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Shipping Finance

Constructing the optimal portfolio in the Shipping Sector

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Introduction

Throughout the human history shipping played an important role for the welfare of mankind. The frights it transported connected different civilization, helped the expansion of the Old World and provided goods even to the most remote areas.

The importance of shipping can be depicted by the fact that even now, in the 21st century, with all the technological boom and advancement ships transport about the 90% of the international freights. That is the reason, which international financial agents, investors and hedge funds choose the shipping sector and their freights in order to invest. There should be mentioned the ability of the commodities market to create value "out of thin air" as same usually say.

In the present Thesis we will try to investigate the possible risk measures an investor could use, as well as a brief investigation of the Shipping Sector and the practical and not only risk the maritime companies face as well as the main financial means the sector has. Following that, we will try to construct the optimal portfolio using a Risk Measure and observe if a financial agent should consider building a portfolio in the sector or not. The data used in the present Thesis have been collected from the *World Bank – Data Bank* combined with the *World Freight Calculator Tool* and *Maritime Traffic*. In order to keep as possible to real life as it can get, we used data from 2000, so that any technological advancement from previous century will not disorientate the researcher. The tool used for the calculations is mainly *GAMS.*

<u>Risk Measures</u>

Risk measures are statistical measures that are historical predictors of investment risk and volatility, and they are also major components in modern portfolio theory (MPT). MPT is the main financial and academical method for assessing the performance of a stock or a stock fund as compared to its benchmark index, usually the market the stock belongs itself.

There are several risk measures and each measure provides a unique way to assess the risk present in investments that are under consideration. Some of the main measures include the variance, Value at Risk and Conditional Value at Risk. Risk measures can be used individually or together to undergo a risk assessment. When comparing two investments, it is wise to compare them using the same method in order to determine which investment holds the most risk.

Variance

The variance remains the most commonly used risk measure in portfolio optimization models. Markowitz (1952) showed that if risk is measured by the variance of returns and expected return by the mean of returns, then uncertain investments can be ordered by their ranking in MV space. The variance is defined as:

$$\text{Var}(X) = \text{E}\,[(X\text{-}\mu)^2] = \sum_{i=1}^{n} (x_i - \mu)^2\, p_i \,,$$

where μ is the expected value of X, x_i the various values that X can take, and p (x_i) is the probability of X taking the value of xi.

When each value of X occurs with the same probability, the variance transforms into

$$\text{Var}(X) = \text{E}\,[(X\text{-}\mu)^2] = \sum_{i=1}^{n} (x_i - \mu)^2\, p_i = \sum_{i=1}^{n} (x_i - \mu)^2\, p = \frac{1}{n} \sum_{i=1}^{n} (x_i - \mu)^2$$

Even though, the Variance model is the most popular approach, it holds the assumptions that either the returns are normally distributed or that the investor's utility function is quadratic.

Two Important Properties of Variance:

1. $\text{Var}(aX) = a^2\text{Var}(X)$, $a \in \Re$
2. $\text{Var}(X+b) = \text{Var}(X)$, $b \in \Re$

Value at Risk

Value at risk (VaR) is a measure of the risk of investments. It estimates how much a set of investments might lose, taking as granted normal market conditions, in a set period of time, usually a day. VaR is typically used by firms and regulators in the financial industry to gauge the amount of assets needed to cover possible losses.

For a specified portfolio, time horizon, and probability p, the VaR can be defined as the maximum possible loss during the time if we exclude the worst possible outcomes, whose probability is less than p. This assumes mark-to-market pricing and no trading in the given portfolio.

Typically the data required for the calculations of VaR are statistical parameters for the underlings and measures of the portfolio's current disclosure to these underlings. The parameters include volatilities and correlations of the assets and, as long as longer time horizons are in consideration, drift rates. The American bank JP Morgan introduced the system Risk Metrics as a publicly accessible service for the estimation of VaR parameters for assets such as bonds, equities and stocks. It proposed a very similar approach for the estimation of risk associated with default, the Credit Metrics.

Estimating volatility

The volatility of an asset is measured as the annualized standard deviation of returns. There are many ways of taking this measurement. In Risk Metrics the volatility σ_i in time i is measured as the square root of a variance that is an exponentially weighted moving average of the square of returns,

$$\sigma_{2,i} = 1 - \lambda\, \Delta t\, X_{ij} = -\infty\, \lambda_{i-j}(R_j - hR_\iota)2$$

where Δt is the time step (usually one day), Rj is the return on day j, and hRi is the mean value over the period from day i to j (it is neglected, because we usually assume that the time horizon is sufficiently small). The parameter $0 < \lambda$ 1 represents the weighting attached to the past volatility versus the present return. This difference in weighting is more easily seen if we simply calculate

$$\sigma_{2,i} = \lambda\sigma_{2,i-1}(1-\lambda)R_\iota /\Delta t$$

JP Morgan has chosen the parameter λ as either 0.94 for a horizon of one day and 0.97 for a horizon of one month.

Estimating correlation

Similarly to the estimating of volatility, Risk Metrics uses an exponentially weighted estimate

$$\sigma_{12,i} = \lambda\sigma_{12,i-1}(1-\lambda)R_{1.\iota}R_{2.i} /\Delta t.$$

Value-at-risk (VaR) is a percentile based metric that has become an industry standard

for risk measurement purposes (Risk metrics, 1996). It is usually defined as the maximal allowable loss with a certain confidence level a -100%. Here VaR is defined as the minimal portfolio return for a prespecified confidence level a - 100%.
Thus,

$$Var(x, a) = \min\{u: F(x, a) \geq 1 - a\} = \min\{u: P\{R(x, \tilde{r}) \leq u\} \geq 1 - a\}.$$

VaR(x, a) is the (1-a)*100% percentile of the distribution of portfolio return.
Despite its popular use in risk measurement, *VaR* is not typically used in mathematical models for optimal portfolio selection. While its calculation for a certain portfolio x reveals that the portfolio return will be below *VaR*(x; a) with likelihood 1 – a*100%, it provides no information on the extent of the distribution's tail which may be quite long, in such cases, the portfolio return may take substantially lower values than *VaR* and result in severe losses. *VaR* lacks a theoretical property for coherent risk measures (Artzner et al., 1999), namely, subadditivity. Moreover, VaR is difficult to optimize. When the asset returns are specified in terms of scenarios the VaR function is non-smooth and non-convex with respect to the portfolio positions x and exhibits multiple local extrema. Efficient algorithms for solving problems with such objective functions are lacking.

Conditional Value at Risk

Conditional value at risk (*CVAR*) is also called expected shortfall, average value at risk (AVaR) and expected tail loss (ETL).

Expected shortfall (ES) is a risk measure—an approach used in the field of financial risk measurement to classify the market risk or credit risk of a portfolio. The "expected shortfall at *q*% level" is the expected return on the portfolio in the worst *q*% of cases. ES is an alternative to *VAR* that is more responsive to the form of the tail of the loss distribution. ***72%***

CVAR evaluates the risk of an investment in a more conservative way, aiming attention at the less rewarding outcomes. For higher values of *q* it rejects the most profitable but implausible possibilities, while for smaller values of *q* it focuses on the worst possible losses. On the other hand, unlike the discounted maximum loss, even for lower values of the expected shortfall does not consider only the single most catastrophic outcome. A value of *q* often used in practice is 5%.

Expected shortfall is a coherent, and moreover a shadow, measure of financial portfolio risk. It requires a quantile-level *q*, and is defined to be the expected loss of portfolio value given that a loss is occurring at or below the *q*-quantile.

Though the formula for *CVAR* uses calculus, it is still forthright. The *CVAR* is calculated as:

CVAR = (1 / (1 - c)) x the integral of xp(x) dx from -1 to VaR

Where:

p(x)dx = is the probability density of getting a return x
c = the cut-off point on the distribution where the analyst sets the VaR breakpoint
VaR = the agreed-upon

VaR level *CVAR* is a related risk measure. It is usually defined as the conditional expectation of losses exceeding VaR at a given confidence level (VaR is also defined as a percentile of a loss function in this case). Here, we define *CVAR* equivalently as the conditional expectation of portfolio returns below the VaR return. As introduced by Rockafellar and Uryasev (2000), for continuous distributions, *CVAR* is defined as

$$CVaR(x.a) = \left(1 - \frac{\sum_{\{s \in \Omega | R(x,r_s) \leq z\}} p_s}{1-a}\right) z + \frac{1}{1-a} \sum_{\{s \in \Omega | R(x,r_s) \leq z\}} p_s \, R(x, r_s)$$

Hence, this definition of *CVAR* that is applicable to continuous distributions measures the expected value of the (1- a)*100% lowest returns for portfolio x (i.e., the conditional expectation of portfolio returns below *VaR* (x, a)).
For discrete distributions, the formula gives a non-convex function in portfolio positions x, and is not a subadditive risk measure. A definition of *CVAR* for general distributions (including discrete distributions) has been introduced by Rockafellar and Uryasev (2002):

$$\mathrm{CVaR}(\mathbf{x}, \alpha) = \left(1 - \frac{\sum_{\{s \in \Omega \,|\, R(\mathbf{x}, \mathbf{r}_s) \leqslant z\}} p_s}{1-\alpha}\right) z + \frac{1}{1-\alpha} \sum_{\{s \in \Omega \,|\, R(\mathbf{x}, \mathbf{r}_s) \leqslant z\}} p_s R(\mathbf{x}, \mathbf{r}_s),$$

where z = VaR (x, a). Note that *CVAR* as defined for discrete distributions may not be equal to the conditional expectation of portfolio returns below *VaR*(x, a). This definition of *CVAR* for discrete distributions measures only approximately the conditional portfolio returns below the respective VaR(x, a) value.

CVAR quantifies the expected portfolio return in a low percentile of the distribution. Hence, it can be used to exercise some control on the lower tail of the return distribution and thus, it is a suitable risk measure for skewed distributions. When the uncertain asset returns are represented by a discrete distribution *CVAR* can be optimized by linear programming (LP). We trail this approach in the derivation below. Let's define for every scenario $s \in \Omega$ an auxiliary variable

$$y_s^+ = \max[0, z - R(x, r_s)],$$

which is equal to zero when the portfolio return for the particular scenario exceeds *VaR*(x, a), and is equal to the return loss in relation to *VaR* when the portfolio return is below VaR(x, a). Using these auxiliary variables we have

$$\sum_{s\in\Omega} p_s y_s^+ = \sum_{\{s\in\Omega | R(x,r_s)\le z\}} p_s y_s^+ + \sum_{\{s\in\Omega | R(x,r_s)> z\}} p_s y_s^+$$

$$= \sum_{\{s\in\Omega | R(x,r_s)\le z\}} p_s\big(z - R(x,r_s)\big)$$

$$= z \sum_{\{s\in\Omega | R(x,r_s)\le z\}} p_s - \sum_{\{s\in\Omega | R(x,r_s)\le z\}} p_s R(x,r_s)$$

$$= z\,(1-a) - \left(\left(1 - a - \sum_{\{s\in\Omega | R(x,r_s)\le z\}} p_s\right) z - \sum_{\{s\in\Omega | R(x,r_s)\le z\}} p_s R(x,r_s)\right)$$

Dividing both sides of the equation by (1 − a) and rearranging terms we get

$$z - \frac{\sum_{s\in\Omega} p_s y_s^+}{1-a} = \left(1 - \frac{\sum_{\{s\in\Omega|R(x,r_s)\le z\}} p_s}{1-a}\right) z + \frac{1}{1-a} \sum_{\{s\in\Omega | R(x,r_s)\le z\}} p_s R(x,r_s)$$

From previous equations we observe that the right hand side term is *CVAR*(x, a). Therefore, the conditional value-at-risk of portfolio return can be optimized using a linear program with the left hand side expression as the objective function. The resulting LP that trades off the optimal *CVAR*-measure of portfolio return at a prespecified confidence level a * 100% against the expected portfolio return μ is written as

$$\begin{aligned}
&Maximize\ z - \frac{1}{1-a}\sum\nolimits_{s=1}^{s} p_s y_s^+ \\
&s.t. \qquad x \in X, \qquad z \in R \\
&\qquad\quad x^T\overline{r} \ge \mu \\
&\qquad\quad y_s^+ \ge z - x^T r_s \qquad s = 1, 2, \dots, S \\
&\qquad\quad y_s^+ \ge 0 \qquad s = 1,2, \dots, S
\end{aligned}$$

Solving the parametric program for different values of the expected portfolio return μ yields the *CVAR*-efficient frontier. For each expected return target μ, the optimal value of program is the corresponding *CVAR*(x, a). The value of the free variable z at the optimal solution of is the corresponding VaR(x, a) value. The Program optimizes the *CVAR* risk measure for portfolio return and simultaneously determines the corresponding VaR value (z). As defined, in terms of portfolio return, *CVAR* is a lower bound for VaR (i.e., *CVAR*(x, a) ≤ VaR(x, a)). Hence, by maximizing *CVAR* program should be expected to yield larger values for VaR as well. Putting aside the computational results, there is a continuous debate among academics and practitioners whether *VaR* or *CVAR* is the most effective metric for risk management. *VaR* is the most common industry method for risk measurement. On the other hand, *CVAR* has achieved popularity as a suitable risk measure in the insurance industry and is gradually gaining acceptance in the financial community. Its appeal lies not only in its theoretical properties of coherence, but also in its ease of application in portfolio optimization models and its ability to reduce the tail of the distribution, therefore exercising risk management control.

Shipping Sector

Transportation keeps the global economy in motion. Without transportation industry, and especially without the shipping sector, it would be impossible to trade, let alone in the scale of our times, goods and services.

The world economy has had such a huge growth over the last fifty years and that increase has been largely driven by globalization and the continuous increase in trade of goods and services. International trade in goods and services has increased from around $4 trillion in 1990 to $24 trillion in 2014, according to 2015 data from the United Nations Conference on Trade and Development. This increase in trade would not have been possible without a similar rise in the abilities and capabilities of the global transportation sector. Transport, not only is the tool for people and goods to move, but also is a key driver of economic and social development. It brings opportunities and helps economies to be more competitive.

The shipping sector has an intimate relationship with the global economy in such way that the risks faced by the industry are influenced by worldwide factors such as increasingly complex markets, disparate regulatory frameworks, the unstoppable march of technology and geopolitical shifts. These factors interact with each other in such complex ways that are difficult to understand, let alone predict, and thus affect the shipping sector as well.

In general, the prolonged economic struggles that the world faces nowadays have made the maritime sector more sensitive to risk than other modes of transportation. Maritime transport providers perceive as their top risks to be, putting aside the common financial and economic risks that ever sector and company face more or less, the digital vulnerability they face and the multiplying potential points of entry.

Digital Vulnerability and rapid technological change

Global commerce is increasingly operating in a world where automation and digitalization are transforming rapidly almost every sector not only of the economy but everyday life as well. While some forms and means of transportation are adopting the new digital tools slowly enough, the total pace of engagement is escalating in an exponential way.

Gradually, maritime companies are embracing the digital revolution. In fact, digital technology is becoming so important and extensive that many businesses are underestimating the extent to which they are now dependent on it. While the opportunities that occur due to the technological advance are abundant to even mention, so are the vulnerabilities and risks. Those that manage to find the balance will thrive. Otherwise they will themselves left behind by the changing markets and consumer expectations, or even left vulnerable to the growing army of threat actors.

Authorities believe that the criminal activity is being assisted by the speed, convenience and most important by the anonymity that the World Wide Web provides. Consultancy firms believe that the global cost of data breaches alone could exceed $2 trillion by the end of 2018. Criminals are clearly flourishing in the unprecedented access and connectivity the internet provides, as the technology advances.

It's easy to understand that the risks inherited by the accelerated progress of the digital economy are a primary concern that it would increase cost efficiency, collective intelligence and product delivery but it would also augment digital entry points to strategic control centers, information about the commerce and private third-party data. As firms become more and more connected, levels of flexibility are increasingly imposed by the weakest link in the digital supply chain. As such, companies have even less individual control to alleviate their digital risks, making in a way security a communal issue. It is a concerted responsibility where every member in all the supply chains is responsible – not only to their own shareholders, but also to their other partners.

The strategic opportunity of Risk

Risk is a path that leads to growth. Firms and industries prefer to mitigate the downsides of risk – it has the ability to minimize or even destroy profits, disrupt operations and damage reputations. But risk can also open opportunities for those able to see the promising gain. Smart firms seek out measured risks to gain comparative and competitive advantage. They don't always follow the safe path. Managing nowadays business risks is a far more complicated process than it was when the responsibility fell exclusively to financial managers and the structural engineers. Today, the assessment of the risk landscape is almost as important as the alleviation strategy, although ideally the two should mutually support and deliver the corporate strategy.

As a matter of fact, in an era where risk is becoming more slippery and obscured, the emphasis has shifted toward the preparation process for and the response to any possible events, rather than the development of some static strategies that could possible mitigate the individual risks. The new complicated, co-depended risk prospect requires a thorough, knowledge-based response that is coordinated from the boardroom, where corporate strategies are planned.

Technological power

The transportation sector values the risks correlated with the digital vulnerability almost as eminently as they do those in the geopolitical circle.

The largest stand-alone risk across all modes of transport is the risk that springs from new and emerging competitors, with expanding competition across all known modes of transportation: sea, land and air. As transportation adopts the technological advancements of the digital age, it must build jointly risk strategies to ensure that all systems in the global value chain are secure and reliable.

A survey conducted by *Willis Towers Watson* found that the extended economic struggle of modern world have made the shipping sector more prone to risk than other modes of transport. Maritime transport providers perceive several digital risks, in the form of data privacy breaches. But shipping companies have also almost zero protection against the complexities of globalization.

Every mean of transportation could benefit from the development of propulsion technology and more efficient fuels. Currently, ship owners face significant regulatory and technical uncertainty, which is raising the investment risks. Some are using advances in computational fluid dynamics and models to streamline hulls and bow structures to design more efficient propellers in order to achieve roughly the same end.

But amongst all the automatization, the digitalization of business processes, the cascade of emerging technologies and the continuously changing markets and consumer trends, probably the maritime industry’s biggest opportunity lies in the competition for talent. People are the connecting factor between corporate strategy and goal achievement. As technology rapidly evolves, the importance of retaining and retraining the associated skills to manage the systems, tools and assets of the industry will not vanish. Even artificial intelligence and robots will need programmers. Those who have the market intelligence to align the skills of their workforce with emerging technology will have grasped an extremely significant opportunity.

Financing Shipping Sector

The main financial sources of the shipping sector are either the bond issue or the leasing method.

Bond Issue

Bonds are issued by government authorities, credit institutions, companies and supranational institutions in the primary markets. The most common procedure for issuing bonds is through underwriting. When a bond issue is underwritten, one or more securities firms or banks, forming a syndicate, buy the entire issue of bonds from the issuer and re-sell them to investors. This security firm has to take the risk of not being able to sell on the issue to investors. Initial issuance is arranged by book runners who form the bond issue, act as advisers to the bond issuer in terms of timing and price of the bond issue and have direct contact with investors.

In contrast, government bonds are usually issued in an auction. In some cases, not only the private banks but also the public may bid for bonds. In other cases, only market makers may bid. The overall rate of return, or yield to maturity, on the bond depends on both the terms of the bond and the price paid. The terms of the bond, such as the coupon, are fixed in prior to selling and the price is determined by the market itself.

In the case of an underwritten bond, the underwriters will charge a fee for underwriting. An alternative process for bond issuance, which is commonly used for smaller issues and avoids this cost, is the private placement bond. Bonds sold directly to buyers may not be tradable in the bond market.

Historically an alternate practice of issuance was for the borrowing public authority to issue bonds over a period of time, usually at a prespecified price, with volumes sold on a particular day dependent on the market conditions. This was called a tap issue or bond tap. Let's see the main aspects of the bonds.

Principal

Principal, nominal, par or face amount is the quantity on which the issuer pays interest, and which, in most cases, has to be repaid at the end of the prespecified period. Some structured bonds can have a compensation amount, which is different from the principal amount and can be linked to performance of some particular assets.

Maturity

The issuer has to repay the nominal amount on the maturity date. Considering that all due payments have been made, the issuer has no additional obligations to the bond holders after the maturity date. The time needed until the maturity date is often referred to as the maturity of a bond. The maturity can be any duration of time, though debt securities with a maturity of less than one year are usually designated money market tools rather than bonds themselves. Most bonds have a maturity of up to thirty years. Several bonds have been issued with terms of half a century or more. In the market for United States Treasury securities, there are three categories of bond maturities:

- short term (bills): maturities between one and five year
- medium term (notes): maturities between six and twelve years;
- Long term (bonds): maturities greater than twelve years.

Coupon

The coupon is the interest rate that the issuer pays to the bond holder. Generally this rate is a fixed rate during the whole life of the bond, which can fluctuate with a money market index, such as EURIBOR, or it can be even more unusual. Interest can be paid at different frequentness: generally it is semi-annual, i.e. every six months, or annual.

Yield

The yield is the rate of return received from investing in the bond. It usually refers either to

- The current yield, or running yield, which is the annual interest payment divided by the current market price of the bond.
- The yield to maturity, which is a more effective measure of the return of the bond. This takes into consideration the current market price and the amount and time of all remaining coupon payments and of the repayment due on maturity. It is similar to the internal rate of return of a bond.

Credit quality

The quality of the issue refers to the probability that the amounts promised will be given to the holders of the bond at the due dates. This will depend on a wide range of factors. For example, high-yield bonds are rated below investment grade because they are of high risk, thus the higher yield. Often these bonds are called junk bonds.

Market price

The quality of the bond, the yield, amounts, currency and timing of interest payments are amongst other factors, the main reasons that influence the market price of a trade able bond.

The price can be quoted as clean or dirty. "Dirty" includes the present value of all future cash flows, including accrued interest, and is most often used in Europe. "Clean" does not include accrued interest, and is most often used in the U.S.

The issue price at which investors purchase the bonds when they are first published will typically be approximately equal to the nominal amount. The net proceeds that the issuer receives are thus the issue price, less issuance fees. The bond’s market price usually varies over its life: it may trade at a premium (above par, usually because market interest rates have fallen since issue), or at a discount (price below par, if market rates have gotten higher or there is a high probability of default on the bond).

Types of bonds

- Fixed rate bonds have a coupon that remains constant throughout the life of the bond. A alternative is stepped-coupon bonds, whose coupon increases during the life of the bond.
- Floating rate notes (FRNs, floaters) have a variable coupon that is linked to a reference rate of interest, such as LIBOR or Euribor. For example, the coupon may be defined as six-month EURIBOR + 0.40%. The coupon rate is recalculated periodically, typically every one or three months.
- High-yield bonds (junk bonds) are bonds that are rated below investment grade by the credit rating agencies. As these bonds are riskier than investment grade bonds, investors expect to earn a higher yield.
- Zero-coupon bonds (zeros) pay no regular interest. They are issued at a substantial discount to par value, so that the interest is effectively rolled up to maturity (and usually taxed as such). The bondholder receives the full principal amount on the redemption date. An example of zero coupon bonds is Series E savings bonds issued by the British government. Zero-coupon bonds may be created from fixed rate bonds by a financial institution separating ("stripping off") the coupons from the principal. By way of explanation, the separated coupons and the final principal payment of the bond may be traded separately.
- Exchangeable bonds allows for exchange to shares of a corporation other than the issuer.
- Convertible bonds let the bondholder to exchange a bond into a number of shares of the issuer's common stock. These are known as hybrid securities, because they combine both equity and some debt features.

Leasing

Leasing is the most common practice within the shipping industry. Usually, a charterer may own a cargo and contract a shipbroker to find a ship to carry the cargo for a certain price, called freight rate. These freight rates may be on a per-ton basis over a certain route (e.g. for wheat between Russia and Italy), in a world scale point (in case of tankers) or rather may be expressed in terms of a total summary – usually in U.S. dollars - per day for the set duration of the charter.

A charterer may also be an organization without a cargo, which takes a ship on charter for a prespecified period from the owner and then trades the ship to carry cargos at a profit above the hire rate, or even makes a profit in a rising market by re-renting the ship out to other charterers.

Depending on the class of the ship and the type of charter, normally a standard contract form called a charter party is used to record the specific rate, duration and terms agreed between the ship owner and the charterer. Time Charter Equivalent is a typical shipping industry performance calculation used mainly to put into comparison period per period changes in a shipping company's performance, regardless of the changes in the mix of charter types.

Empirical Application

In order to start constructing the portfolio, we had to collect the necessary data. The data first used was the commodities value, extracted from the *World Bank – Data Bank.* However, just the value of the commodity is not enough for an investor to start planning her strategy, we had to calculate the value of a unique voyage each time, since it can be pretty obvious, even to the most oblivious that, a different voyage with different freight should have different value.

In order to calculate the value of each different voyage we had to use the priceless tools of *World Freight Calculator Tool* and *Maritime Traffic*. Firstly, we chose 50 different voyages randomly. Then combining the values of each commodity with each voyage though the *World Freight Calculator Tool* we managed to extract all the necessary data.

The values that we extorted are really "eye openers". Let's take a moment and observe the descriptive statistics of our data and specifically the 4 moments, *Variance*, *Mean*, *Skewness & Kurtosis*, from a data sample.

Commodity	*Voyage Info*	*Variance %*	*Mean %*	*Skewness*	*Kurtosis*
Crude Oil (petroleum)	Shuwaikh, Kuwait - Singapore, Singapore	4.224	0.073	-0.117	-0.779
Crude Oil (petroleum)	Cochin, India - Fujairah, United Arab Emirates	4.018	0.065	0.244	0.585
Crude Oil (petroleum)	Suez, Egypt - Trieste, Italy	3.967	0.066	0.096	0.580
Sugar	Shell Haven, United Kingdom - Vigo, Spain	3.864	0.070	0.049	0.410
Cocoa Beans	Onne, Nigeria - Jakarta, Indonesia	3.988	0.115	0.194	0.611
Natural Gas	Galway, Ireland - Drapetsona Bay, Greece	3.922	0.062	0.061	0.581

We observe that rates exhibit considerable variance and excessive skewness, especially compares to their *mean*. The distribution of *Variance* is not normal making it impossible for the investor to use it as a Risk Measure, since it would be inefficient and problematic as measure. We also observe more in the tails (fat-tails) than the normal distribution. These justify the use of another Risk Measure - *CVAR* to be precise.

As long as the extorted values are concerned, something reasonably expected is that the longer and more dangerous the voyage the higher the value. Example given is the voyage *Gemlike, Turkey - Thessaloniki, Greece* with commodity *Wheat, No.1 Hard Red Winter*, has extremely lower value than voyage *Novorossiysk, Russia - Livorno, Italy* with the same commodity. In general, we could say that the voyages between Mediterranean ports are of less value due to the safety the area provides in contrast to voyages that have dangerous route near areas with military conflict or fragile peace treaties, like in Somalia, Syria.

Secondly, we can observe that some commodities have lower value than expected, like *Natural Gas* that its value does not even exceed *Coal, 12,000- BTU / pound, less than 1% sulfur, 14% ash* as an outsider the sector would believe. Only the *voyage Port Said, Egypt - Tiksi, Russia* with *Natural Gas* has above average value, but mainly due to the longer trip rather than the commodity itself.

Also, we can see how some world changing events affected the values of each commodity. For example the values *Natural Gas* skyrocketed compared to *Crude Oil (petroleum)*, that mainly the lost a lot of value, after the horrific events of 9/11 at World Trade Center and the war that US declared to Taliban.

Last but not least, we can observe an unexpected result, both *Zinc, high grade 98% pure* and *Cocoa Beans* commodities have the highest value reaching and exceeding in some point 4 million $(!). After though, some research we come to conclusion that both of them have that lofty value due to the difficulty of extraction as long as *Zinc, high grade 98% pure* is taking into account and because of the rarity that *Cocoa Beans* and the deforestation of the main source – Amazon rainforest.

Constructing Portfolios

The data that has been collected contains the value of the freights of 50 different voyages. The freights are not of the same commodity, but there are 11 different, in order to have a more accurate perspective of the dilemmas that the investor, in this case a shipping company, faces every day, so he can create the optimal portfolio, containing the best possible voyages . The period we study is from the January 2000 up to November 2016 and the values depict the monthly average.

We will use the *Conditional Value at Risk* measure and we will try to create the optimal portfolio in the sector, for the three classical types of investors- risk averse, risk lover and neutral.

The mathematical formula of *Conditional Value at Risk* which we will use for the calculations is

$$\min_{\chi,\zeta} \sum_{i=1}^{n} -|\mathrm{E}[y_i]x_i$$

$$subject\ to$$

$$\zeta + (1-a)^{-1} \sum_{j=1}^{J} \pi_j\, z_j \leq \omega \sum_{k=1}^{n} q_k x_k^0$$

$$z_j \geq \sum_{i=1}^{n} \left(-y_{ij}x_i + q_i x_i^0\right) - \zeta, \quad z_j \geq 0, \quad j = 1, \dots, J$$

$$q_i x_i \leq v_i \sum_{k=1}^{n} q_k x_k \ , \quad i = 1, \dots, n$$

$$\sum_{i=1}^{n} q_i x_i^0 = \sum_{i=1}^{n} c_i q_i \left(u_i^+ + u_i^-\right) + \sum_{i=1}^{n} q_i x_i \ ,$$

$$x_i - x_i^0 = u_i^+ + u_i^- \ , \quad i = 1, \dots, n \ ,$$

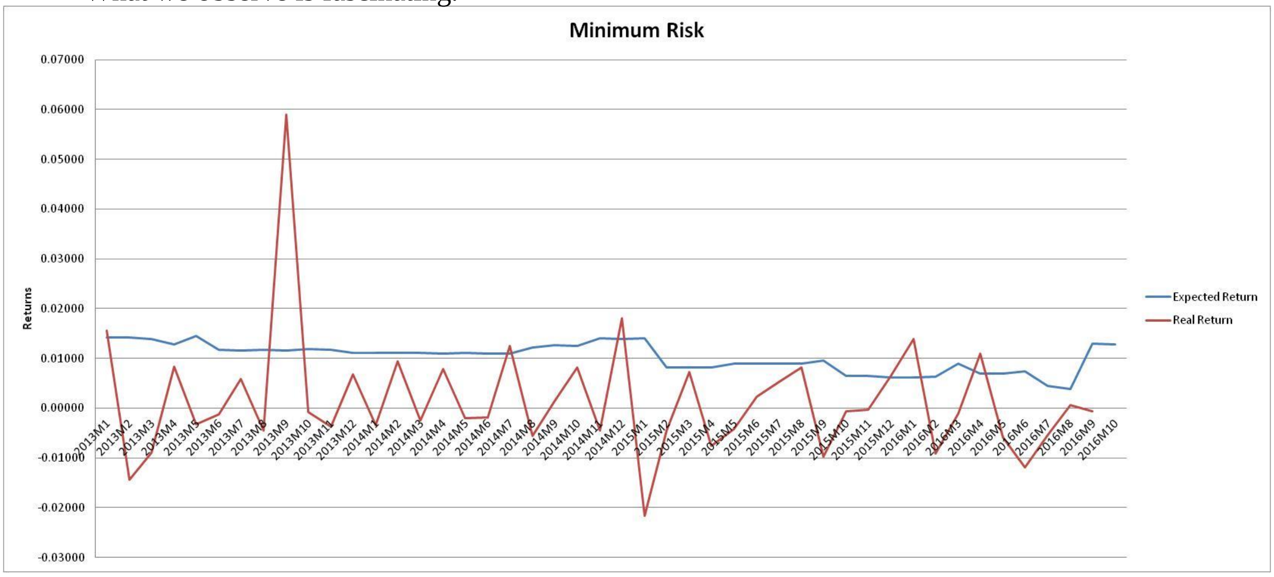
$$0 \leq u_i^- \leq \underline{u_i^-}, \quad 0 \leq u_i^+ \leq \bar{u}_i^+, \quad i = 1, \dots, n$$

$$\underline{x_i} \leq x_i \leq \bar{x}_i \ , \quad i = 1, \dots, n.$$

First and foremost, the values of each freight/voyage are transformed into returns. Secondly, using the back-testing method we divide our data to 46 equal periods, were each time, after we run the *CVAR* command in *GAMS*, we remove the older observation and add the following (2000/1-2012/12, 2000/2-2013/1 …). As mentioned above, the back-testing method is being used for the three types of investors, but each time we differentiate the preference of each investor. For example, the risk averse will try to maximize the *CVAR* that the constructed portfolio ascribes. On the other hand, the risk lover investor will try to maximize the return of the portfolio, while the neutral investor will have as target return the mean return of the other two investors.

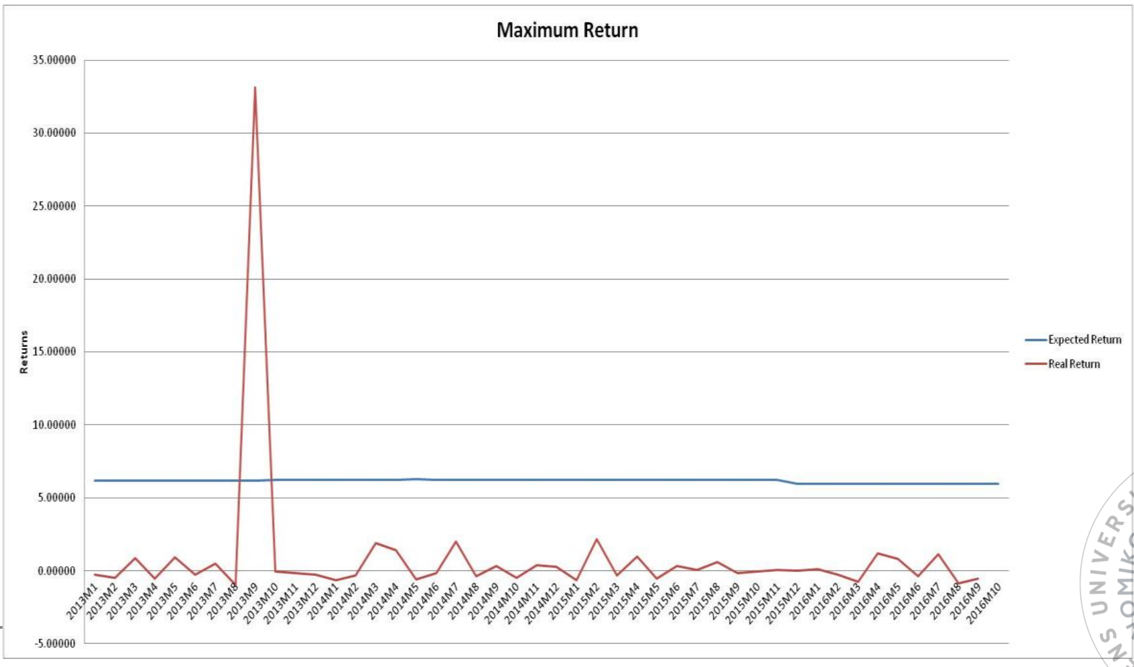
The results from each *GAMS* run, generate different portfolios with several weights, where each unique portfolio has its own *CVAR*, *VAR* and expected return. However, this is the real world so we need the real return. In order to calculate it, we multiply for each portfolio the weight of each freight with the return of its next period and then we summarize (The first generated portfolio is from 2000/1-2012/12, so we multiply with the returns the moment 2013/1, …).

What we observe is fascinating.

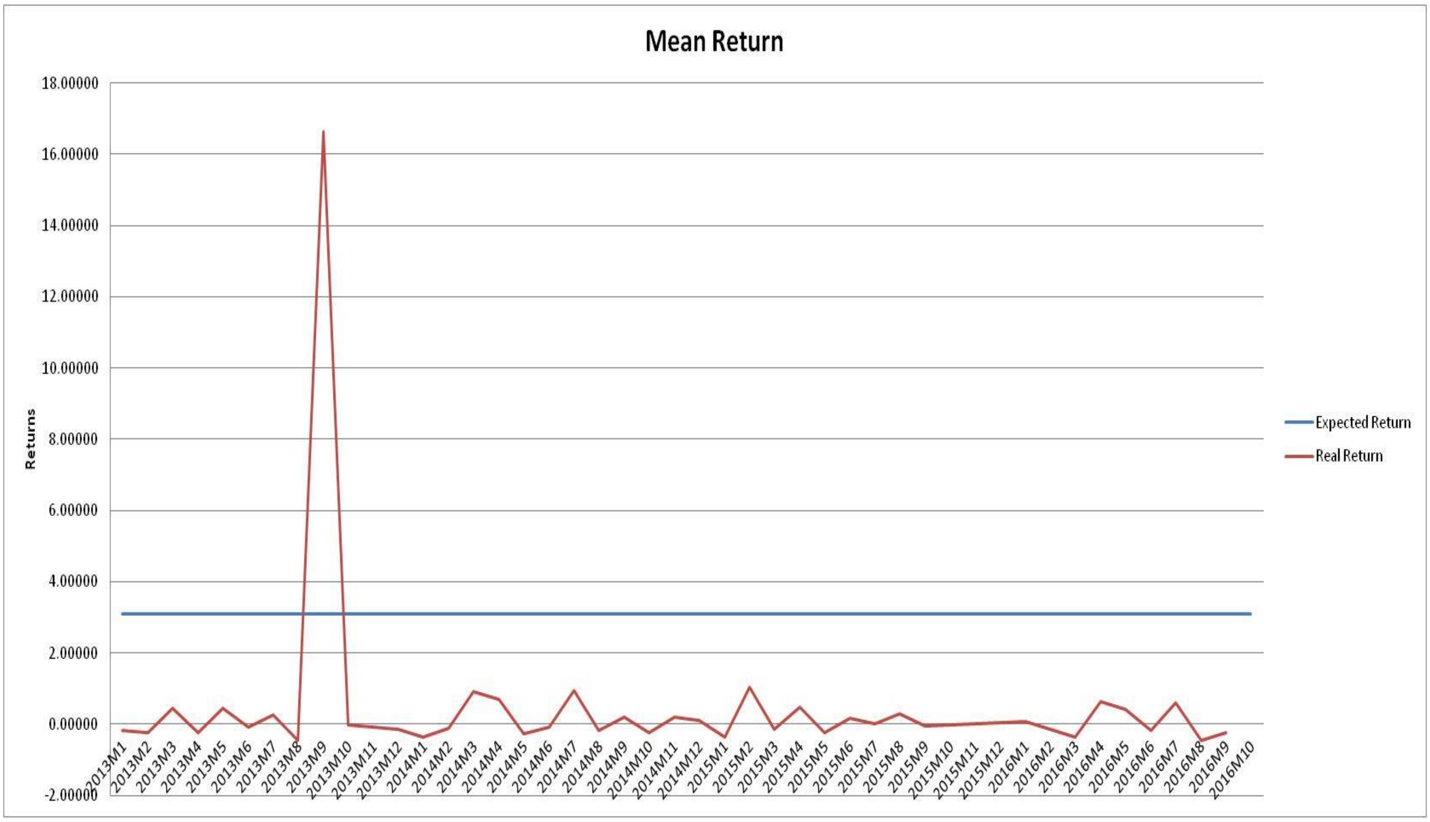


The above graph depicts the difference between the estimated, by *GAMS*, Expected Return and the calculated Real Return for the risk averse investor. The Expected Return is by far above zero and has less volatility that the Real Return. Also, Real Return in terms of average is lower than the Expected Return, yet is above zero. The risk averse investor, who tries to minimize the *CVAR*, has in real terms an average return about 0.15%. In the 16 years period it is not high, though it is a viable choice to invest if someone wants to avoid risk.

What happens though, when an investor prefers to maximize the return? First and foremost, she does not even care about the possible risk. *GAMS* calculations depicts that she is willing to put at risk almost all the amount, 99% to be precise. That is easily observable, due to the



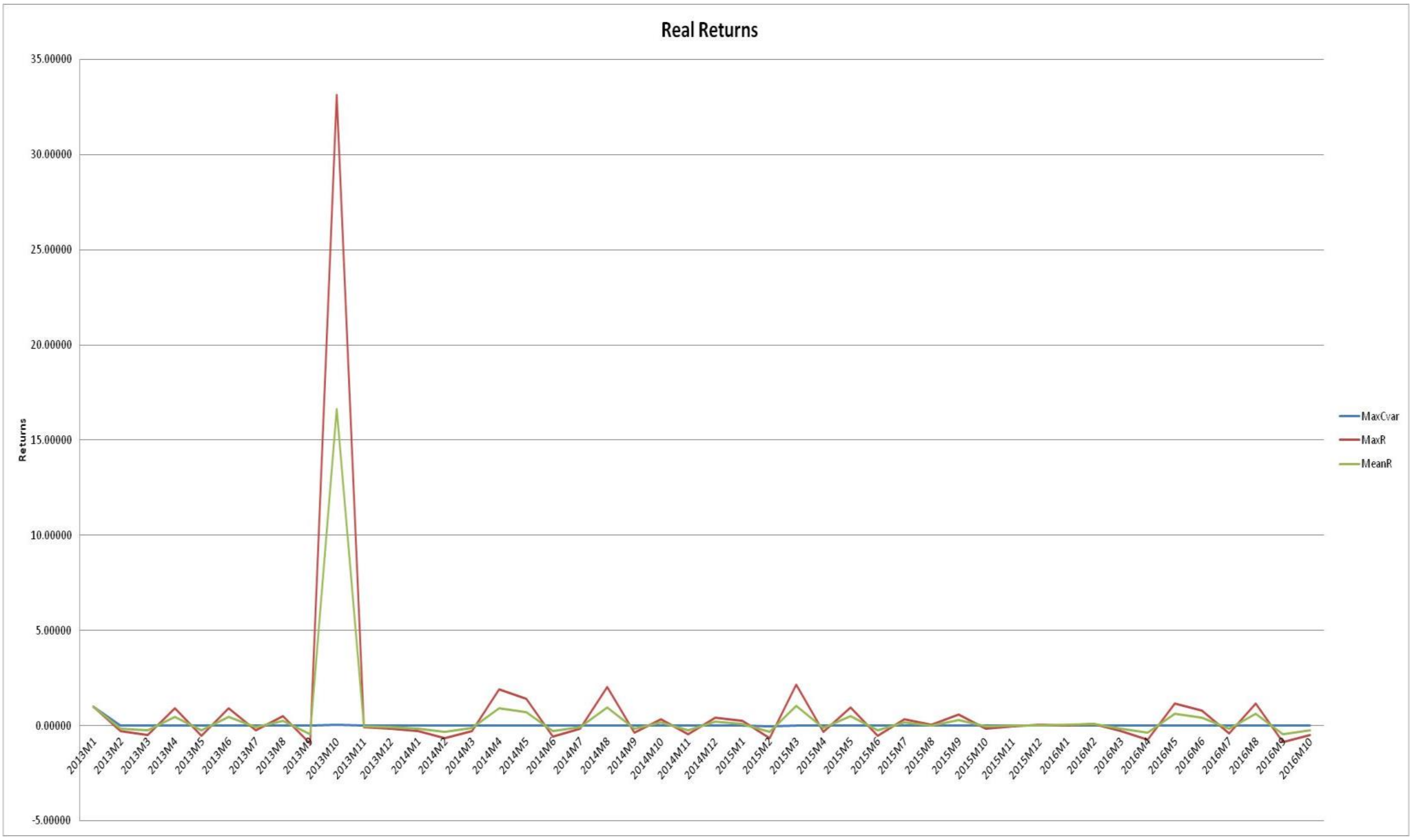
fact that, she prefers to invest the entire amount on just one (!) freight/voyage. The Expected Return is extremely high, it can reach up to 6 times the invested amount! On the other hand though, the Real Return follows a bit strange pattern. It has a big volatility, and at around the 3rd quarter of 2013 has enormous boom, up to point of 33 times the initial invested amount. We can easily understand that the cunning risk lover investor, following the trend of our decade (e.g. Bit Coin), chose the biggest bubble among the 50 in order to maximize her returns, hopping that it won't burst soon enough. This "bubble" is the voyage between USA-Miami specifically – and Rio Hana at the Dominican Republic with almost pure aluminum. This boom makes sense because that time was the start of the discussions between US government and Cuban authorities, giving the investors the sense of stability in the area of Mexico Gulf, thus this value burst. In this 16 years period, the Real Return fluctuates around 87%. The amazing thing about this strategy is that even without this boom the investor would benefit a Real Return at 13%, so it is a smart choice for an investor who wants to enjoy a high



return without fearing the risk of loss.

We should now examine how a risk neutral investor operates. As we foretold, the calculation for the risk neutral investor in *GAMS* is pretty simple. We find out the mean Expected Return between risk lover investor and risk averse and we use it as target return, in this case is *3.084*. This is the reason the Expected Return is a flat line in the appropriate graph. When we compare it with the Real Return we can observe a similar pattern with the risk lover investor, but with less volatility and lower peak at the 3rd quarter of 2013. This is easy explainable because the risk neutral, even though she invests a significant amount at the same freight as the risk lover, she also prefer to hedge some of the amount by choosing more safe choices. The Real Return as well is positive thought out the period, at the scale of 44,42%. If we remove the 3rd quarter she still has a positive outcome, at the time at an obviously lower rate, at 7%. Nevertheless, the return is positive and great.

Comparing the three outcomes of the Real Return at the following graph someone would say that the best possible choice is to try and maximize return. She wouldn't be wrong since the results depict that the mentioned strategy pays off almost 90% (!), which is high even for such a long period, and double the amount of the risk neutral strategy.

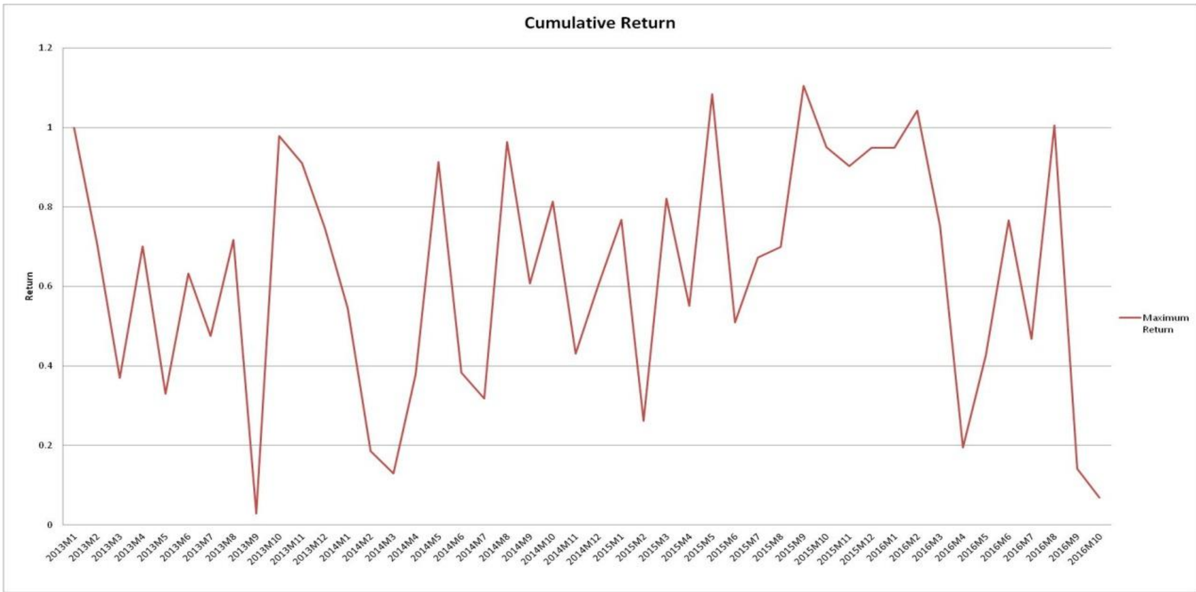


However, this approach is not considered to be a professional one and should not be practiced. The most thorough approach is to use the cumulative Real Return on each strategy. The cumulative return is simple. You just use the equation

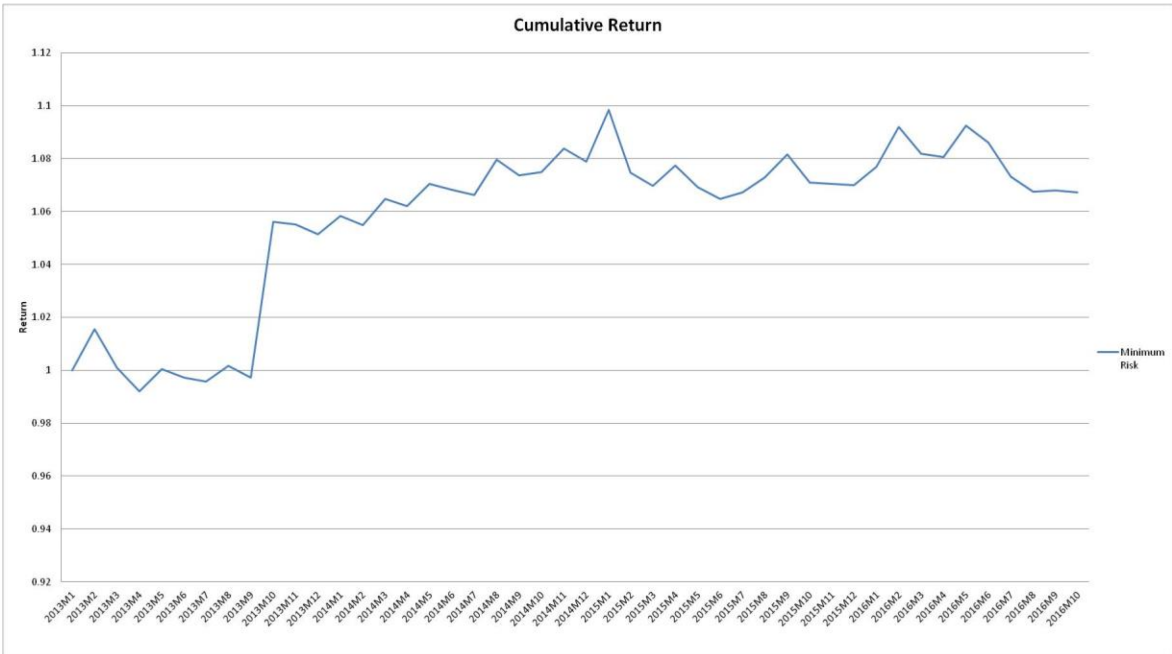
$$1 * (1 + r_1) * (1 + r_2) * (1 + r_3) * \dots (1 + r_t)$$

where *t* is the period that we at which we want to find the cumulative return. Using the equation we can observe baffling results.

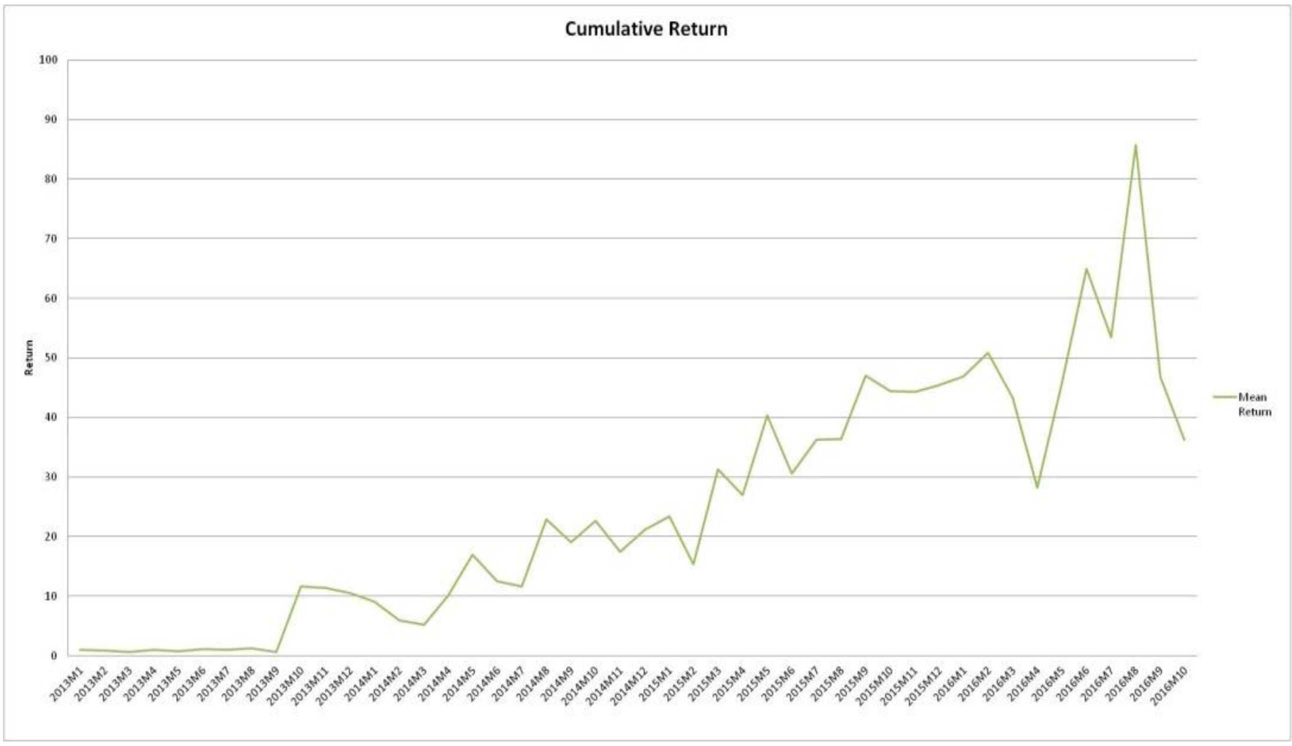
The maximum return strategy struggles to provide return. Even the higher point cannot exceed the 10% return, which is far from similar to the Real Return approach. Needless to say, taking into account the Real cumulative Return the risk lover would not invest.



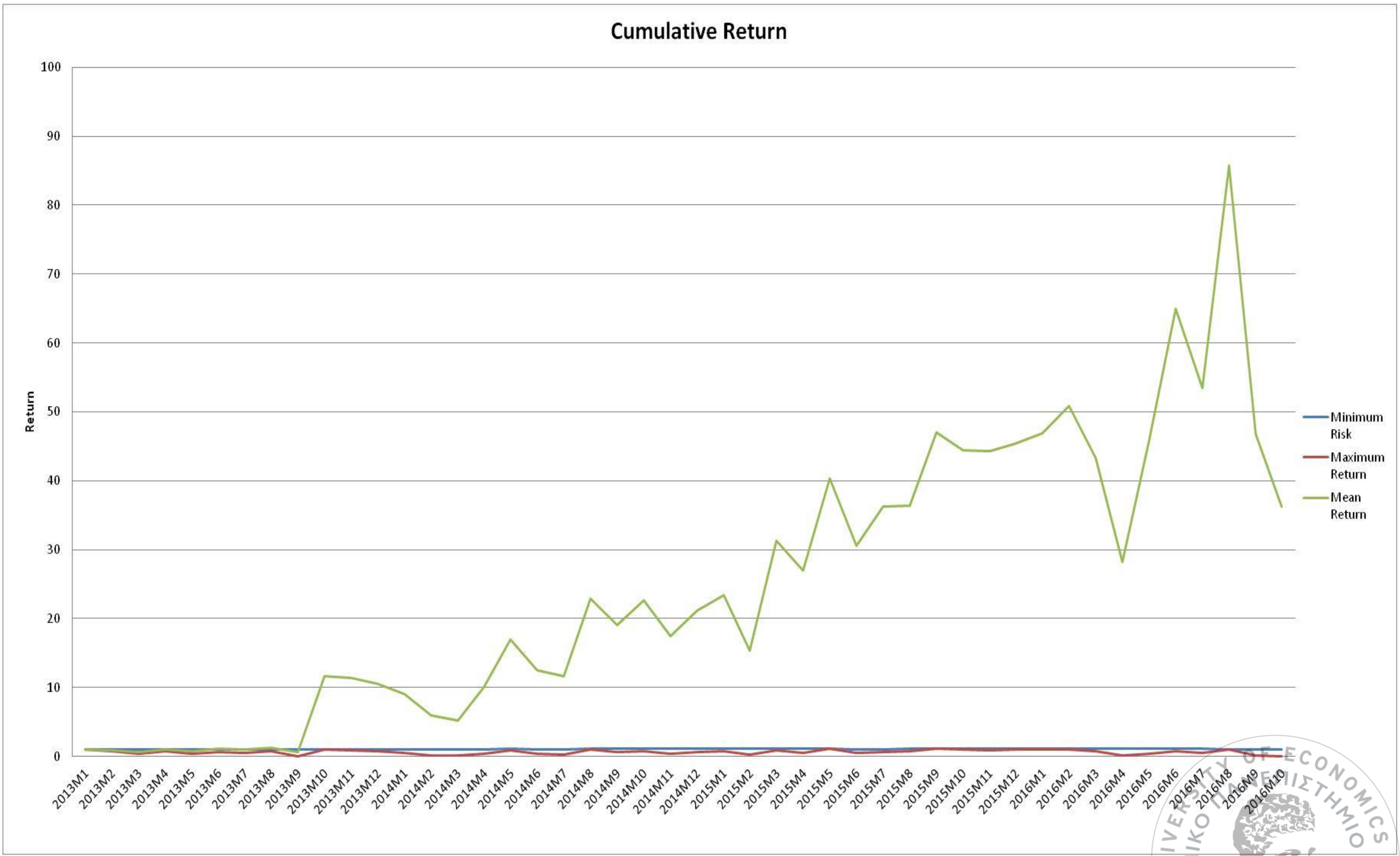
As we study the Real Cumulative Return of the risk averse investor we can observe the high and constant return the investor gains, up to the point of 30%, three times the strategy that tries to maximize return(!).



Last but not least, there is the risk neutral investor. She not only gains the highest Real Return of them all, but she never suffers any loses during the 16 year period. Probably is one of the best choices to invest, because it can reach that high up to the point of 8 times the starting amount. It would be unnecessary to mention that this strategy is highly recommended to rational and sane investor.



Putting the three strategies in the same graph can easily be depicted the superiority of the risk neutral strategy and the how inferior the risk lover strategy can be evinced.



Conclusion

The results the calculations provide are contradicting.

If you take into account just the Real Return we could say, without a second thought, that someone could invest in the sector and gain a fair return, regardless the strategy they would choose to follow. However, this is not a valid approach, because Real Return calculation just depicts at period *t* the Real Return of the corresponding portfolio. That is why, as mentioned previously, that this is not a professional approach (it is mentioned here for educational purposes only and to show the difference between the proper approach).

That is why we examine the Cumulative Real Return. This approach provides the return over time. We can observe that the high risk – high return strategy has negative Real Return over the 16 year period. Since the investor only cares about return, putting into risk the 99% of the amount, it is pretty obvious that in the real world rarely this strategy pays offs, as we can see here.

On the other hand, risk averse strategy, after a brief period of time, specifically 9 months, has a constant, with some fluctuations, positive Real Return. Even though the main concept of this strategy it to protect the amount and put it at the lowest possible risk we can observe that she manages to gain a fair amount of return.

The final strategy we studies, the risk neutral, has the best performance of them all. Not only it has permanent and constant positive Real Return, its lower points are poles apart from the higher points of the other two strategies, especially the high risk – high return one. This occurs because the risk neutral investor, since she combines the other two strategies into one, hedges a fair amount of risk and thus tries and overcomes the obstacles the risk lover has. Also, since she tries to have a target return, the choices she takes are a bit more profitable that the risk averse's choices. These are the reasons that the risk neutral strategy in the shipping sector –with this 50 voyages- is superior that the other two.

Nevertheless, the shipping sector and the choices it contains to construct a portfolio are vast, but we can be fair and say that a risk averse investor would be glad to choose the shipping sector for her portfolio. Because, not only is a powerful sector, almost impossible to collapse, but also she will enjoy a pretty high return as the current study depicts. Let's not forget that there are the reasons that motivate a risk averse investor. We would recommend to the risk neutral investor to choose the sector, since as our calculations depict, it would be an excellent choice. Last but not least, the risk lover should avoid the shipping sector, since she prefers to invest on bubbles and the sector has few to none to offer.

As a final, and a bit clichéd conclusion, we would say that the shipping sector is an excellent choice for a rational investor. It would be recommended without a second thought.

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