partners Ratios

As we can see from the Table 20 three ratios suggested to proceed with the deal, when three ratios suggested to decline the deal. However, all ratios agree that the deal was successful because all ratios increased for the following year.

Sortino ratio for assuming acquisition is ∞ because its TDD was zero. Therefore, when we divide by it, it gives us the ratio of ∞. Also, as we can see Sortino for the following year increased drastically, it increased from 0.5959 to 5.368.

In addition, it might be useful to look at the daily returns for 20 days before and after the announcement. It will allow us to see the market's reaction to the acquisition. Average daily return before the announcement was -0.114% and after the announcement was 0.158%. This shows that market reacted positively on this acquisition.

In the Table 21 we can see all data for BIP acquisition that will help to build all ratios from the Table 21.

	Return	Standard Deviation	Excess Return	Excess Standard Dev.	TDD	d
BIP Alone	0.1007	0.2579	0.0331	0.1713	0.1337	-0.1648
Assuming Acquisition	0.1162	0.1968	0.0275	0.2024	0.0000	0.1162
Following Year	0.2137	0.2422	0.1137	0.1425	0.0392	-0.4640

	$\rho_{1,B}$	TE	a	b	1-a-b	$\rho_{T,B}$
BIP Alone	0.7523	0.1713	0.4065	0.5811	0.0124	0.9472
Assuming Acquisition	1.0944	0.2673	0.3556	0.8946	-0.2502	0.9472
Following Year	0.8781	0.1425	0.5817	-0.0983	0.5167	0.8546

	VaR	Monthly Return	Benchmark Return	Benchmark Standard Dev.	Risk Free Rate
BIP Alone	-0.0844	0.0075	0.0676	0.2154	0.0202
Assuming Acquisition	-0.0729	0.0156	0.0676	0.2154	0.0202
Following Year	-0.0773	0.0185	0.1008	0.1298	0.0033

Table 21: BIP Data

4.2 Partners Real Estate Investment Trust Case-Studies

Crosswinds Holdings sold Griffin Skye (GRS) to Partners Real Estate Investment Trust (PAR) for CAD 17.37M. The deal was announced on 17/10/2011 and completed on 6/2/2012. Therefore, the weights for the new company are 0.1633 and 0.8367 for GRS and PAR respectively because the deal was set to be 17.73M and PAR market cap was 88.97M.

	Sharpe Ratio	Information Ratio	M2	M3	Sortino	RAROC
PAR Alone	0.18496	0.19741	0.05971	0.04603	0.39875	-0.18072
Assuming Acquisition	1.12473	-0.09427	0.28723	0.14291	∞	-0.08686
Following Year	0.27043	-0.63097	0.03043	0.10899	0.42102	0.06747
Decision	Accept	Decline	Accept	Accept	Accept	Accept
Right/Wrong	Right	Right	Wrong	Right	Right	Right

Table 22: Partners Real Estate Investment Trust Ratios

As we can see from the Table 22 almost all ratios suggested to accept the deal and only Information ratio suggested to decline. However, for the following year three ratios suggested that the deal was successful and three the opposite. Information ratio is the only ratio that suggested to decline and agreed with its decision for the following year.

Another noticeable change is in M3, It is one of the three ratios that suggested that the company should proceed with the acquisition and confirm its decision in the following year. Which shows that correlation has a great impact on the decision process. Also, we can see from the Table 23 that correlation between PAR and S&P500 decreased from 0.96 to 0.79 which means that by acquiring Griffin Skye they managed to diversify risk.

Sortino ratio here is ∞ for the assuming acquisition for the same reasons as for BIP because risk was 0.

In addition, it might be useful to check the daily returns for 20 days before and after the announcement. The average returns were 0.23% and 0.048% before and after the announcement. As we can see market wasn't happy with this acquisition since return decreased. However, all ratios show that acquisition was successful.

In the Table 23 we can see all data for RAP acquisition that will help to build all ratios from the Table 23.

	Return	Standard Deviation	Excess Return	Excess Standard Dev.	TDD	d
PAR Alone	0.1558	0.7330	-0.0843	0.8945	0.3456	-0.6654
Assuming Acquisition	0.1162	0.1968	0.0275	0.2024	0.0000	2.5792
Following Year	0.2137	0.2422	0.1137	0.1425	0.0899	-0.2282

	$\rho_{1,B}$	TE	a	b	1-a-b	$\rho_{T,B}$
PAR Alone	0.7523	0.5718	0.1435	0.6366	0.2199	0.9593
Assuming Acquisition	0.7485	0.2673	0.3556	0.8946	-0.2502	0.9593
Following Year	0.2430	0.1547	0.4876	0.6367	-0.1243	0.7902

	VaR	Monthly Return	Benchmark Return	Benchmark Standard Deviation	Risk Free Rate
PAR Alone	-0.1911	0.0345	0.0333	0.2452	0.0114
Assuming Acquisition	-0.1920	0.0167	0.0333	0.2452	0.0114
Following Year	-0.0585	0.0039	0.1415	0.1081	0.0012

Table 23: PAR Data

4.3 AT&T Case-Studies

AT&T announced on 05/18/2014 that it will acquire DIRECTV for 66,668.8M and the deal was completed on 07/27/2015. It is one of the largest acquisition in 2015. At the time AT&T market cap was $184,466.54M which gives us the weights for the deal of 0.265 and 0.735 for DIRECTV and AT&T correspondingly.

	Sharpe Ratio	Information Ratio	M2	M3	Sortino	RAROC
T Alone	0.04698	-0.12523	0.05131	0.06673	0.17913	-0.02755
Assuming Acquisition	0.26510	0.13268	0.09312	0.08577	0.68447	-0.09012
Following Year	1.53728	1.08014	0.22583	0.12323	4.14363	0.55454
Decision	Accept	Accept	Accept	Accept	Accept	Decline
Right/Wrong	Right	Right	Right	Right	Right	Wrong

Table 24: AT&T Ratios

It is safe to assume that since it was a huge acquisition mangers did a great job checking all numbers and making sure acquisition would be successful. That is what we can see from all measures. As we can see from the Table 24 all measures except for RAROC suggested to proceed with the deal and they all confirmed their decision for the following year except for RAROC. Overall, all ratios agree that the deal was successful.

Also, we can notice not only that all ratios increased for the following year the increase is huge. For example, Sortino increased from 0.18 to 4.14. M3 which provides us with the risk-adjusted return increased from 6.7% to 12.3% due to decrease in correlation.

In addition, it might be useful to check the daily returns for 20 days before and after the announcement. The average returns were -0.1016% and -0.1885% before and after the announcement. As we can see market wasn't happy with this acquisition since return decreased.

In the Table 25 we can see all data for RAP acquisition that will help to build all ratios from the Table 25.

	Return	Standard Deviation	Excess Return	Excess Standard Dev.	TDD	d
T Alone	0.0517	0.2008	-0.0216	0.1728	0.1234	-0.0453
Assuming Acquisition	0.0885	0.0685	0.0216	0.1625	0.0901	-0.0344
Following Year	0.2165	0.1391	0.1805	0.1671	0.0516	0.0436

	$\rho_{1,B}$	TE	a	b	1-a-b	$\rho_{T,B}$
T Alone	0.6135	0.1728	0.4340	0.6545	-0.0884	0.9333
Assuming Acquisition	0.6536	0.1625	0.4580	0.6233	-0.0813	0.9333
Following Year	0.3102	0.1671	0.5136	0.7311	-0.2447	0.8838

	VaR	Monthly Return	Benchmark Return	Benchmark Standard Deviation	Risk Free Rate
T Alone	-0.0664	0.0018	0.0734	0.1917	0.0423
Assuming Acquisition	-0.0772	0.0070	0.0734	0.1917	0.0423
Following Year	-0.0310	0.0172	0.0173	0.1452	0.0026

Table 25: AT&T Data

4.4 General Comments about M&A

If we look at all tables we will notice that only M3 and Sortino ratios gave consistent decisions among all rations. Therefore, correlation has a great impact on the ratios.

In addition, using this method we accounted for the correlation between the acquire and the target company. However, M3 accounted also for the correlation between the companies and the benchmark as well which gives better results as we can see from these examples.

Overall, accounting for correlation through calculating ratios before acquisition and assuming acquisition provides very useful information and allows investors to evaluation a potential acquisition.

In case of mergers procedure will be exactly the same. The only difference will be in the way weights for each company are calculated. It gets more complicated if it wasn't 100% merger from both sides but it is still possible to calculate weights but investors should be careful and consistent in their calculations.

5 Conclusion

Risk-adjusted performance measures can play an important role when choosing new investments. Ranking managers can help to determine the best or the worst manager not only based on pure return but also adjusting for risk.

These measures can be applied not only while choosing new investments but also when hiring new manager. If fund wants to hire a new manager, they can calculate presented measures and select manager that attract them the most based on ratios between return and risk.

Managers of acquiring company can calculate risk-adjusted performance measures for acquire but it is more valuable to adjust for correlation. As we can see from the case-studies it is beneficial to apply Dowds approach to all measures since the results were confirmed for the following year return.

If we look at all measures then we will see that only Sharpe, M3, and Sortino ratios proved their decisions from the previous year to the following year. Therefore, we can see that it is valuable for investors to adjust for correlation not only between acquirer and acquire but also between acquirer and a benchmark.

In addition, next year annual return proved the conclusions we drew from risk-adjusted performance measures. It is clear there are thousands of factors could influence stock return during the year. However, we took only one-year return to minimize the impact of other factors to stock returns.

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