IMPLEMENTATION OF A PORTFOLIO CONSTRUCTION METHOD

Dieket Marcellin Néba
directed by Enric Monte Moreno

July 19, 2016

Contents

1 Motivation

"Portfolio management is the art and science of making decisions about investment mix and policy, matching investments to objectives, asset allocation for individuals and institutions, and balancing risk against performance.": Investopedia

Financial markets are markets in which people trade financial securities, commodities, and other fungible items of value at low transaction costs and at prices that reflect supply and demand.The following picture shows a screen shot of Yahoo finance feature on stock market. Concretely, the prices series of Nasdaq index on Friday 17 June 2016.

1 day Nasdaq composite index

We can see prices going up and down probably reflecting the solidity of financial statements of its components along time or better what traders think it will be in some weeks or months. However, stock prices are determined by matching buy and sell orders.[4] Each buy order is an offer to buy certain number of shares for a certain price, called bid. Each sell order is an offer to sell certain number of shares at a certain price called ask. The price of any stock at any moment is determined by finding the price at which the maximum number of shares will be transacted. After that price is determined, the transactions are completed and that price is shown as the price of the stock at that moment. This process is continued repeatedly during trading hours, as well as during the after-market trades.

For the sake of the picture, let's look at the same stock for a 10 years period.

10 years Nasdaq composite index

This means that if an individual had bought the components of this market index at their current prices on January 1st of 2008, his gain would have been almost of 100% today. Just fantastic.

But it is enough ? Is there a way to avoid this loss on 2009 in the same picture ? Many

techniques for portfolio constructions exist. Among them, the mean-variance portfolio selection method, probably the most popular, the universal portfolio selection very resource consuming, the Capital Pricing Asset Management, very used as modern and technical analysis.

The mean-variance portfolio method selects the portfolio with the least variance after duly calculating its variance with the corresponding mathematic formulas. In this technique, we use convex optimization method to work out the weight of each stock corresponding to the minimum variance of the portfolio for a given level of mean return.

The Capital Asset Pricing management is an extension of the former method adding the government bond as a new risk-free stock thus determining the so called market portfolio, then introducing a new portfolio selection method.

Technical analysis holds on the belief that stock market prices are governed by successions of trends. It then searches trading opportunities buying stocks when prices are on upward trend and selling in the downward case. It then develops a number of indicators that detect upcoming trends.

Also, new methods appeared that definitely tried to solve the problem I posed above.What really happened in 2009 ? everybody knows the answer: world financial and debt crisis. At that time, bad economic perspective lead investors to sell their stocks on a contracted period. The overabundance of offer over demand made the prices to crash down. Investors sell their stock at low price when they do not find good perspective for their stock and conversely at a higher price when the expectations are positive.

Today researches made by investors about the health of their stock is captured collectively by search engines. That information has been very relevant in number of applications.Such information is delivered by Google on the form of the evolution of searches for a given term browsed in the search engine by users in any region of the world. That service is called Google Trends and many applications and hindsights have been developed upon it. [8] [9] [10] [11] [12] [17] [18] [19]

We will mainly focus on two of them because they all deal about financial markets and they more or less answer well the questions previously posed. The first one [12] allows to have considerable interesting returns that beat the DJIA benchmark under certain conditions and the second one [17] is designed to be robust in case of financial distress.

After having described all the techniques mentioned above, we will present one new product. It is derived from the trading technique aforementioned. It beats the above mentioned techniques as well as the DJIA in terms of return on investment with or without transaction costs.

2 Generalities On Financial Markets

2.1 Introduction

It is interesting to acknowledge that financial market stand for a marketplace that is not obligatorily physical although it can be. Physical markets are stock exchange or commodity exchange like the New York Stock Exchange (NYSE), Bombay Stock Exchange (BSE) or Bolsa de Madrid.

The new York Stock Exchange

Stock exchanges often function as "continuous auction" markets, with buyers and sellers consummating transactions at a central location, such as the floor of the exchange.

Companies, governments or public sector institutions can obtain funds with their initial public offering of stocks and bonds to investors through investment banks or finance syndicates of securities dealers in the "primary market". After this initial issuance, subsequent trading from one investor to an other is done in the "secondary market".

In a stock exchange or bourse, stockbrokers and traders buy and/or sell stocks, bonds and other securities.We call security whatever financial asset that is tradable. Equity and debt securities, i,e stocks and bonds, as well as derivatives products form securities.

A stockbroker, also called a Registered Representative, investment advisor or simply, broker, is a professional individual who executes buy and sell orders for stocks and other securities through a stock market, or over the counter, for a fee or commission. Stockbrokers are usually associated with a brokerage firm and handle transactions for retail and institutional customers. Brokerage firms and broker-dealers are also often referred to as stockbrokers.

A trader is person or entity, in finance, who buys and sells financial instruments. Traders are either professionals (institutional) working in a financial institution or a corporation, or individual (retail).

Several categories and designations for diverse kinds of traders are found in finance, these may include: Day trader, Floor trader, High-frequency trader, Pattern day trader, Rogue trader, Stock trader.

When the stock market is not physical it can be purely electronic like Nasdaq, which is an American stock exchange. It is the second-largest exchange in the world by market capitalization, behind only the New York Stock Exchange.

Electronic trading brings together buyers and sellers through an electronic trading platform and network to create virtual market places. The electronic trading platform also known as an online trading platform, is a computer software program that can be used to place orders for financial products over a network with a financial intermediary such as brokers, market makers, Investment banks or stock exchanges. Such platforms allow electronic trading to be carried out by users from any location and are in contrast to traditional floor trading in a stock exchange using open outcry and telephone based trading.

Electronic trading platforms typically stream live market prices on which users can trade and may provide additional trading tools, such as charting packages, news feeds and account management functions. They may also be designed to automatically trade specific strategies based on technical analysis.

In Nasdaq for example, the electronic platform is owned by Nasdaq, Inc. an American multinational financial services corporation that owns and operates the NASDAQ stock market as well as eight other European stock exchanges.

Nasdaq was worthing 4500 billion dollars US in 2012, CAC 40 in Paris 1200 Billion euros, deutsche börse 2300 billion, Bolsa de Madrid 1300 billion, NYSE 19 Trillion in 2015.

Electronic trading systems are typically proprietary software (etrading platforms or electronic trading platforms), running on standard manufactured hardware and operating systems, often using common underlying protocols, such as TCP/IP.Exchanges typically develop their own systems but they can also use another exchange technology or whether a 3rd-party specialist software.

2.2 Automated Trading

Automated Trading[1] is the act of making trades in a market, based purely on instructions generated by algorithms. Each algorithm is assumed to have access to current and historical prices of instruments that can be bought and sold, and can perform any computations it wants based on these prices.

The algorithm will be coded in some programming language and will run as an application that places its own orders. It can also assist the activity of a trader by suggesting him orders and let the person put through trades according to the prescription of that algorithm.

Automated trading is carried out by hedge funds and proprietary trading groups, but can also be performed by an individual with a trading account with a broker. All that is needed is a common computer, and a source of historical data. Many companies offer historical data services online. What allows non-professional traders to get involve into the field. A well know market data provider is Yahoo Finance, but the champion in the matter is Bloomberg that offers all the inventory for professional traders.

Automated trading systems can execute repetitive tasks at speeds with orders of magnitude greater than any human equivalent.As of 2014, more than 75 percent of the stock shares traded on United States exchanges (including the New York Stock Exchange and NASDAQ) originate from automated trading system orders.

In order to use and trust a computer to place order on a market algo trading follow a typical conception rule called backtesting. Backtesting is the fact of making experimentations on a selected trading strategy in order to test it. A trading strategy is the rule which sets the conditions in which a trading decision buy/sell should be executed. The backtesting judges the performance of the strategy in order to decide whether to implement it on a real time market or not. Backtesting is also called in a more professional way validation.

2.3 High Frequency Trading

High frequency trading[5] also known as high-frequency trading refers to computerized trading using proprietary algorithms. There are two types algo trading. Algo execution trading is when an order (often a large order) is executed via an algo trade. The algo program is designed to get the best possible price. It may split the order into smaller pieces and execute at different times. The second type of algo trading is not executing a set order but looking for small trading opportunities in the market. It is estimated that 50 percent of stock trading volume in the U.S. is currently being driven by algo trading.

3 Generalities On Portfolio Theory

3.1 Introduction

Nowadays, when an individual goes to the bank, he can ask his banker to hold a portfolio of assets. Clearly, the goal is to have the maximum return that is the more money possible given his initial investment. But as prices can be very erratic as on the picture below, the banker is set to ask the client his risk profile.

5 years Microsoft composite price

The risk profile of a client is his level of acceptance for risk. In portfolio theory, the risk is the "risk" of seeing the portfolio return deviate of its expected value; what is naturally measured by the standard deviation of the returns.

In portfolio theory, as we will see in details in next session, we are interested in two main parameters, the return and the risk. The standard deviation is seen as a good approximation of the risk but higher moments can be included for better precisions.[6]

The return of the portfolio is the weighted return of the assets which constitute it .[13]
$R_t = \sum_{i=1}^{i=N} w_{i,t} r_{i,t}$,
where $r_{1,t}, r_{2,t}, ..., r_{N,t}$ are the returns of assets $A_1, A_2, ..., A_N$ at time t.

We suppose here that each return $r_{i,t}$ is the realization of a random variable r_i independent of t and we introduce its covariance matrix:

$$\Sigma = \mathbb{E}[(\underline{r_t} - \mathbb{E}[\underline{r_t}])(\underline{r_t} - \mathbb{E}[\underline{r_t}])^T]$$

where $\underline{r_t} = (r_{1,t}, r_{2,t}, ..., r_{N,t})$ and $\underline{w_t} = (w_{1,t}, w_{2,t}, ..., w_{N,t})^T$, the respective weights of each asset in the portfolio. The weight here is the fraction of value of the asset inside the overall portfolio.

But in practice, the expected return and the covariance matrix are replaced by their respective estimators. An estimator of the expected value is:

$$\overline{r_i} = \frac{1}{T} \sum_{t=1}^{T} r_{i,t}$$

An estimator of the covariance between two return random variables is:

$$Cov(r_i, r_j) = \frac{1}{T-1} \sum_{t=1}^{T} (r_{i,t} - \overline{r_i})(r_{j,t} - \overline{r_j})$$

3.2 The Utility Theory

The theory of the firm is the microeconomic concept founded in neoclassical economics that states that firms (corporations) exist and make decisions in order to maximize profits. The theory of the firm goes along with the theory of the consumer, which states that consumers seek to maximize their overall utility.

As we intend to maximize the return of the investments, utility theory has been for decades the ground of thinking for investment management. Utility theory provide the mathematical background to develop the theory.

The main concept of utility theory used here is the utility function.The utility function permits to measure the satisfaction of a given consumers when using a good. It permits to measure the investor preference between a set of possible investments.

According to the words of [John Norstad, 1999],"In investment management, utility functions give us a way to measure investor's preference for wealth and the amount of risk they are willing to undertake in the hope of attaining greater wealth. This makes it possible to develop a theory of portfolio optimization. Thus utility theory lies at the heart of modern portfolio theory."

In order to select an appropriate utility function for the investor, we have to know his risk profile. In investment theory, three types of investors are encountered. The risk averse investor, the risk seeker and the risk neutral. Individuals are said to be risk averse if they always prefer to receive a fixed payment to a random payment of equal expected value. Risk seeker or risk loving investors prefer a random payment to a fixed payment of equal expected value and risk neutral are indifferent about choosing one or other type of payment.

Being W the final wealth of the investor:

For a risk averse investor the utility function $U$is a concave function of W: $U''(W) < 0$.
The utility function for a risk loving investor is a convex function of the wealth: $U''(W) > 0$.
Finally for the risk neutral investor, the utility function is a linear function of the final wealth: $U''(W) = 0$.

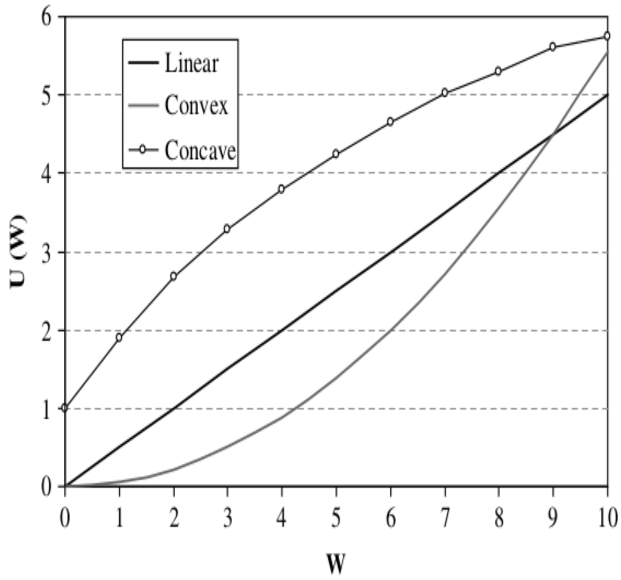


Figure I.6.1 Convex, concave and linear utility functions

Then the utility function is constructed according to those criteria.
An utility function f should have the following properties:[6]

$$f : \Omega \to \mathbb{R} \tag{1}$$

where Ω is the space of all possibles outcomes and R is the space of real numbers

(i) Transitive preferences . If an investor says he prefers outcome A to outcome B and he also prefers B to C, then he should prefer A to C

(ii) Independence . If the investor is indifferent between outcomes A and B then for any outcome C he is also indifferent between the two gambles:

G1 = A with probability p and C with probability 1-p and
G2 = B with probability p and C with probability 1-p

(iii) Certainty equivalence . For any gamble there is a certain equivalent value such that the investor is indifferent between the gamble and the certain equivalent.

(iv) Stochastic dominance . Suppose G1 and G2 are two gambles over outcomes A and B, A is preferred to B and G1 associates a higher probability with A than does G2 . Then we should prefer G1 to G2.

In modern portfolio theory, we use an exponential utility function, which satisfies the previous properties.

4 Modern Portfolio Theory

4.1 Origins Of The Theory

The Modern portfolio theory also called mean-variance portfolio method has been created by H. Markowitz in the early 60's. As would suggest Harry Markowitz, "portfolio theory differs from the theory of the firm and the theory of the consumer which I was taught". This theory suggest that individuals use to be risk averse. In addition, between a set of possible investments the investor would prefer the one that maximize the expected utility instead of maximizing the expected return.

Indeed maximizing the expected return yields to invest in one sole asset. On the contrary, modern portfolio theory recommends portfolio diversification through expect utility maximization. An empirical value for the expected utility is defined as :

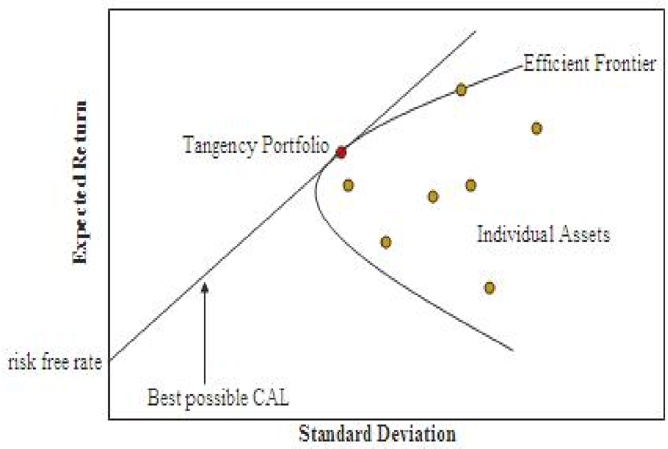
$$\mathbb{E}[U] = \sum U(R_t)/T$$

where R_t is the rate of return at time t and T is the number of periods in the sample.

H. Markowitz criticized the old investment theory that was just based on utility theory and expected return because that did not take into account the uncertainty of future returns. Actually nobody knows the future and taking the expected value of a given distribution for a granted future was unreasonable. H. Markowitz reminded us that if an investor knew future returns with certainty, he would only invest in the security with the highest future return and it would actually make no sense to choose a "multi-stocks portfolio".

Then he decided to account that uncertainty on future returns as the risk of the portfolio measured by the variance of returns i.e the second moment of probability distribution on returns.The higher is the risk, the more uncertain is the expected return. It then comes a trade-off between risk an return solved by the Pareto efficiency allocation problem explained below.

A say a natural approach for an investor to construct a well diversified portfolio could then be to select a point from the set of Pareto optimal for expected return and variance also known as efficient frontier.Here's the image of wikipedia for the efficient frontier:



The efficient frontier also called Pareto optimal in remind of Pareto efficiency is a set of couples (expected,return, risk) where it is impossible to improve the risk without degrading the expected return and vice-versa. it establishes a real trade off between expected return and risk.

The efficient frontier which is the upper half part of the hyperbola shows the lowest level of risk for a given level of expected return. it represents the portfolio risk and return when there is no risk free rate aggregated to the portfolio.

Individual assets are located inside the hyperbola and they show a higher risk for the same level of return than the diversified portfolio or a lower return for the same amount of risk than for the diversified portfolio.

Markowitz also tried to demonstrate that making investment strategy based only on expected return and variance could lead to achieve maximum of investor utility function. At this effect, he showed that expected utility for most utility functions could be fairly approximated with one function of expected return and variance. He exhibited one exception function that would probably not fit any investor because preferences are definitely not interesting for any investor.

$$f(E,V) = U(E) + 0.5 * U^{''}(E) * V$$

where E is the expected return and V its variance This approximation was better for diversified rather than for one-stock portfolios.

Let's then try to implement the idea of Markowitz expressed in his own words: "the natural approach for an economics student was to imagine the investor selecting a point from the set of Pareto optimal expected return, variance of return combinations". In order to continue with the development of the theory, it is important to recall that the mean-variance criterion is derived from an investor exponential utility .

Suppose the investor has an exponential utility of the form:

$$U(R) = -\exp(-\gamma R)$$

with $\gamma > 0$

Let's try to maximize the exact expected utility of the portfolio return for the provided exponential utility.

The return on the portfolio is:

$R_t = \underline{w_t}^T \underline{r_t}$.

Its expected utility is then:

$$\begin{aligned}\mathbb{E}[U(R_t)] &= \mathbb{E}[U(\underline{w_t}^T \underline{r_t})],\\ &= \mathbb{E}[-\exp(-\gamma \underline{w_t}^T \underline{r_t})]\end{aligned}$$

We consider the general expression for the expectation of the exponential of a gaussian variable $\epsilon = \mathcal{N}(\mu, \sigma)$: $\mathbb{E}[\exp(-a\epsilon)] = \exp(-a\mu + \frac{1}{2}a^2\sigma^2)$

So according to that expression, we also have:

$$\mathbb{E}[U(R_t)] = \mathbb{E}[-\exp(-\gamma \underline{w_t}^T \underline{r_t})] = -\exp(-\gamma\mu + \tfrac{1}{2}\gamma^2\sigma^2)$$

So, in order to maximize $\mathbb{E}[U(R_t)]$, we have to minimize $\exp(-\gamma\mu + \frac{1}{2}\gamma^2\sigma^2)$ what comes to minimize $-\gamma\mu + \frac{1}{2}\gamma^2\sigma^2$ because $\exp(x)$ is an increasing function of x. The general problem of portfolio allocation then comes to choose the weights vector $\underline{w_t}$ that minimizes the expression:

$$\begin{cases} \min\limits_{\underline{w_t}} -\underline{w_t}^T \,\mathbb{E}[\underline{r_t}] + \dfrac{1}{2}\gamma \underline{w_t}^T \Sigma \underline{w_t} \\ \qquad\qquad subject\,to: \ \underline{w_t}^T \underline{1} = 1 \\ \qquad\qquad\qquad w_i > 0 \ \forall i \end{cases} \tag{2}$$

However the problem may be formulated in many other ways.

Indeed, as said before, a trade off exists between the expected return of the portfolio $\underline{w_t}^T\,\mathbb{E}[\underline{r_t}]$ and the portfolio variance $\frac{1}{2}\gamma\underline{w_t}^T\Sigma\underline{w_t}$ as suggests the minimizing expression.

And recalling the origin of our problem say, investors are risk averse, it comes that an investor would probably choose the less risky portfolio for a given value of the expected return, Thus an other way of solving this equation adapting it to our problem is to minimize:

$\gamma\underline{w_t}^T\Sigma\underline{w_t}$ subject to $\underline{w_t}^T\,\mathbb{E}[\underline{r_t}] = \mu$.

Thus solving the problem:

$$\begin{cases} \min\limits_{\underline{w_t}} \gamma\underline{w_t}^T\Sigma\underline{w_t} \\ \quad subject\,to: \\ \begin{cases} \underline{w_t}^T\,\mathbb{E}[\underline{r_t}] = \mu \\ \underline{w_t}^T\underline{1} = 1 \\ w_i > 0 \;\forall i \end{cases} \end{cases} \tag{3}$$

where $\underline{1} = (1, 1, ..., 1)^T$

for a given risk the investor want to maximize it return making the ratio expected return over risk highest possible. We could also look at this ratio that is not so far from the classical Sharpe ratio and see what happens in terms of actual portfolio returns when we intend to maximize it. γ appears in the minimizing term because it is a risk factor as counts the variance of the portfolio.

This yields the following optimization problem:

$$\begin{cases} \max\limits_{\underline{w_t}} \underline{w_t}^T\,\mathbb{E}[\underline{r_t}]/\gamma\underline{w_t}^T\Sigma\underline{w_t} \\ subject\,to: \begin{cases} \underline{w_t}^T\,\mathbb{E}[\underline{r_t}] = \mu \\ \underline{w_t}^T\underline{1} = 1 \\ w_i > 0 \;\forall i \end{cases} \end{cases} \tag{4}$$

Problems (2),(3),(4) are instances of quadratic programming problems that can be solved easily with standard software or by the method presented in section 4.1

4.2 A First Optimization Problem

This part is about solving the system of following equations which yields a quadratic programming problem .[21]

$$\begin{cases} \min_{\underline{w_t}} -\underline{w_t}^T \, \mathbb{E}[\underline{r_t}] + \frac{1}{2}\gamma \underline{w_t}^T \Sigma \underline{w_t} \\ subject\, to: \; \underline{w_t}^T \underline{1} = 1 \\ w_i > 0 \; \forall i \end{cases} \tag{5}$$

For any minimization problem of the form:

$$\begin{cases} minimize \; f(x) \\ subject \; to \; Ax = b \\ f_i(x) \leq 0, \; i = 1, ..., m \end{cases} \tag{6}$$

where $f, f_1, ..., f_m(x) : \mathbb{R}^n \rightarrow \mathbb{R}$ are convex and twice continuously differentiable and $A \in R^{p*n}$ with $rank(A) = p < n$

Suppose that an optimal x^* exists and also that the problem is feasible, i.e it exists a point that satisfies the constraints, then it exists a dual optimal $\lambda^* \in R^m$, $\nu^* \in R^p$ that satisfy the Karush–Kuhn–Tucker (KKT) conditions.

$$\begin{cases} Ax^* = b, \;\; f_i(x^*) \leq 0, \; i = 1, ...m \\ \lambda^* \geq 0 \\ \nabla f(x^*) + \sum_{i=1}^{m} \lambda_i^* \nabla f_i(x^*) + A^T \nu^* = 0 \\ \lambda_i^* f_i(x^*) = 0, \; i = 1, ..., m \end{cases} \tag{7}$$

The software library we use to solve our experimentation is based on the interior point algorithm. Here, we explain some key points of this method. First, the original problem with the inequality constraints is formulated as an equality constrained problem to which the barrier method is applied. Further on, we detail barrier procedure.

The new optimization problem is:

$$\begin{cases} minimize \; f(x) + \sum_{i=1}^{m} I_{-}(f_i(x)) \\ subject \; to \; Ax = b \end{cases} \tag{8}$$

Where $I_{-} : \mathbb{R} \rightarrow \mathbb{R}$ is the indicator function for the non-positive reals.

$$I-(u) = \begin{cases} 0 & u \leq 0 \\ \infty & u < 0 \end{cases} \tag{9}$$

Then the indicator function is approximated by the function $\hat{I_{-}}(u) = -(1/t)log(-u)$ Being t a parameter that sets the accuracy of the approximation.

We replace then the original problem by its following approximation:

$$\begin{cases} minimize \; tf(x) + \sum_{i=1}^{m} log(-f_i(x)) \\ subject \; to \; Ax = b \end{cases} \tag{10}$$

The objective here is convex, and under some appropriate condition, barrier method can be used to solve it.

Being $x^*(t)$ a solution of (10), $\exists\hat{\nu} \in R^p$ such that:

$$t\nabla f(x^*(t)) + \nabla\phi(x^*(t)) + A^T\hat{\nu} = 0 \tag{11}$$

with $\phi(x) = \sum_{i=1}^{m} log(-f_i(x))$

Then, being $\lambda_i^*(t) = -1/(tf_i(x^*(t))),\ i = 1, ..., m,\ \ \nu^*(t) = \hat{\nu}/t;$,

It is easy to show that the pair (λ^*, ν^*) satisfy the KKT conditions, equals m/t and that $x^*(t)$ converges towards an optimal point as $t \to \infty$ Being ϵ a guaranteed specified accuracy, we take $t = m/\epsilon$ and we resolve the following problem using the Newton method:

$$\begin{cases} minimize\ m/\epsilon f(x) + \phi(x)) \\ \qquad\qquad subject\ to\ Ax = b \end{cases} \tag{12}$$

The barrier method for solving equation (14) lies in the following algorithm:

Given strictly feasible $x,\ i.e\ f_i(x) < 0, \forall i,\ t := t^{(0)} > 0, \mu > 1,\ tolerance\ \epsilon > 0.$

1. Compute x^* by minimizing $tf + \phi$ subject to $Ax = b$, starting at x.
2. Update $x := x^*$
3. Stopping criterion quit if $m/t < \epsilon$
4. Increase t. $t := \mu t$

The step 1 of the algorithm also called centering step can be solve using one of various descent methods like gradient descent, steppest method, Newton method etc.

Here, we expose some main lines of the Newton method who is said to work well in analytically.

Descent methods try to produce a minimizing sequence $x^k, k = 1, ...$ where

$x^{(k+1)} = x^{(k)} + t^{(k)}\Delta x^{(k)}$ with $t^{(k)} > 0$ expect for $x^{(k)}$ optimal.

The Newton method consists in the following algorithm:

Given a starting point $x \in domf,\ tolerance\ \epsilon > 0$

1. Compute the Newton step and decrement $\Delta x_{nt} := -\nabla^2 f(x)^{-1}\nabla f(x); \lambda^2 = \nabla f(x)^T\nabla^2 f(x)^{-1}\nabla f(x)$
2. Stopping criterion quit if $\lambda^2/2 \le \epsilon$
3. Choose step size t by backtracking line search.
4. Update $x := x + \Delta x_{nt}$

The backtracking line search consists in the following algorithm:

Given a descent direction Δx for f at $x \in domf,\ \alpha \in (0, 0.5)\ \beta \in (0, 1)$.

t:=1
while $f(x + t\Delta x) > f(x) + \alpha t\nabla f(x)^T\Delta x,\ t := \beta t$

An identification of our problem to the proposed framework gives:

$$
\begin{cases}
x = \underline{w_t} \\
f(x) = -\underline{w_t}^T \, \mathbb{E}[\underline{r_t}] + \frac{1}{2}\gamma \underline{w_t}^T \Sigma \underline{w_t} \\
A = (1, 1..., 1), \;\; b = 1 \\
f_i(x) = -w_i
\end{cases} \tag{13}
$$

4.3 Minimum Variance Portfolio For A Target Return

The minimum variance portfolio is the classic way of implementing modern portfolio theory. It is also what we implemented in our experimentations. We saw in section 4.1 the the efficient frontier was giving the set of couples (return, variance) that were maximizing the expected utility. The minimum variance portfolio is the point with the less variance.

Here, we pose the optimization problem [21] as finding the weights of the portfolio that minimizes the variance given the return.

$$
\textit{The problem is set as} : \begin{cases}
\min_{\underline{w_t}} \gamma \underline{w_t}^T \Sigma \underline{w_t} \\
subject\, to : \\
\begin{cases}
\underline{w_t}^T \, \mathbb{E}[\underline{r_t}] = \mu \\
\underline{w_t}^T \underline{1} = 1 \\
w_i > 0 \; \forall i
\end{cases}
\end{cases} \tag{14}
$$

The minimization problem is of the same as type as for the direct maximization solution:

$$
\textit{General form} : \begin{cases}
\textit{minimize } f(x) \\
\textit{subject to } Ax = b \\
f_i(x) \leq 0, \;\; i = 1, ..., m
\end{cases} \tag{15}
$$

And we can identify the variables of our minimization problem:

$$
\textit{Identification} : \begin{cases}
x = \underline{w_t} \\
f(x) = \frac{1}{2}\gamma \underline{w_t}^T \Sigma \underline{w_t} \\
A = \begin{bmatrix} E[r_{1,t}] & E[r_{2,t}] & E[r_{N,t}] \\ 1 & 1 & 1 \end{bmatrix} \\
b = \begin{bmatrix} \mu \\ 1 \end{bmatrix} \\
f_i(x) = -w_i
\end{cases} \tag{16}
$$

4.4 The Capital Asset Pricing Management

The Capital Asset Pricing Management provides a portfolio selection method. Although, we won't implement it here, we present it in this section for the sake of the completeness.

The Capital Asset Pricing Management first introduce to any portfolio the risk free asset. What is the government bond which fluctuations are negligible because its value is very stable along time.

The weight of the risk free asset in the overall portfolio is calculated according the following formula :[6]

$$w^* = \frac{\mathbb{E}[r_p] - r_f}{\gamma \sigma_p^2} \tag{17}$$

where w^* is the weight of the risk free asset, $sigma_p$ the variance of the original risky portfolio and $\mathbb{E}[r_p$ its expected value. Here follows the demonstration of the formula.

Given any portfolio P we can form another portfolio by placing a proportion w of our funds in P and a proportion $1 - w$ in the risk free asset r_f. The return on the portfolio is given by:

$$r = wr_p + (1 - w)r_f \tag{18}$$

The new expected return is:

$$\mathbb{E}[r] = w\,\mathbb{E}[r_p] + (1 - w)r_f \tag{19}$$

That is, the new expected return will lie on the line between P and r_f at a point that is determined by w. The standard deviation of returns on the new portfolio is given by:

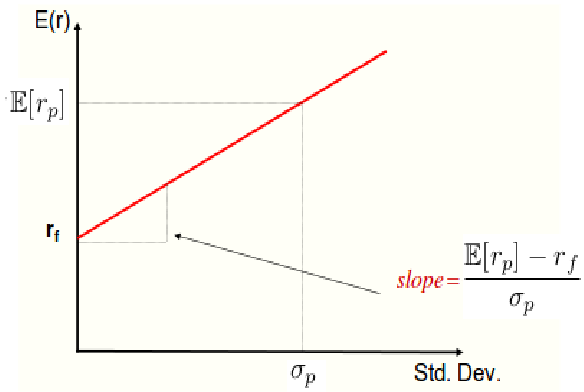
The variance of the combined portfolio is:

$$\sigma^2 = \mathbb{E}[(r - \mathbb{E}[r])^2] = \mathbb{E}[(wr_p - w\,\mathbb{E}[r_p])^2] = w^2\,\mathbb{E}[(r_p - \mathbb{E}[r_p])^2] = w^2\sigma_p^2 \tag{20}$$

We can derive the Capital Allocation Line, i.e. the set of investment possibilities created by all combinations of the risky and riskless asset.

Combining (24) and (25), we can characterize the expected return on a portfolio with σ.

$$\mathbb{E}[r] = r_f + \underbrace{\left[\frac{\mathbb{E}[r_p] - r_f}{\sigma_p}\right]}_{\text{Sharpe ratio}} \sigma \tag{21}$$



The CAL shows all risk-return combinations possible from a portfolio of one risky-asset and the risk-free return.

Mathematically, the optimal portfolio is the solution to the following problem:[3]

$$U^* = \max_w U(r) \tag{22}$$

where U is the utility function of the investor.In the case where the utility function is the exponential function for the risk averse investor, it comes:

$$U^* = \max_w(\mathbb{E}[r] - \frac{1}{2}\gamma\sigma^2) \tag{23}$$

Then combining with the previous equalities, the problem comes:

$$\max_w U(r) = \max_w(r_f + w\,\mathbb{E}[r_p - r_f] - \frac{1}{2}\gamma w^2\sigma_p^2) \tag{24}$$

$$\frac{\mathrm{d}U}{\mathrm{d}w}|_{w=w^*} = 0 \Rightarrow w^* = \frac{\mathbb{E}[r_p] - r_f}{\gamma\sigma_p^2} \tag{25}$$

The Capital Asset Pricing Management also introduces the market equilibrium in which the expected excess return on the risky asset $\mathbb{E}[r_i] - E[r_f]$ is proportional to the expected excess return on the market portfolio $\mathbb{E}[r_p] - r_f$:

$$\mathbb{E}[r_i] - E[r_f] = \beta_i(\mathbb{E}[r_p] - r_f) \tag{26}$$

The proportionality factor is called the systematic risk[2] of the asset.

$$\beta_i = Cov(r_p, r_i)/\sigma_p^2 \tag{27}$$

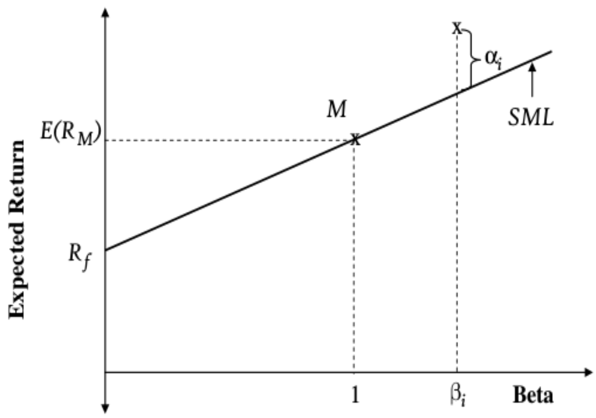
For a given asset i $sigma_i^2$ is the risk associated with its own fluctuations around its mean, but not with respect to the market portfolio.

We can thus view β_i as a measure of non-diversifiable risk. the correlated-with-the-market part of risk that we can't reduce by diversifying.

In the case the market is not in equilibrium equation (26) becomes

$$\mathbb{E}[r_i] - E[r_f] = \beta_i(\mathbb{E}[r_p] - r_f) + \alpha_i \tag{28}$$

With α_i whether positive or negative according to the following figure.



Security Market Line

We call security market line the line which joins the points $(r_f, 0), (1, \mathbb{E}[R_M]))$ where M is the market portfolio here.

The trading decision regarding asset i when the market is not in equilibrium can be made according to the following rules:

if $\alpha_i > 0$ we buy the asset, otherwise $\alpha_i < 0$ triggers a sale of the asset.

5 Technical analysis

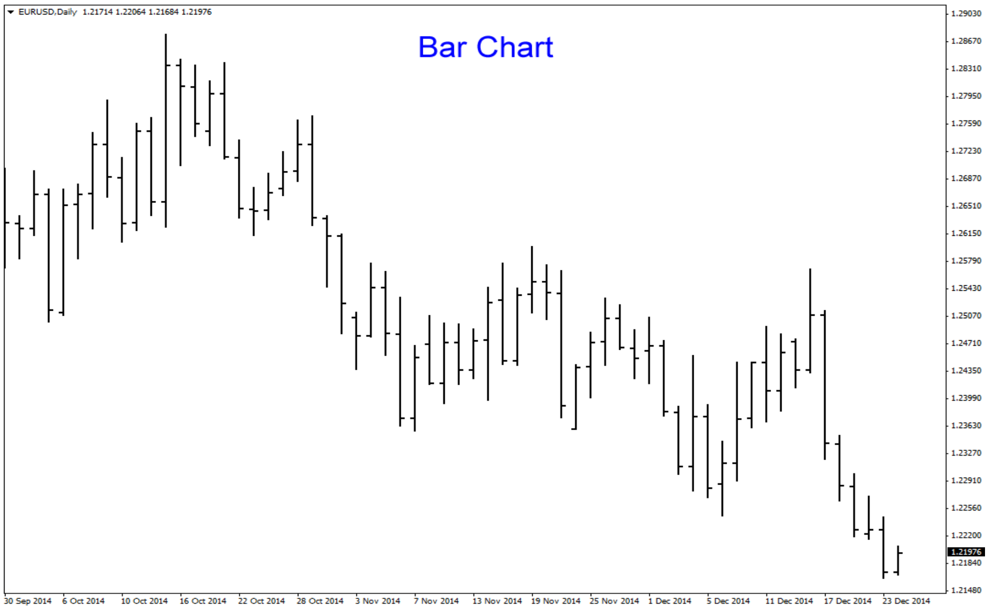
5.1 The charts

Technical analysis is a security analysis methodology that studies the direction of prices through past market data, primarily price and volume.

Technical analysis use different graphical representations in the forecasting of prices among them many originating from Japan. They are: The zig-zag, the bar charts, the candles, the candlevolume, the equivolume, the point and figure, the kagi, the renko, the three line break, the range bars, the heikin ashi. As technical analyst have been working most of time visually on those graphs, here we picture some of those representations

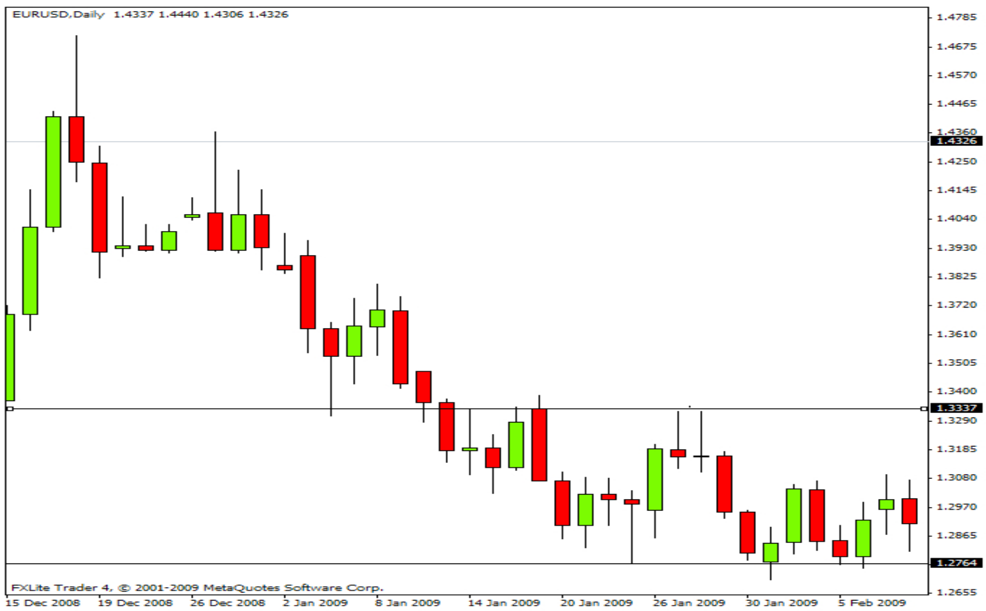
Zig-zag representation

The zig-zag representation is obtained by joining with a segment the prices (usually the closures) of the securities or contracts recorded at fixed intervals of time. This representation is use as this to determine trends but more elaborate representation and usage exist.



Bar chart representation

In the bar chart, the opening is indicated by a tooth facing left and the closure from a tooth facing to the right, while the vertical bar goes from the maximum to the minimum quotes achieved during the session.



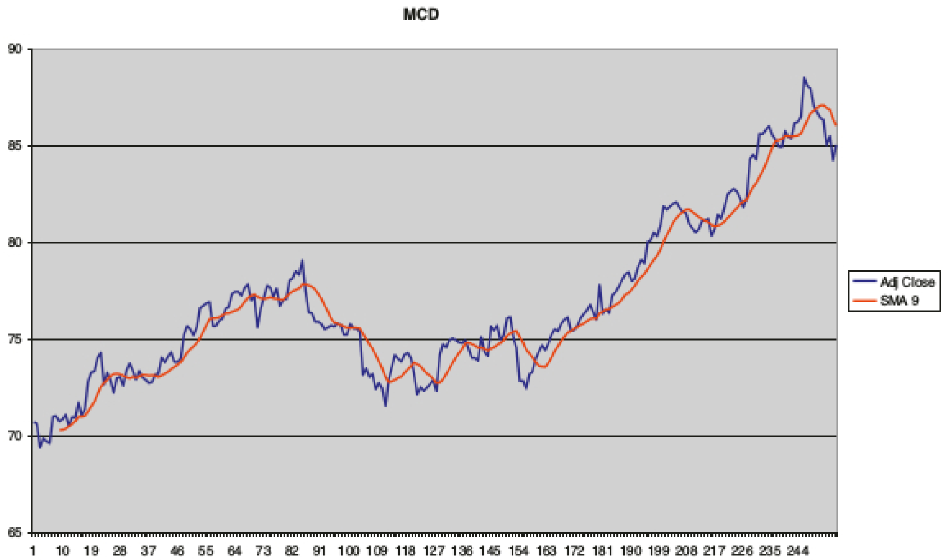
Candles representation

This representation talks from itself with red color whether the close < open and green color when close > open. The thickest part (the candle itself, or body) goes from opening to closing when red and from closing to opening when green.

5.2 The Indicators

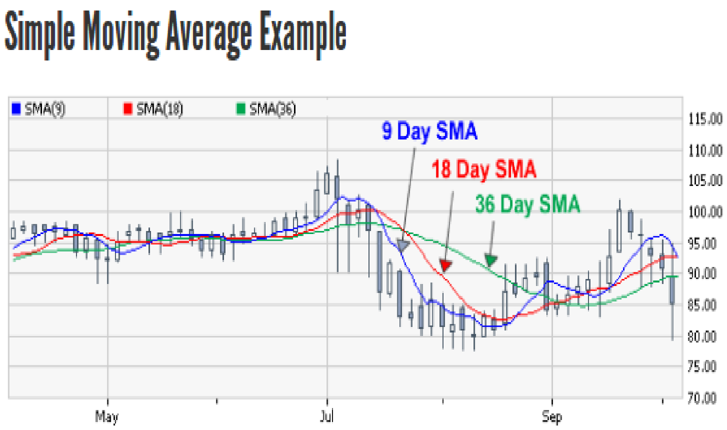
The work of a chartist or technical analysis is made simple by the use of indicators. They are formulas that the technical analyst create to help him make his investment decisions. When the chartist designs an indicator, he confronts the result of this indicator to one graphical representation so he can see entry or exit point for trading opportunities.

One of the most popular indicators is the simple moving average filter.



Simple Moving Average On Mac Donald's stock

To use the simple moving average indicator (SMA), one has to draw the price lines for two SMA with two different averaging period like on the figure below.



Simple Moving Average For Different Periods

This figure [14] consists of three moving averages at 9 bars, 18 bars and 36 bars; the signals are late on true prices; but the longer is the moving average, the greater is the delay; when the trend is upward, the moving averages stand below the price line and pass over it when the trend is downward.

We see that the price trends upward shortly after the shorter moving average passes above the long one (golden cross) and the price trends downward when the shorter moving average passes below the longer one (devil cross). From there, it seems obvious to go long (we buy the stock) on the golden cross and go short (sell stocks) on the devil cross.

The other types of indicator apart from the filter are the oscillators. They are formulas elaborated on price and volume. One popular indicator is the Relative Strength Index (RSI)

To find the value of the RSI, in a worksheet, we draw two columns: in the first we insert a 1 for a rise in prices and a 0 for a drop of prices and in the second column, instead, a 1 corresponds to a drop in prices while a 1 stands for a rise in price.. Afterwards we calculates the simple average (for a given number of days) for the first column and, then that of the second, and finally the first one is divided by the second (this parameter is indicated by p).

Then, the formula of the RSI is : $RSI = 100 - 100/(1 + p)$.

The trading protocol here is to say if $RSI \geq 70$, the security is overbought and it is expected to decline then go short and if $RSI \leq 30$, the security is oversold and it is expected to rise then go long.

Common names for oscillators are Dynamic Zone RSI, MACD, MACD Zero lag, Stochastic, Accumulation and Distribution, Chaikin Money Flow, Money Flow, On Balance Volume.

Common filters are EMA (Exponential moving average), WMA (Weighted Moving Average), Triangular Moving Average (RMA)...

The indicator can then be followed by a decision rule of the type long/short, in which case the block indicator + decision rule takes the name of trading system.

5.3 The Trading System

In our experimentations, we implement the trading system based on the RLC filter on the Dow Jones Industrual Average (DJIA) and on Apple (AAPL).

Trading system uses an input variable which are the prices (and/or, at most, the volumes) and an output variable (the indicator or, in the case of a complete trading system, the equity).

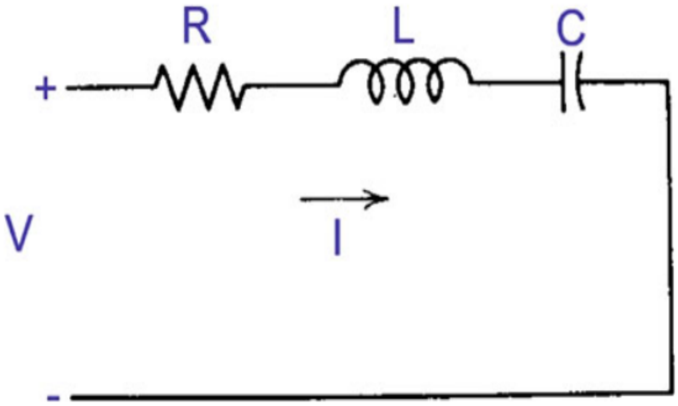
```
//Trading System RLC
R=rr
L=ll
C=cc
lag=la
RLC=RLC[1]+(R+L+1/C)*close–(R+2*L)*close[1]+L*close[2]
c1=RLC>RLC[lag]
IF c1 THEN
   buy 1 shares at market tomorrowopen
ENDIF
c2=RLC<RLC[lag]
IF c2 THEN
   sellshort 1 shares at market tomorrowopen
ENDIF
//Optimize rr, ll, cc and la 3 to 31 in steps of 2
```

Code for the RLC filter trading system

Here, RLC is the indicator output. As for the two SMA indicators, we make a comparison of two indicators values delayed from "lag" time t.

We then make a buy or sell decision in function of the result of that comparison.

The values of the R, L, C component



The original RLC circuit

Here is the physical filter at the origin of our trading system. The input current is the price, the output; the voltage is the indicator output.

We have: $V = V_{-1} + (R + L + C^{-1})I - (R + 2L)I_{-1} + LI_{-2}$.

We denote $O = O_{-1} + (R + L + C^{-1})I - (R + 2L)I_{-1} + LI_{-2}$.

where O and O_{-1} are respectively the output at time t and $t - 1$ and I, I_{-1}, I_{-2} are the price at time t, $t - 1$ and $t - 2$. We can go further in the calculation and characterize the filter taking the Z transform of the expression.

We have:

$O(z) = z_{-1}O(z) + (R + L + C^{-1})I(z) - (R + 2L)z^{-1}I(z) + Lz^{-2}I(z)$

So $H(z) = O(z)/I(z) = \frac{(R+L+C^{-1})-(R+2L)z^{-1}+Lz^{-2}}{1+z^{-1}}$

$H(z) = \frac{(R+L+C_{-1})z^2-(R+2L)z+L}{z^2+z}$

We recognize here a pole-zero system, the **auto-regressive moving average (ARMA)** model.

6 Google Trends Based Trading strategy

The Google Trend Trading method[17] was born after a succession of new considerations. Some papers were creating new information in the field of finance related to the application Google Trends.

In particular Bordino, I. et al.[7] showed that there was a strong correlation between the web search queries and the stock market trading volumes.

An investigation[16] showed that the number of clicks on search results stemming from a given country correlates with the amount of investment in that country. An other study has shown that Internet users from countries with a higher per capita GDP are more likely to search for information about years in the future than years in the past.[18]

According to Herbert Simon, actors begin their decision making processes by attempting to gather information.[20] In today's world, information gathering often consists of searching online sources.

A scientific paper[17] then developed a trading strategy based on those considerations. This strategy supposes a relationship between the volume of search queries for a specific term and the overall direction of interesting trader decision.

The traded asset was the DJIA, a famous market index which reflects very well the health of us economy. The search term was the word "debt"

The method analyzes the closing prices $p(t)$ of the Dow Jones Industrial Average (DJIA) on the first trading day of week t.
To quantify changes in information gathering behavior, we use the relative change in search volume: $\Delta n(t, \Delta t) = (n(t) - N(t-1, \Delta t))$ *with* $N(t-1, \Delta t) = (n(t-1) + n(t-2) + ... + n(t-\Delta t))/\Delta t$, where t is measured in units of weeks.

We implement this strategy by selling the DJIA at the closing price p(t) on the first trading day of week t, if $\Delta n(t-1, \Delta t) > 0$ and buying the DJIA at price $p(t+1)$ at the end of the first trading day of the following week. Note that mechanisms exist which make it possible to sell assets in financial markets without first owning them. If instead $\Delta n(t-1, \Delta t) < 0$, then we buy the DJIA at the closing price $p(t)$ on the first trading day of week t and sell the DJIA at price $p(t+1)$ at the end of the first trading day of the coming week.

The overall performance were said to be very good although trading costs were not taken into account.

We're are going to implement this method and discuss results with and without trading costs. This method is particularly interesting as we mentioned in motivation part rightly because the searches for term "debt" increase in time of financial distress. Also its evolution along time shows the concern of investors and this could be an alert about their future investment decision thus inspire us anticipating trading decisions. We expect in all the cases very interesting trading decisions in time of financial crisis.

7 Google Trend Based Portfolio selection

7.1 Procedure

The Google Trends based Portfolio method[12] is a novel approach to portfolio diversification using the information of searched items on Google Trends. The diversification is based on an idea that popularity of a stock measured by search queries is correlated with the stock riskiness. Popular stocks are penalized as there are assigned lower portfolio weights while the less popular , or peripheral, stocks are brought forward to decrease the total riskiness of the portfolio.

The portfolio diversification strategy is based on the search volume of stock-related terms. Diversification strategy is constructed as follows. To discriminate for the popularity of the stock, we use a power-law rule to obtain portfolio weights. Let $V_{i,t}$ be a search volume of stock-related term of stock i at week t.

The weight $w_{i,t}$ of stock i in the portfolio at time t is defined as

$$w_{i,t} = \frac{V_{i,t}^{-\alpha}}{\sum\limits_{j=1}^{N} V_{i,t}^{-\alpha}} \tag{29}$$

The normalization factor $\sum\limits_{j=1}^{N} V_{i,t}^{-\alpha}$ ensures that $\sum w_{i,t} = 1$ for all t. Note that if $\alpha > 0$, the more frequently looked up stocks are assigned a lower weight, and if $\alpha < 0$, the more searched for stocks are preferred in the portfolio. For $\alpha = 0$, a uniformly diversified portfolio with $w_{i,t} \equiv w = 1$ for all i and t is retrieved.

The power-law discrimination rule ensures that even highly popular stocks are still at least marginally present in the portfolio. Therefore, popular stocks are discriminated but do not to have their weights in the portfolio vanish too quickly and too frequently.

7.2 Browsed Information

To make our experiments, we will need a set of assets that will constitute our portfolio, a keyword which search volume will determine the level of risk of our asset and a trading period.

We are interested in working with the stocks of the Dow Jones Industrial average (DJIA) because they constitute a good benchmark for the field of portfolio management.

In order to get the information in a system like Yahoo finance, one has to provide the identity name of the company. That identity is specific at each data provider and is called a "ticker symbol" or more shortly "tick symbol"

They usually do not differ so much from one data provider to another and is somewhat linked to the name of the company.For example Apple has "AAPL", Google, "GOOG" and Wall Mart "WMT" at Yahoo finance.

We will use Yahoo finance as our data provider like its quote information is available at download but not only visible on a web page. In addition to that, many professional scripts exist on the web. Good libraries for downloading and manipulating quoting information from Yahoo finance.

We analyze two types of searched terms – the ticker symbol (e.g. GE for General Electric Company or XOM for Exxon Mobil Corporation) and the combination of the word "stock" and ticker symbol (e.g. "stock GE" and "stock XOM").

Even though the Google Trends database ranges back to the beginning of 2004, we analyze two different periods for the two approaches – 3.1.2005–21.5.2016 for the former and 5.1.2009–21.5.2016 (234 weeks) for the latter – due to data availability (zero-value observations are very frequent for the dates before the analyzed periods).

We also had to omit tickers AA, BA, BAC, CAT, DD, DIS, HD, KO, MCD, PG, T, TRV, UNH, VZ for the first approach due to infrequent queries but also ambiguity and interchangeability of the ticker symbols with stock unrelated terms and abbreviations.

For the second approach, we had to erase observations for AXP, MRK, TRV, UNH, UTX due to infrequent search queries.

We are interested in performance of the proposed methodology in the in-sample procedure. The in-sample performance is then based on portfolio weights rebalancing at week t according to Eq. 2 and gaining/losing in the same period.

8 The Metrics

8.1 Standard deviation of portfolio return

Let σ^2 be the standard deviation of the portfolio return:

The classical formula for standard deviation of a portfolio is:

$$\sigma^2 = \underline{w_t}^T \Sigma \underline{w_t} \tag{30}$$

Where Σ is the covariance matrix of the portfolio and $\underline{w_t}^T$ the vector of weights.

$$\Sigma_{i,j}^{(in)} = \begin{cases} Cov(r_i, r_j)\ if\ i \neq j \\ Var[r_i] = \sigma_i^2\ if\ i = j \end{cases} \tag{31}$$

Being $r_{i,t}$ the return,

$$r_{i,t} = \frac{p_{i,t} - p_{i,t-1}}{p_{i,t-1}} \tag{32}$$

Where, $p_{i,t}$ is the closing price of asset i the first day of week t.

8.2 Sharpe ratio

The Sharpe ratio is:

$$S_r = \frac{\mu}{\sigma} \tag{33}$$

Where μ is the expected return of the portfolio and σ is its standard deviation.

8.3 Evolution of portfolio value

The formula for the return on investment is:

$$P_{ev,t} = 100 * (P_{v,t} + Gl_t)/P_{v,t_0}$$

Where $P_{v,t} = \sum_{i=1}^{N} n_{i,t} p_{i,t}$ is the portfolio value at time t, $n_{i,t}$ is the number of shares of assets i in the portfolio at time t and Gl_t is the total gain or loss in trading the shares from time t_0 to time t.

$$Gl_t = Gl_{t-1} + \sum_{i=1}^{i=N} (n_{i,t-1} - n_{i,t}) p_{i,t} (1 + Transaction\_cost)$$

with $Gl_{t_0} = P_{v,t_0} * Transaction\_cost$

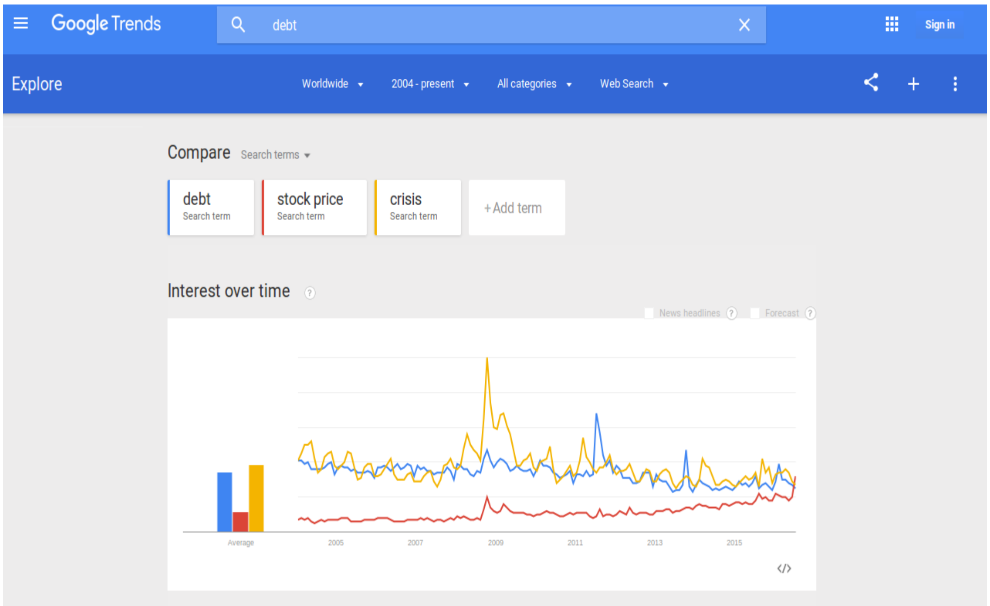
9 Google Trends

9.1 Description

Google Trends is a service provided by Google over the internet. It was launched on May, 11^{th} 2006.It aims to provide information over the terms searched into its search engine. The information that Google trends delivers is the evolution in percentage of the number of searches performed for a given term over the Google search engine within a period in a given location in the world.

Two usages exist: The graphical interface showed in the following picture and the program interface. For programing, we use the application program interface that has been developed on purpose. Otherwise, the graphical interface helps visualize results to make programing decisions faster.

In the following figures, we can see relative search volumes for the keywords "debt", "stock price" and "crisis"

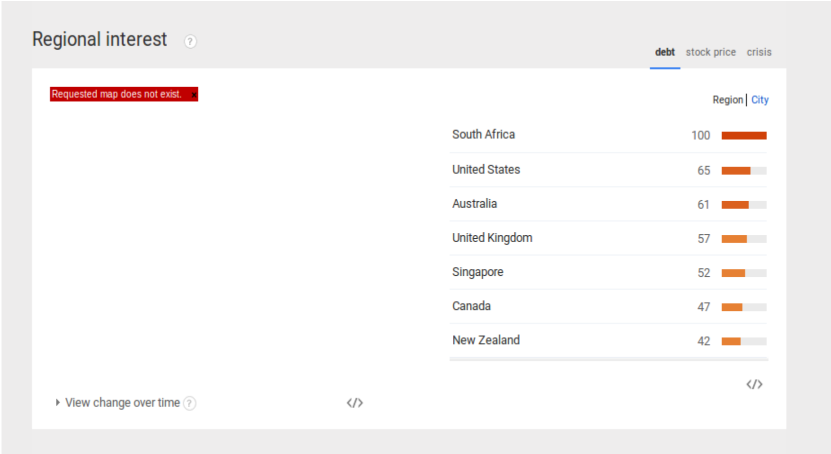


Screen shot of Google trends search results

The graphical interface allows to introduce the search terms in the top frame. Then, it is possible to give characterizations for the result specifying in the drop down menu, the region, the period of search, a category, and the origin of the search. The region can be whether a country or the whole world. Categories can be finance,art, business, food and so on. Origin specifies the Google application in which the user made the search. It can be web search , image search, Youtube, and so on. It is also possible to specify the time zone of the research. Then, one can download the time series of the search volumes after signing into his Google account.

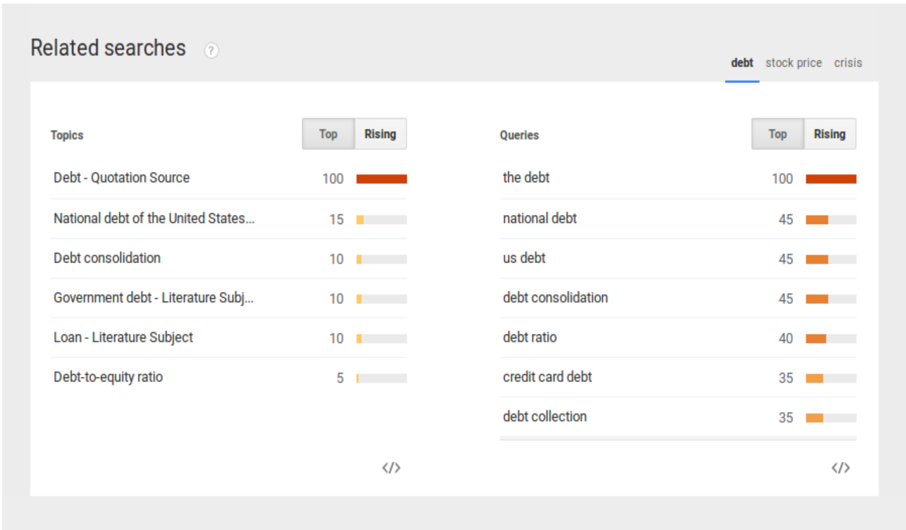
The graph that is showed in the downward frame corresponds to the result, It's a time series where each value is a percentage of the top value that is 100.

The following figure is the regional interest that ranks the top 10 subregions of the above specified region in the order of number of searches performed in each. Regional interest is also displayed by cities.



Screen shot of regional interest

The following figure shows the related searches. It shows topics and queries related to the performed keyword that have been browsed in the Google search engine. The topics are searched terms proposed by Google trends in its portal, that are actually trends of the moment.



Screen shot of related search

9.2 Extraction code

The following figure show the code that has been used to extract data from Google trends. This program performs some web queries specifying the above parameters.

```
def save_trends(num_exp,path,group,keywords):

with open('Credentials') as csvfile:
csvreader = csv.reader(csvfile, delimiter=',')
for cred in csvreader:
google_username = cred[0]
```

```
google_password = cred[1]

# connect to Google
connector = pyGTrends(google_username, google_password)

if num_exp== 1: date= "01/2005 144m" #102m

else: date= "01/2009 96m" # 58m
# make request
connector.request_report(keywords,date=date)

# wait a random amount of time between requests
time.sleep(randint(5, 10))

connector.save_csv(path, group)
```

Extraction code

In order to extract data via the API, it is essential to provide one's credential for Google applications or Gmail. What is done in the first lines of the program. The request is then made in the line *connector.request_report(keywords,date=date)* specifying the period and the keywords. Then the result is saved in the comma separated value format in the path *path* under the name *group*.

10 The Experiments

10.1 Method

Metrics show the worth of a method over an other one. So its calculation is very important as it determines gains from using such methods. Bad metrics results could mislead the user and in that case cause financial loss.

Calculation of the standard deviation is made according to the formula $\sigma^2 = \underline{w_t}^T \Sigma \underline{w_t}$.

For this purpose, we calculate Σ the covariance matrix of the returns. We decide the length of the return vectors used in the covariance matrix. In our case, we use a length $l = 13$ for the first experiment and $l = 6$ for the second. It is true that the length of the return vector shapes the value of the Sharpe ratio and in order to compare it to an other method, it is preferable to have the same values for the parameters. The actual value used for the parameter does not matter for comparison purpose, however, we use $l = 13$ and $l = 6$ because it rather gives similar results to the literature as it does not exist a reference value for l.

We also decide to have a constant length for the return vector from the beginning to the end of the trading period.

For this purpose we initialize the value of Σ for $t = t_0$ with return vectors for t going from $t = t_0 - 13$ to $t = t_0$ for the first case and $t = t_0 - 6$ to $t = t_0$ for the second . We then keep the length of the return vector constant for each time t stacking a new set of return vectors at t and unstacking return vectors respectively for time $t-13$ and $t-6$ oin each experience.

For the expected return, we keep the same length of return vectors. We estimate the expected return of a given asset at time t taking its mean over the l previous periods. And we realize the dot product with the vector of weights according to the formula:
$\mathbb{E}[R_t] = \underline{w_t}^T \underline{\mathbb{E}[r_t]}$.

We then calculate the Sharpe ratio dividing the expected return by the standard deviation.

To calculate the portfolio evolution, we start the period of trading by buying the shares with a given initial amount of money.

Then at each time t, whether, we determine the new number of shares in the portfolio given the new weights of assets and the same amount of money than the initial time for the first explained method or we just trade the totality of shares according to a buy or sell procedure in the other case.

We then proceed to a purchase or sale of stocks in order to meet the new number of shares in the portfolio. Indeed, when the number of shares $n_{i,t}$ increases, we have to buy shares at price $p_{i,t}$.and when $n_{i,t}$ decreases,we have to sell shares at price $p_{i,t}$.

The result of the operation as a gain/loss equals the difference between the amount received from sold shares minus the amount spent in bought shares. It comes the following formula for the rebalancing gain/loss introduced in section 8.3

$Gl_t = Gl_{t-1} + \sum_{i=1}^{i=N}(n_{i,t-1} - n_{i,t})p_{i,t}(1 + Transaction\_cost)$

To this value, we add the actual value of the portfolio $P_{v,t} = \sum_{i=1}^{N} n_{i,t}p_{i,t}$ to get the shift of value of the portfolio between time t and time t_0 at the end we have to divide the first value by the second to get the evolution in percentage.

The prices of the assets are downloaded from Yahoo finance using an application program interface (api). This api takes as parameters the tick symbol for to the asset and the trading dates and returns as result the corresponding historical information .

We are only interested by the closing prices for each assets.

One way of proceeding consists in specifying in the api the actual date for each period and proceed to the extraction of the information. The alternative way consists in only specifying the beginning and the ending of the whole trading period and download the information at once and then proceed to the extraction of prices at each trading period one by one.

The dates provided to the api must be synchronized to the Google Trends weekly dates. As they fall on Sunday, one has to add one civil day to the dates provided by Google Trends to get the actual desired date.

For the weights calculation in the Google Trends portfolio method, we apply the volume rescaling procedure that allows the weights for each asset to be calculated for a same search volume basis. Indeed, in Google Trends, it is not possible to put all the search terms in the application and let it return the search volumes scaled according to a unique reference.

For this reason we want to rescale them so they are defined according to a same reference.What we do here is to ask the search volumes for groups of five search terms.

For the first experience we have 16 tick symbols, so 16 search terms. We form 4 groups. We keep one keyword as a reference which belongs to all the groups. Each group has 5 keywords except the last one that only has 4. Then, we make the query for each group.

The reference keyword can be whatever of the set of keywords. But if we select big names like "IBM" or "GE" to be the reference keyword, then as they are very looked at then the majority of search volumes will be 0 all the time. However, this does not influence the final rescaled volumes for each keyword.

Then, to rescale, we multiply each search volume vector for a given keyword in a given group by the ratio between the reference keyword search volume value in, said, the first group at a given time t and the search volume value of the reference keyword within the said group at the same time t .

When a rescaled search volume worth 0 then when applying the weight formula, for alpha positive this logically triggers a division by zero error. To solve that, we decide to give a very high value to that result say 10^3 so it becomes possible to apply the normalization part of the weight formula.

10.2 Results Without Transaction Costs

Here, we show the results of our implementations displaying the output of our three metrics applied on our portfolio along time over two different periods along the experiments for the Google Trends Portfolio and for the Buy and Hold DJIA strategy.

We present the standard deviation and the Sharpe ratio of the last trading session and the evolution of the portfolio value all along the weeks. We plot the portfolio evolution, in case of the Google Portfolio, the one corresponding to the value of α that maximizes the Sharpe ratio.

In the first set the Google trends portfolio is consituted of assets of the DJIA as of 30.6.2013 except the tickers AA, BA, BAC, CAT, DD, DIS, HD, KO, MCD, PG, T, TRV, UNH, and VZ. This first set of experiments goes from 3.1.2005 to 21.5.2016.

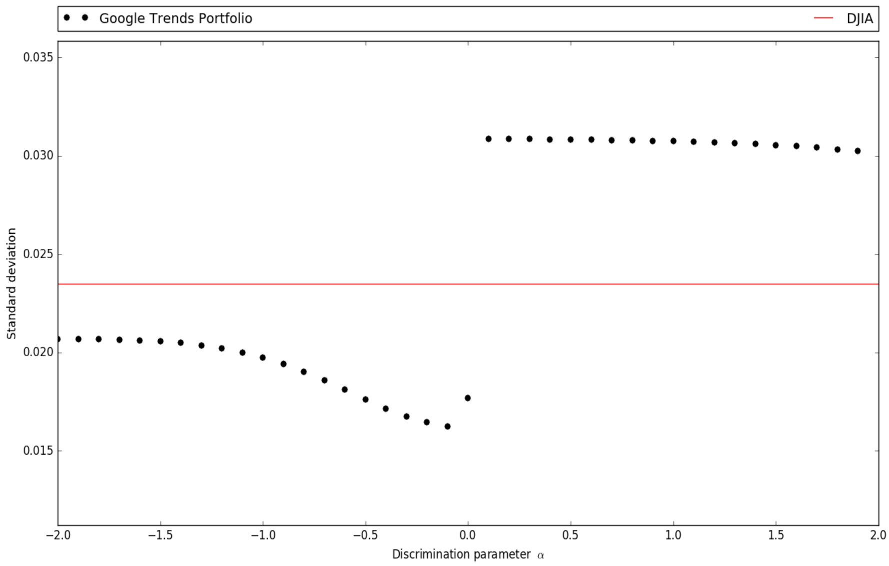
In the second experimentation, we change the period as well as the stocks for the Google Trends Portfolio method. New stocks are those of the DJIA as of 30.6.2013 except AXP, MRK, TRV, UNH and UTX. What changes for the DJIA is only the period which, in fact, is included the former. Tis time, the period goes from 5.1.2009 to 21.5.2016.

10.2.1 Details

For the Google Trends Portfolio method, we calculate the weights in each portfolio according to the formula specified in section 7.1

We download the search volumes from Google Trends by groups of five search terms. Then we proceed to rescale them so the figures are all related to a same reference. The rescaling procedure consists in multiplying eahc search volume in each group by the ratio of the first non null value to its corresponding value in a reference search term

10.2.2 First Set: Standard Deviation



The DJIA is represented by the red line while the Google trends portfolio has the black dots. We find here typical values of standard deviation for portfolio returns. The red line cuts the set of dots into two parts in $\alpha = 0$ where the standard deviation for the Goggle Trends portfolio is maximum. The values of the standard deviation are lower for $\alpha < 0$ as we see on the table below, this corresponds to favor the companies with high search volume.

Relation weights,search Volumes					
alpha	**date**	**tick**	**relative volume**	**rescaled volume**	**weight**
-0.3	2005-01-02 - 2005-01-08	hpq	0	0	0
-0.3	2005-01-02 - 2005-01-08	ibm	95	95	0.2428337387
-0.3	2005-01-02 - 2005-01-08	ge	38	38	0.184470542
-0.3	2005-01-02 - 2005-01-08	csco	0	0	0
-0.3	2005-01-02 - 2005-01-08	xom	0	0	0
-0.3	2005-01-02 - 2005-01-08	axp	10	0.2702702703	0.0418341961
-0.3	2005-01-02 - 2005-01-08	mrk	18	0.4864864865	0.0499014516
-0.3	2005-01-09 - 2005-01-15	hpq	0	0	0
-0.3	2005-01-09 - 2005-01-15	ibm	99	99	0.2435255546
-0.3	2005-01-09 - 2005-01-15	ge	38	38	0.1827212517
-0.3	2005-01-09 - 2005-01-15	csco	0	0	0
-0.3	2005-01-09 - 2005-01-15	xom	0	0	0
-0.3	2005-01-09 - 2005-01-15	axp	13	0.3513513514	0.0448307982
-0.3	2005-01-09 - 2005-01-15	mrk	16	0.4324324324	0.047712202
-0.3	2005-01-16 - 2005-01-22	hpq	0	0	0
-0.3	2005-01-16 - 2005-01-22	ibm	100	100	0.2468835812
-0.3	2005-01-16 - 2005-01-22	ge	39	39	0.1861279485
-0.3	2005-01-16 - 2005-01-22	csco	0	0	0
-0.3	2005-01-16 - 2005-01-22	xom	0	0	0
-0.3	2005-01-16 - 2005-01-22	axp	12	0.3243243243	0.0442370406
-0.3	2005-01-16 - 2005-01-22	mrk	14	0.3783783784	0.0463308323
-0.3	2005-01-23 - 2005-01-29	hpq	0	0	0
-0.3	2005-01-23 - 2005-01-29	ibm	100	100	0.2410547046

-0.3	2005-01-23 - 2005-01-29	ge	38	38	0.1803228202
-0.3	2005-01-23 - 2005-01-29	csco	0	0	0
-0.3	2005-01-23 - 2005-01-29	xom	0	0	0
-0.3	2005-01-23 - 2005-01-29	axp	13	0.3513513514	0.0442423412
-0.3	2005-01-23 - 2005-01-29	mrk	20	0.5405405405	0.0503458982
-0.3	2005-01-30 - 2005-02-05	hpq	0	0	0
-0.3	2005-01-30 - 2005-02-05	ibm	99	99	0.2444052166
-0.3	2005-01-30 - 2005-02-05	ge	37	37	0.1819199928
-0.3	2005-01-30 - 2005-02-05	csco	0	0	0
-0.3	2005-01-30 - 2005-02-05	xom	0	0	0
-0.3	2005-01-30 - 2005-02-05	axp	15	0.4054054054	0.046966346
-0.3	2005-01-30 - 2005-02-05	mrk	17	0.4594594595	0.0487634105
-0.2	2005-01-02 - 2005-01-08	hpq	0	0	0
-0.2	2005-01-02 - 2005-01-08	ibm	95	95	0.1740242983
-0.2	2005-01-02 - 2005-01-08	ge	38	38	0.1448844877
-0.2	2005-01-02 - 2005-01-08	csco	0	0	0
-0.2	2005-01-02 - 2005-01-08	xom	0	0	0
-0.2	2005-01-02 - 2005-01-08	axp	10	0.2702702703	0.0538796574
-0.2	2005-01-02 - 2005-01-08	mrk	18	0.4864864865	0.0606009352
-0.2	2005-01-09 - 2005-01-15	hpq	0	0	0
-0.2	2005-01-09 - 2005-01-15	ibm	99	99	0.1742446978
-0.2	2005-01-09 - 2005-01-15	ge	38	38	0.1438762971
-0.2	2005-01-09 - 2005-01-15	csco	0	0	0
-0.2	2005-01-09 - 2005-01-15	xom	0	0	0
-0.2	2005-01-09 - 2005-01-15	axp	13	0.3513513514	0.0563872427
-0.2	2005-01-09 - 2005-01-15	mrk	16	0.4324324324	0.0587781868
-0.2	2005-01-16 - 2005-01-22	hpq	0	0	0
-0.2	2005-01-16 - 2005-01-22	ibm	100	100	0.1763225753
-0.2	2005-01-16 - 2005-01-22	ge	39	39	0.1460564841
-0.2	2005-01-16 - 2005-01-22	csco	0	0	0
-0.2	2005-01-16 - 2005-01-22	xom	0	0	0
-0.2	2005-01-16 - 2005-01-22	axp	12	0.3243243243	0.0560407353
-0.2	2005-01-16 - 2005-01-22	mrk	14	0.3783783784	0.0577953879
-0.2	2005-01-23 - 2005-01-29	hpq	0	0	0
-0.2	2005-01-23 - 2005-01-29	ibm	100	100	0.172706871
-0.2	2005-01-23 - 2005-01-29	ge	38	38	0.1423201311
-0.2	2005-01-23 - 2005-01-29	csco	0	0	0
-0.2	2005-01-23 - 2005-01-29	xom	0	0	0
-0.2	2005-01-23 - 2005-01-29	axp	13	0.3513513514	0.0557773583
-0.2	2005-01-23 - 2005-01-29	mrk	20	0.5405405405	0.0607960369
-0.2	2005-01-30 - 2005-02-05	hpq	0	0	0
-0.2	2005-01-30 - 2005-02-05	ibm	99	99	0.1746029327
-0.2	2005-01-30 - 2005-02-05	ge	37	37	0.1434051803
-0.2	2005-01-30 - 2005-02-05	csco	0	0	0
-0.2	2005-01-30 - 2005-02-05	xom	0	0	0
-0.2	2005-01-30 - 2005-02-05	axp	15	0.4054054054	0.0581436648
-0.2	2005-01-30 - 2005-02-05	mrk	17	0.4594594595	0.0596175239

Table 1

As we can see in the table above, for $\alpha < 0$ highest search volumes weight more. what corresponds to very few companies, the rest weighting to 0. This obviously decreases the risk on the overall portfolio. For $\alpha > 0$, it is exactly the contrary. Lowest search volume weight more as we can confirm in the table below.

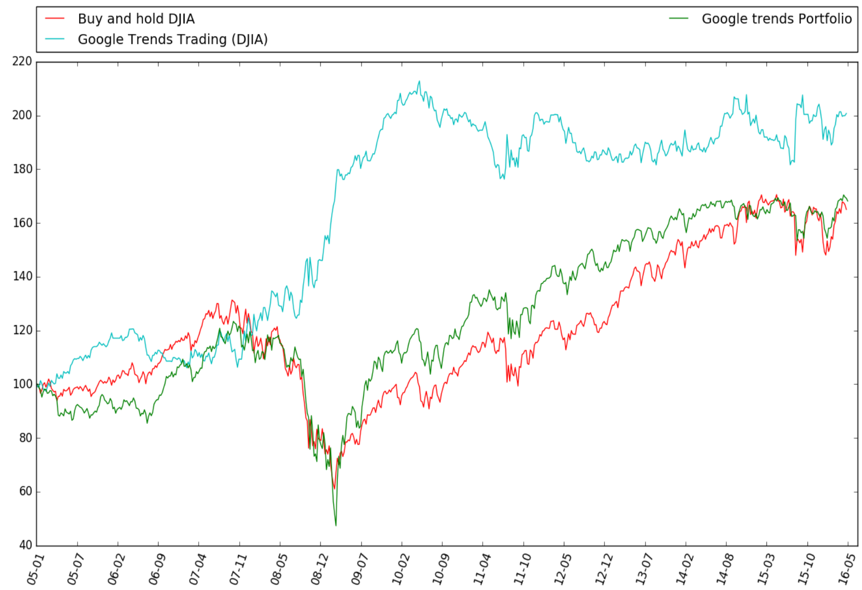
Relation weights,search Volumes					
alpha	**date**	**tick**	**relative volume**	**rescaled volume**	**weight**
0.1	2005-01-02 - 2005-01-08	hpq	0	0	0.3318800732
0.1	2005-01-02 - 2005-01-08	ibm	95	95	0.000210479
0.1	2005-01-02 - 2005-01-08	ge	38	38	0.0002306762
0.1	2005-01-02 - 2005-01-08	csco	0	0	0.3318800732
0.1	2005-01-02 - 2005-01-08	xom	0	0	0.3318800732
0.1	2005-01-02 - 2005-01-08	axp	10	0.2702702703	0.0003782695
0.1	2005-01-02 - 2005-01-08	mrk	18	0.4864864865	0.0003566762
0.1	2005-01-09 - 2005-01-15	hpq	0	0	0.331887146
0.1	2005-01-09 - 2005-01-15	ibm	99	99	0.0002096172
0.1	2005-01-09 - 2005-01-15	ge	38	38	0.0002306811
0.1	2005-01-09 - 2005-01-15	csco	0	0	0.331887146
0.1	2005-01-09 - 2005-01-15	xom	0	0	0.331887146
0.1	2005-01-09 - 2005-01-15	axp	13	0.3513513514	0.000368482
0.1	2005-01-09 - 2005-01-15	mrk	16	0.4324324324	0.0003609097
0.1	2005-01-16 - 2005-01-22	hpq	0	0	0.3318753854
0.1	2005-01-16 - 2005-01-22	ibm	100	100	0.0002093992
0.1	2005-01-16 - 2005-01-22	ge	39	39	0.0002300746
0.1	2005-01-16 - 2005-01-22	csco	0	0	0.3318753854
0.1	2005-01-16 - 2005-01-22	xom	0	0	0.3318753854
0.1	2005-01-16 - 2005-01-22	axp	12	0.3243243243	0.0003714301
0.1	2005-01-16 - 2005-01-22	mrk	14	0.3783783784	0.0003657484
0.1	2005-01-23 - 2005-01-29	hpq	0	0	0.3318990339
0.1	2005-01-23 - 2005-01-29	ibm	100	100	0.0002094141
0.1	2005-01-23 - 2005-01-29	ge	38	38	0.0002306894
0.1	2005-01-23 - 2005-01-29	csco	0	0	0.3318990339
0.1	2005-01-23 - 2005-01-29	xom	0	0	0.3318990339
0.1	2005-01-23 - 2005-01-29	axp	13	0.3513513514	0.0003684952
0.1	2005-01-23 - 2005-01-29	mrk	20	0.5405405405	0.0003529581
0.1	2005-01-30 - 2005-02-05	hpq	0	0	0.3318866681
0.1	2005-01-30 - 2005-02-05	ibm	99	99	0.0002096169
0.1	2005-01-30 - 2005-02-05	ge	37	37	0.0002312968
0.1	2005-01-30 - 2005-02-05	csco	0	0	0.3318866681
0.1	2005-01-30 - 2005-02-05	xom	0	0	0.3318866681
0.1	2005-01-30 - 2005-02-05	axp	15	0.4054054054	0.000363246
0.1	2005-01-30 - 2005-02-05	mrk	17	0.4594594595	0.0003587278
0.2	2005-01-02 - 2005-01-08	hpq	0	0	0.331825222
0.2	2005-01-02 - 2005-01-08	ibm	95	95	0.0001334642
0.2	2005-01-02 - 2005-01-08	ge	38	38	0.0001603071
0.2	2005-01-02 - 2005-01-08	csco	0	0	0.331825222
0.2	2005-01-02 - 2005-01-08	xom	0	0	0.331825222
0.2	2005-01-02 - 2005-01-08	axp	10	0.2702702703	0.0004310719
0.2	2005-01-02 - 2005-01-08	mrk	18	0.4864864865	0.0003832615
0.2	2005-01-09 - 2005-01-15	hpq	0	0	0.3318415103
0.2	2005-01-09 - 2005-01-15	ibm	99	99	0.0001323743
0.2	2005-01-09 - 2005-01-15	ge	38	38	0.0001603149
0.2	2005-01-09 - 2005-01-15	csco	0	0	0.3318415103
0.2	2005-01-09 - 2005-01-15	xom	0	0	0.3318415103

0.2	2005-01-09 - 2005-01-15	axp	13	0.3513513514	0.0004090556
0.2	2005-01-09 - 2005-01-15	mrk	16	0.4324324324	0.0003924163
0.2	2005-01-16 - 2005-01-22	hpq	0	0	0.3318151958
0.2	2005-01-16 - 2005-01-22	ibm	100	100	0.000132098
0.2	2005-01-16 - 2005-01-22	ge	39	39	0.0001594716
0.2	2005-01-16 - 2005-01-22	csco	0	0	0.3318151958
0.2	2005-01-16 - 2005-01-22	xom	0	0	0.3318151958
0.2	2005-01-16 - 2005-01-22	axp	12	0.3243243243	0.0004156238
0.2	2005-01-16 - 2005-01-22	mrk	14	0.3783783784	0.0004030055
0.2	2005-01-23 - 2005-01-29	hpq	0	0	0.3318682243
0.2	2005-01-23 - 2005-01-29	ibm	100	100	0.0001321191
0.2	2005-01-23 - 2005-01-29	ge	38	38	0.0001603278
0.2	2005-01-23 - 2005-01-29	csco	0	0	0.3318682243
0.2	2005-01-23 - 2005-01-29	xom	0	0	0.3318682243
0.2	2005-01-23 - 2005-01-29	axp	13	0.3513513514	0.0004090886
0.2	2005-01-23 - 2005-01-29	mrk	20	0.5405405405	0.0003753185
0.2	2005-01-30 - 2005-02-05	hpq	0	0	0.3318411699
0.2	2005-01-30 - 2005-02-05	ibm	99	99	0.0001323742
0.2	2005-01-30 - 2005-02-05	ge	37	37	0.0001611721
0.2	2005-01-30 - 2005-02-05	csco	0	0	0.3318411699
0.2	2005-01-30 - 2005-02-05	xom	0	0	0.3318411699
0.2	2005-01-30 - 2005-02-05	axp	15	0.4054054054	0.0003975139
0.2	2005-01-30 - 2005-02-05	mrk	17	0.4594594595	0.0003876866

Table 2

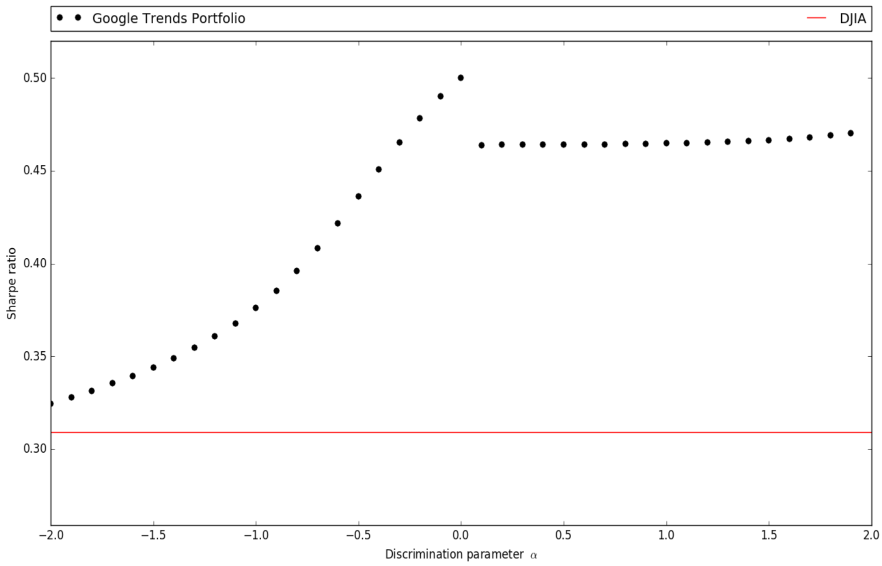
As we can see, tick symbols with 0 search volumes have the highest weights. Applying normally the weight formula would trigger a division by 0. The value $V^{-\alpha}$ would be infinite. Instead of this, we give it the value 1000 and we normalize. We can see that the three values "hpq", "csco" and "xom" almost have each 1/3 of the total weight.

10.2.3 First Set: Evolution Of Portfolio Value



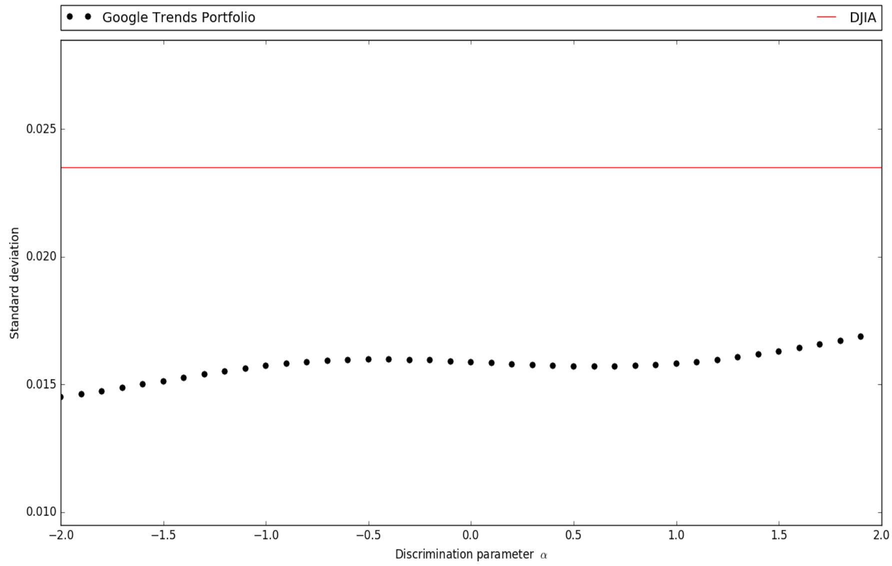
The returns pictured here for the Google trends Portfolio corresponds to the α that maximizes the Sharpe ratio. Before 2007 crisis, all the methods were very close in terms of returns. But the crisis of 2007 definitely opened a gap between them. The Google trading strategy definitely took the lead of the ranking from the beginning of the crisis to the end. But its advantage is being narrowed with time mainly from the beginning of the recovery of the crisis in 2012. Also, all the methods suffer a loss of return on investment at the heart of 2008 crisis except the Google trading strategy that shows an important increase of returns in that period. We can also see on that picture that the Google trends Portfolio returns are very erratic compare to the Buy and hold as was suggesting the standard deviations calculated above.

10.2.4 First Set: Sharpe Ratio



The Google trends Portfolio has the best Sharpe ratio of both for any value of α. The maximum of Sharpe Ratio is reached for $\alpha = 0$ what corresponds to the uniform portfolio and the peak value (0.5) remains far high compared to the DJIA (0.3). The Sharpe ratio increases between $\alpha = -2$ qnd $\alpha = 0$, this is mainly explained by the fact that the standard deviation is decreasing over the same interval. But later, the standard deviation stagnates as well as the Sharpe ratio. With equal returns, a greater Sharpe Ratio means a better investment as it implies lower variance.

10.2.5 Second set: Standard Deviation



The Google trends Portfolio gets the best standard deviation of both. This can be seen in the portfolio returns on the following figure. Indeed, the Google trends has the most hysteric graph while the mean variance graph is more flat and this of the DJIA is smoother than the others. In addition The Google Trends Portfolio is the less risky investment what actually means that the expected value remains stable along time. But as we seen before this is not a criteria to choose an investment. The Google Trends portfolio would be the best if the Return ws better. What we will check in the following figure. The standard deviation for the Google portfolio is minimum for $\alpha = 0.4$. We see that the values are globally lower what is partially explained by the fact that there is no much economical shock in the period, what would have disrupted the return series. We put here below the table of weights as a matter of comparison with the former procedure.

Relation weights,search Volumes					
alpha	**date**	**tick**	**relative volume**	**rescaled volume**	**weight**
-0.3	2009-01-04 - 2009-01-10	hpq	1	1	0.0346595604
-0.3	2009-01-04 - 2009-01-10	ge	23	23	0.0887853683
-0.3	2009-01-04 - 2009-01-10	ibm	9	9	0.0670032398
-0.3	2009-01-04 - 2009-01-10	aa	3	3	0.0481902774
-0.3	2009-01-04 - 2009-01-10	t	6	6	0.0593291908
-0.3	2009-01-04 - 2009-01-10	ba	4	0.8	0.0324153
-0.3	2009-01-04 - 2009-01-10	bac	18	3.6	0.0508995333
-0.3	2009-01-11 - 2009-01-17	hpq	1	1	0.0343718189
-0.3	2009-01-11 - 2009-01-17	ge	26	26	0.0913470485
-0.3	2009-01-11 - 2009-01-17	ibm	8	8	0.0641400821
-0.3	2009-01-11 - 2009-01-17	aa	2	2	0.0423166729
-0.3	2009-01-11 - 2009-01-17	t	5	5	0.0557049151
-0.3	2009-01-11 - 2009-01-17	ba	6	1.2	0.0363042015
-0.3	2009-01-11 - 2009-01-17	bac	34	6.8	0.0610878991
-0.3	2009-01-18 - 2009-01-24	hpq	1	1	0.0344142875
-0.3	2009-01-18 - 2009-01-24	ge	30	30	0.0954718106
-0.3	2009-01-18 - 2009-01-24	ibm	13	13	0.074288534
-0.3	2009-01-18 - 2009-01-24	aa	2	2	0.0423689578

-0.3	2009-01-18 - 2009-01-24	t	6	6	0.0589093401
-0.3	2009-01-18 - 2009-01-24	ba	5	1	0.0344142875
-0.3	2009-01-18 - 2009-01-24	bac	48	9.6	0.06782974
-0.3	2009-01-25 - 2009-01-31	hpq	1	1	0.0334603059
-0.3	2009-01-25 - 2009-01-31	ge	32	32	0.0946400369
-0.3	2009-01-25 - 2009-01-31	ibm	10	10	0.0667620875
-0.3	2009-01-25 - 2009-01-31	aa	2	2	0.0411944687
-0.3	2009-01-25 - 2009-01-31	t	6	6	0.0572763432
-0.3	2009-01-25 - 2009-01-31	ba	4	0.8	0.0312936992
-0.3	2009-01-25 - 2009-01-31	bac	42	8.4	0.0633597847
-0.3	2009-02-01 - 2009-02-07	hpq	1	1	0.0340558908
-0.3	2009-02-01 - 2009-02-07	ge	33	33	0.0972179427
-0.3	2009-02-01 - 2009-02-07	ibm	10	10	0.0679504355
-0.3	2009-02-01 - 2009-02-07	aa	2	2	0.0419277197
-0.3	2009-02-01 - 2009-02-07	t	6	6	0.0582958474
-0.3	2009-02-01 - 2009-02-07	ba	4	0.8	0.031850719
-0.3	2009-02-01 - 2009-02-07	bac	54	10.8	0.0695375477
-0.2	2009-01-04 - 2009-01-10	hpq	1	1	0.037228438
-0.2	2009-01-04 - 2009-01-10	ge	23	23	0.0696980106
-0.2	2009-01-04 - 2009-01-10	ibm	9	9	0.0577727868
-0.2	2009-01-04 - 2009-01-10	aa	3	3	0.0463766171
-0.2	2009-01-04 - 2009-01-10	t	6	6	0.0532727438
-0.2	2009-01-04 - 2009-01-10	ba	4	0.8	0.0356035098
-0.2	2009-01-04 - 2009-01-10	bac	18	3.6	0.0480989189
-0.2	2009-01-11 - 2009-01-17	hpq	1	1	0.0370457708
-0.2	2009-01-11 - 2009-01-17	ge	26	26	0.07107769
-0.2	2009-01-11 - 2009-01-17	ibm	8	8	0.0561508885
-0.2	2009-01-11 - 2009-01-17	aa	2	2	0.042554416
-0.2	2009-01-11 - 2009-01-17	t	5	5	0.0511131488
-0.2	2009-01-11 - 2009-01-17	ba	6	1.2	0.0384215503
-0.2	2009-01-11 - 2009-01-17	bac	34	6.8	0.0543551149
-0.2	2009-01-18 - 2009-01-24	hpq	1	1	0.0372221959
-0.2	2009-01-18 - 2009-01-24	ge	30	30	0.0734896606
-0.2	2009-01-18 - 2009-01-24	ibm	13	13	0.062171402
-0.2	2009-01-18 - 2009-01-24	aa	2	2	0.0427570752
-0.2	2009-01-18 - 2009-01-24	t	6	6	0.0532638115
-0.2	2009-01-18 - 2009-01-24	ba	5	1	0.0372221959
-0.2	2009-01-18 - 2009-01-24	bac	48	9.6	0.0585135217
-0.2	2009-01-25 - 2009-01-31	hpq	1	1	0.0364344468
-0.2	2009-01-25 - 2009-01-31	ge	32	32	0.0728688935
-0.2	2009-01-25 - 2009-01-31	ibm	10	10	0.0577447066
-0.2	2009-01-25 - 2009-01-31	aa	2	2	0.041852189
-0.2	2009-01-25 - 2009-01-31	t	6	6	0.0521365668
-0.2	2009-01-25 - 2009-01-31	ba	4	0.8	0.0348441742
-0.2	2009-01-25 - 2009-01-31	bac	42	8.4	0.0557658128
-0.2	2009-02-01 - 2009-02-07	hpq	1	1	0.0369249388
-0.2	2009-02-01 - 2009-02-07	ge	33	33	0.0743057757
-0.2	2009-02-01 - 2009-02-07	ibm	10	10	0.0585220842
-0.2	2009-02-01 - 2009-02-07	aa	2	2	0.0424156165
-0.2	2009-02-01 - 2009-02-07	t	6	6	0.0528384458
-0.2	2009-02-01 - 2009-02-07	ba	4	0.8	0.0353132575
-0.2	2009-02-01 - 2009-02-07	bac	54	10.8	0.0594298365

Table 3

Relation weights,search Volumes					
alpha	**date**	**tick**	**relative volume**	**rescaled volume**	**weight**
0.1	2009-01-04 - 2009-01-10	hpq	1	1	0.0434995091
0.1	2009-01-04 - 2009-01-10	ge	23	23	0.0317915405
0.1	2009-01-04 - 2009-01-10	ibm	9	9	0.0349188639
0.1	2009-01-04 - 2009-01-10	aa	3	3	0.0389737532
0.1	2009-01-04 - 2009-01-10	t	6	6	0.0363637975
0.1	2009-01-04 - 2009-01-10	ba	4	0.8	0.0444810835
0.1	2009-01-04 - 2009-01-10	bac	18	3.6	0.0382696161
0.1	2009-01-11 - 2009-01-17	hpq	1	1	0.0435642519
0.1	2009-01-11 - 2009-01-17	ge	26	26	0.031450889
0.1	2009-01-11 - 2009-01-17	ibm	8	8	0.035385168
0.1	2009-01-11 - 2009-01-17	aa	2	2	0.0406468842
0.1	2009-01-11 - 2009-01-17	t	5	5	0.0370879868
0.1	2009-01-11 - 2009-01-17	ba	6	1.2	0.0427771785
0.1	2009-01-11 - 2009-01-17	bac	34	6.8	0.0359649424
0.1	2009-01-18 - 2009-01-24	hpq	1	1	0.0432487425
0.1	2009-01-18 - 2009-01-24	ge	30	30	0.0307794857
0.1	2009-01-18 - 2009-01-24	ibm	13	13	0.0334641
0.1	2009-01-18 - 2009-01-24	aa	2	2	0.0403525036
0.1	2009-01-18 - 2009-01-24	t	6	6	0.0361541669
0.1	2009-01-18 - 2009-01-24	ba	5	1	0.0432487425
0.1	2009-01-18 - 2009-01-24	bac	48	9.6	0.0344942225
0.1	2009-01-25 - 2009-01-31	hpq	1	1	0.0438765269
0.1	2009-01-25 - 2009-01-31	ge	32	32	0.0310253897
0.1	2009-01-25 - 2009-01-31	ibm	10	10	0.0348523642
0.1	2009-01-25 - 2009-01-31	aa	2	2	0.0409382471
0.1	2009-01-25 - 2009-01-31	t	6	6	0.0366789689
0.1	2009-01-25 - 2009-01-31	ba	4	0.8	0.0448666087
0.1	2009-01-25 - 2009-01-31	bac	42	8.4	0.0354653552
0.1	2009-02-01 - 2009-02-07	hpq	1	1	0.0434913797
0.1	2009-02-01 - 2009-02-07	ge	33	33	0.0306585627
0.1	2009-02-01 - 2009-02-07	ibm	10	10	0.0345464308
0.1	2009-02-01 - 2009-02-07	aa	2	2	0.0405788921
0.1	2009-02-01 - 2009-02-07	t	6	6	0.0363570016
0.1	2009-02-01 - 2009-02-07	ba	4	0.8	0.0444727706
0.1	2009-02-01 - 2009-02-07	bac	54	10.8	0.0342815784
0.2	2009-01-04 - 2009-01-10	hpq	1	1	0.0450665062
0.2	2009-01-04 - 2009-01-10	ge	23	23	0.0240717865
0.2	2009-01-04 - 2009-01-10	ibm	9	9	0.0290405868
0.2	2009-01-04 - 2009-01-10	aa	3	3	0.0361767575
0.2	2009-01-04 - 2009-01-10	t	6	6	0.0314936967
0.2	2009-01-04 - 2009-01-10	ba	4	0.8	0.0471233213
0.2	2009-01-04 - 2009-01-10	bac	18	3.6	0.0348813584
0.2	2009-01-11 - 2009-01-17	hpq	1	1	0.0451686322
0.2	2009-01-11 - 2009-01-17	ge	26	26	0.0235419411
0.2	2009-01-11 - 2009-01-17	ibm	8	8	0.0298001837
0.2	2009-01-11 - 2009-01-17	aa	2	2	0.0393215782
0.2	2009-01-11 - 2009-01-17	t	5	5	0.032737306
0.2	2009-01-11 - 2009-01-17	ba	6	1.2	0.0435512565

0.2	2009-01-11 - 2009-01-17	bac	34	6.8	0.0307847164
0.2	2009-01-18 - 2009-01-24	hpq	1	1	0.04440473
0.2	2009-01-18 - 2009-01-24	ge	30	30	0.0224908041
0.2	2009-01-18 - 2009-01-24	ibm	13	13	0.0265852387
0.2	2009-01-18 - 2009-01-24	aa	2	2	0.0386565627
0.2	2009-01-18 - 2009-01-24	t	6	6	0.0310312295
0.2	2009-01-18 - 2009-01-24	ba	5	1	0.04440473
0.2	2009-01-18 - 2009-01-24	bac	48	9.6	0.0282471728
0.2	2009-01-25 - 2009-01-31	hpq	1	1	0.0458052752
0.2	2009-01-25 - 2009-01-31	ge	32	32	0.0229026376
0.2	2009-01-25 - 2009-01-31	ibm	10	10	0.0289011748
0.2	2009-01-25 - 2009-01-31	aa	2	2	0.0398758081
0.2	2009-01-25 - 2009-01-31	t	6	6	0.0320099685
0.2	2009-01-25 - 2009-01-31	ba	4	0.8	0.0478958075
0.2	2009-01-25 - 2009-01-31	bac	42	8.4	0.0299267558
0.2	2009-02-01 - 2009-02-07	hpq	1	1	0.0449473224
0.2	2009-02-01 - 2009-02-07	ge	33	33	0.0223357756
0.2	2009-02-01 - 2009-02-07	ibm	10	10	0.0283598432
0.2	2009-02-01 - 2009-02-07	aa	2	2	0.0391289168
0.2	2009-02-01 - 2009-02-07	t	6	6	0.0314104078
0.2	2009-02-01 - 2009-02-07	ba	4	0.8	0.0469986981
0.2	2009-02-01 - 2009-02-07	bac	54	10.8	0.0279266649

Table 4

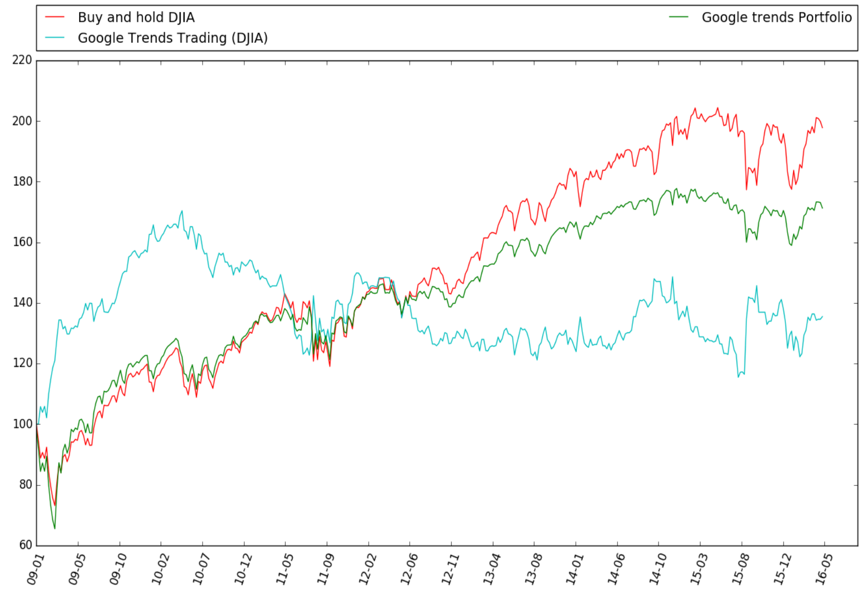
Relation weights,search Volumes					
alpha	**date**	**tick**	**relative volume**	**rescaled volume**	**weight**
1.2	2009-01-04 - 2009-01-10	hpq	1	1	0.048412038
1.2	2009-01-04 - 2009-01-10	ge	23	23	0.0011242942
1.2	2009-01-04 - 2009-01-10	ibm	9	9	0.0034662697
1.2	2009-01-04 - 2009-01-10	aa	3	3	0.0129541183
1.2	2009-01-04 - 2009-01-10	t	6	6	0.0056386075
1.2	2009-01-04 - 2009-01-10	ba	4	0.8	0.0632769272
1.2	2009-01-04 - 2009-01-10	bac	18	3.6	0.0104085532
1.2	2009-01-11 - 2009-01-17	hpq	1	1	0.0457410208
1.2	2009-01-11 - 2009-01-17	ge	26	26	0.0009169335
1.2	2009-01-11 - 2009-01-17	ibm	8	8	0.0037722274
1.2	2009-01-11 - 2009-01-17	aa	2	2	0.0199099357
1.2	2009-01-11 - 2009-01-17	t	5	5	0.0066304323
1.2	2009-01-11 - 2009-01-17	ba	6	1.2	0.0367526245
1.2	2009-01-11 - 2009-01-17	bac	34	6.8	0.0045845336
1.2	2009-01-18 - 2009-01-24	hpq	1	1	0.039328399
1.2	2009-01-18 - 2009-01-24	ge	30	30	0.0006639888
1.2	2009-01-18 - 2009-01-24	ibm	13	13	0.0018112327
1.2	2009-01-18 - 2009-01-24	aa	2	2	0.01711868
1.2	2009-01-18 - 2009-01-24	t	6	6	0.0045806253
1.2	2009-01-18 - 2009-01-24	ba	5	1	0.039328399
1.2	2009-01-18 - 2009-01-24	bac	48	9.6	0.0026060383
1.2	2009-01-25 - 2009-01-31	hpq	1	1	0.0522422872
1.2	2009-01-25 - 2009-01-31	ge	32	32	0.0008162857
1.2	2009-01-25 - 2009-01-31	ibm	10	10	0.0032962655

1.2	2009-01-25 - 2009-01-31	aa	2	2	0.0227397763
1.2	2009-01-25 - 2009-01-31	t	6	6	0.0060847212
1.2	2009-01-25 - 2009-01-31	ba	4	0.8	0.0682832523
1.2	2009-01-25 - 2009-01-31	bac	42	8.4	0.0040633763
1.2	2009-02-01 - 2009-02-07	hpq	1	1	0.0430492794
1.2	2009-02-01 - 2009-02-07	ge	33	33	0.0006482599
1.2	2009-02-01 - 2009-02-07	ibm	10	10	0.0027162259
1.2	2009-02-01 - 2009-02-07	aa	2	2	0.0187382872
1.2	2009-02-01 - 2009-02-07	t	6	6	0.0050140007
1.2	2009-02-01 - 2009-02-07	ba	4	0.8	0.0562675366
1.2	2009-02-01 - 2009-02-07	bac	54	10.8	0.0024766086
1.3	2009-01-04 - 2009-01-10	hpq	1	1	0.0478519827
1.3	2009-01-04 - 2009-01-10	ge	23	23	0.0008121827
1.3	2009-01-04 - 2009-01-10	ibm	9	9	0.0027503292
1.3	2009-01-04 - 2009-01-10	aa	3	3	0.0114720837
1.3	2009-01-04 - 2009-01-10	t	6	6	0.0046591137
1.3	2009-01-04 - 2009-01-10	ba	4	0.8	0.0639562444
1.3	2009-01-04 - 2009-01-10	bac	18	3.6	0.0090512109
1.3	2009-01-11 - 2009-01-17	hpq	1	1	0.0444904529
1.3	2009-01-11 - 2009-01-17	ge	26	26	0.0006438749
1.3	2009-01-11 - 2009-01-17	ibm	8	8	0.0029802304
1.3	2009-01-11 - 2009-01-17	aa	2	2	0.0180687385
1.3	2009-01-11 - 2009-01-17	t	5	5	0.0054904232
1.3	2009-01-11 - 2009-01-17	ba	6	1.2	0.0351019471
1.3	2009-01-11 - 2009-01-17	bac	34	6.8	0.0036813342
1.3	2009-01-18 - 2009-01-24	hpq	1	1	0.0378919991
1.3	2009-01-18 - 2009-01-24	ge	30	30	0.0004552919
1.3	2009-01-18 - 2009-01-24	ibm	13	13	0.0013502717
1.3	2009-01-18 - 2009-01-24	aa	2	2	0.0153889335
1.3	2009-01-18 - 2009-01-24	t	6	6	0.0036893588
1.3	2009-01-18 - 2009-01-24	ba	5	1	0.0378919991
1.3	2009-01-18 - 2009-01-24	bac	48	9.6	0.0020026032
1.3	2009-01-25 - 2009-01-31	hpq	1	1	0.0519445793
1.3	2009-01-25 - 2009-01-31	ge	32	32	0.0005739119
1.3	2009-01-25 - 2009-01-31	ibm	10	10	0.002603396
1.3	2009-01-25 - 2009-01-31	aa	2	2	0.0210960545
1.3	2009-01-25 - 2009-01-31	t	6	6	0.0050575899
1.3	2009-01-25 - 2009-01-31	ba	4	0.8	0.0694261768
1.3	2009-01-25 - 2009-01-31	bac	42	8.4	0.0032657066
1.3	2009-02-01 - 2009-02-07	hpq	1	1	0.0416708466
1.3	2009-02-01 - 2009-02-07	ge	33	33	0.0004423481
1.3	2009-02-01 - 2009-02-07	ibm	10	10	0.0020884896
1.3	2009-02-01 - 2009-02-07	aa	2	2	0.0169236225
1.3	2009-02-01 - 2009-02-07	t	6	6	0.0040572867
1.3	2009-02-01 - 2009-02-07	ba	4	0.8	0.0556948887
1.3	2009-02-01 - 2009-02-07	bac	54	10.8	0.0018896503

Table 5

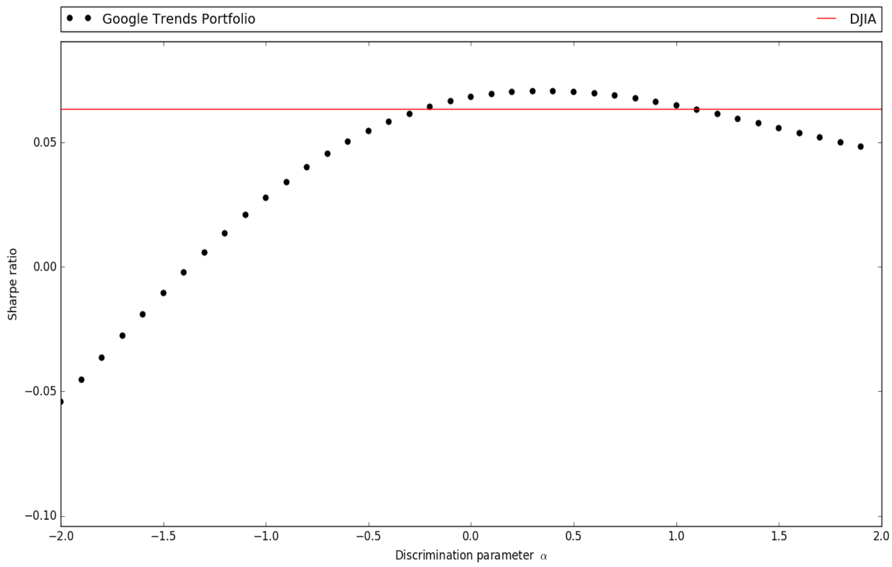
We can see that for that category of keywords ("stock" + tick), there is no such 0 search volume, so the calculation is direct and exact. For $0 < \alpha < 1$, lower search volumes weight more. for $\alpha < -1$ the difference of weights is stressed with the difference of search volume, having greater weight, the asset with higher search volume for $\alpha > 1$, the remark worths but in the opposite sense.

10.2.6 Second set: Evolution Of Portfolio Value



The Google portfolio strategy is outpassed by the DJIA after crisis recovery. We see that The Google Trends strategies underperform as long as we get out of the crisis. Those strategies become clearly unresponsive for a recovered economy. Possibly, the keywords no longer have the same sense for the users as it was during the crisis. Probably those keywords are under used both in terms of meaning and intensity and probably that should bother the original sense of those strategies what we will confirm in the performance assessment in next sections.

10.2.7 Second set: Sharpe Ratio



The Google trends is clearly the best investment for α between -0.5 and 1. The maximum of Sharpe ratio is reached for $\alpha = 0.4$. As the standard deviation has almost remained constant along values of α, we can say that the expected return was going increasingly with α varying between -2 and 0.4 as the Sharpe ratio has been increasing in that range of α values.

The Google Trends portfolio method is rather worst for values of α out of the above mentioned range.

10.3 Results With Transaction Costs

In that section, we add the transaction fees. We top them at about 1.5% of the transactions values including account management fees. This should be seen as a good estimation for an average trading account regarding the brokering fees suggested by the picture below.

Online Trading

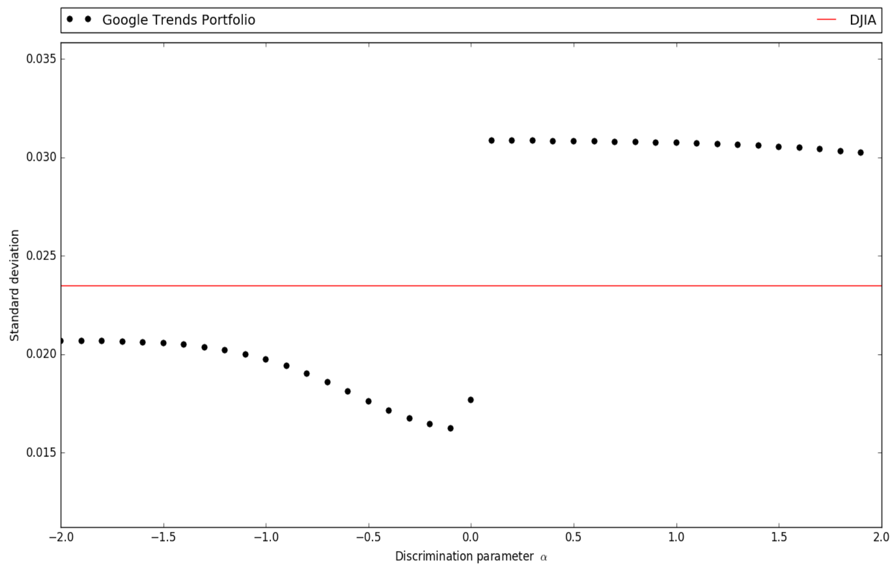
	Gold	Platinum
Stocks An additional \$0.01 per share and \$0.005 is charged for each share over 1,000 for Gold and Platinum, respectively. Certain Exchange Traded Funds may be traded without commissions.	\$8.95	\$5.95
Foreign Stock Trade Service Additional charge for purchase or sale of foreign securities. Does not apply to American Depositary Receipts (ADRs). A Foreign Financial Transaction Tax (FTT) may also apply to transactions in some foreign securities.	\$70	\$70
Options[1]	\$8.95 + \$0.75 per contract	\$5.95 + \$0.75 per contract

All options subject to:

- Options trades subject to \$25 minimum commission on representative assisted option trades.
- Commission rates are calculated with a 5% maximum charge of the trade's principal value subject to the minimum commission in the account's channel and tier.
- Option commission applies only to option contract trades. When a contract is exercised or assigned and the underlying security is bought or sold, the Internet commission rate applies to the trade, based on your current commission level.
- For options orders, an options regulatory fee will apply (depending on what exchange the order executed on).

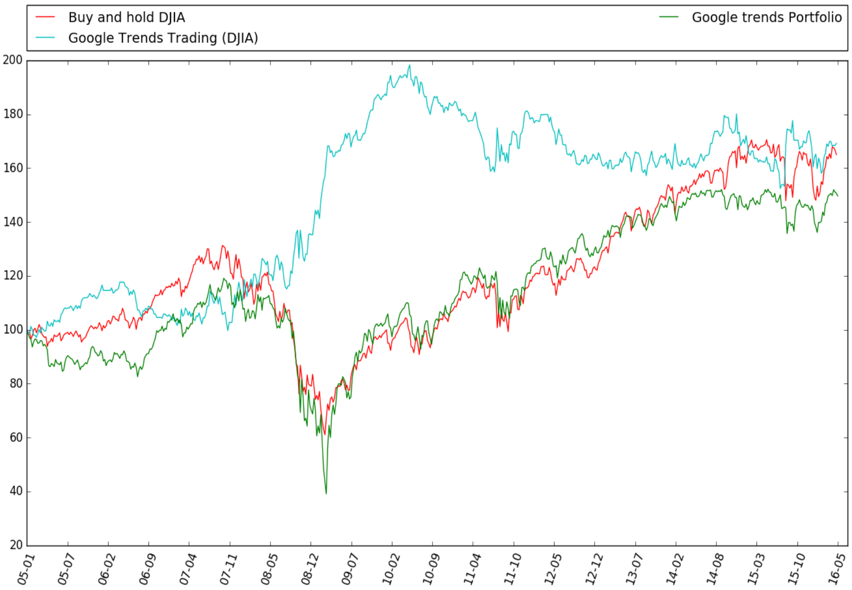
A typical transaction fees for online trading

10.3.1 First set: Standard Deviation



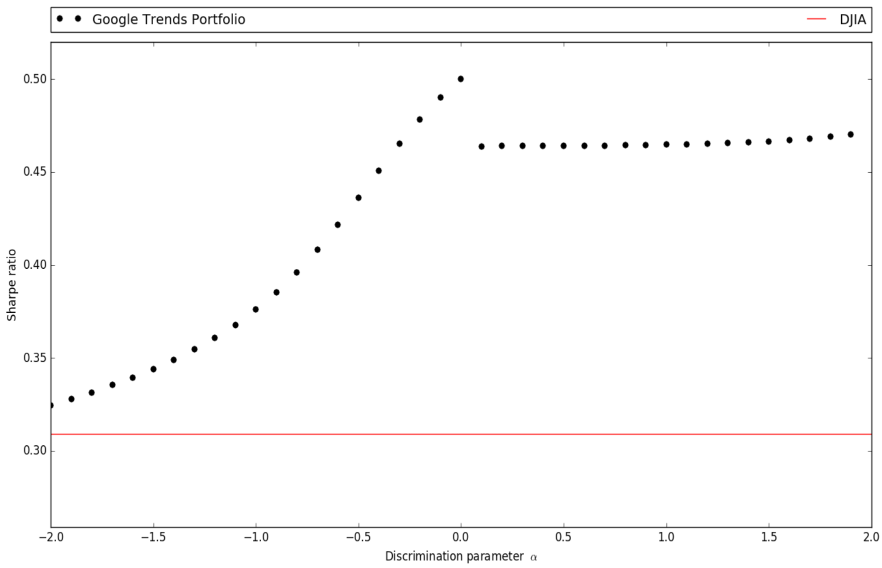
The values of the standard deviation do not change when adding the transaction fees. The standard deviation is the total error around the mean value. For sure the mean value changed, but not the error as we take the same percentage of transaction fees along the weeks. The choice of the brokerage company and its offer formula does not affect the risk of our portfolio. In the contrary, it affects the returns as we will see later.

10.3.2 First set: Evolution Of Portfolio Value



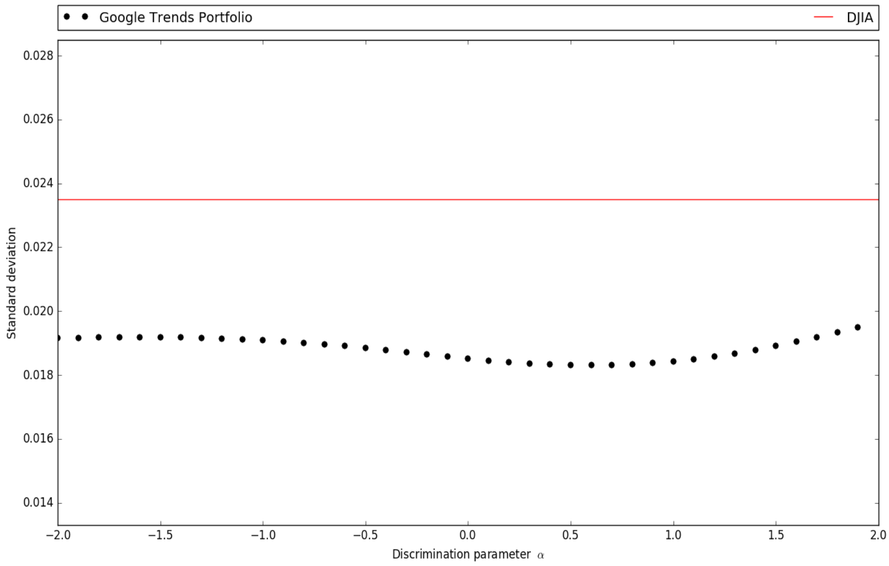
The return on investment are all lowered except this of the Buy and hold strategy which remain unchanged. Actually, we trade no share for this strategy after the first buy.

10.3.3 First set: Sharpe Ratio



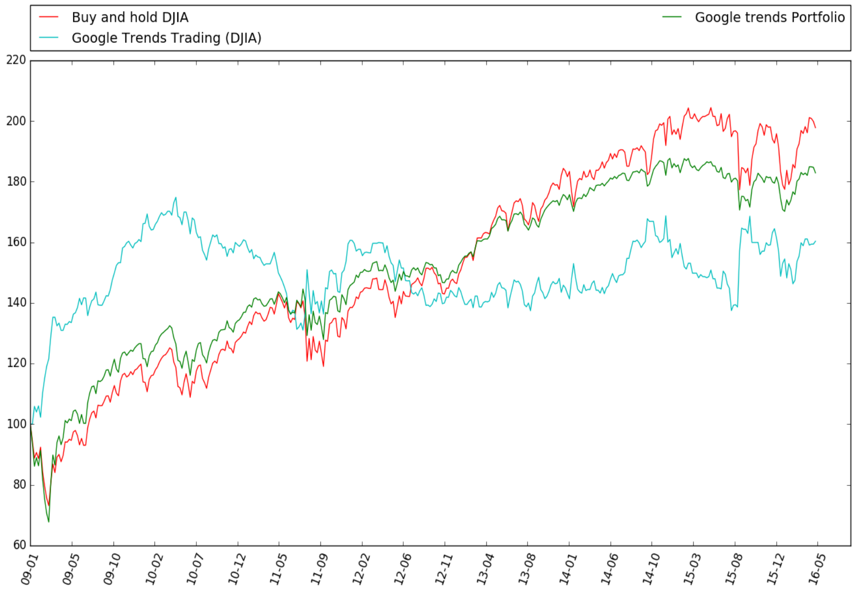
The Sharpe ratio values remain unchanged. Probably the mean returns did not change enough due to very low transaction fees. Indeed, for portfolio construction it occurs very low amount of transactions along trading weeks due to little change on the market.

10.3.4 Second set: Standard Deviation



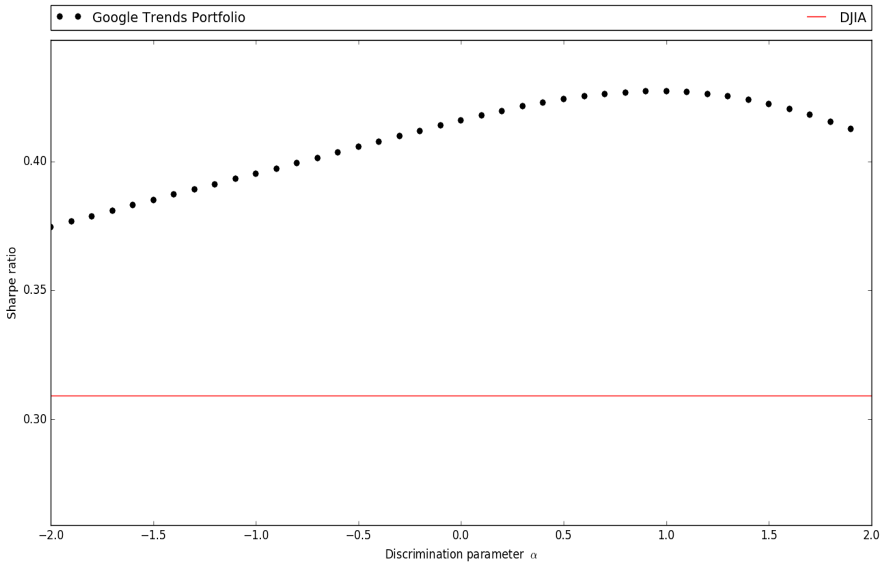
This section also worths the remarks made in the previous one as the only changing parameters are the period and the stocks.

10.3.5 Second set: Evolution Of Portfolio Value



This picture shows the relative worsening of the Google Trends trading and Google Trends Portfolio strategies compared to the DJIA for reasons already specified. We can see when including the transaction fees that the Google Trading lowers much the returns.

10.3.6 Second set: Sharpe Ratio



As for the standard deviation, Sharpe ratios remain unchanged.

10.4 Relation Weights, Search Volumes

The following table shows an extract of the weights for a given shape, keyword and volume for only 7 keywords and for the 10 first trading periods. It also shows the rescaled volume associated.

Relation weights,search Volumes					
alpha	**date**	**tick**	**relative volume**	**rescaled volume**	**weight**
0.3	2009-01-04 - 2009-01-10	hpq	1	1	0.0463706879
0.3	2009-01-04 - 2009-01-10	ge	23	23	0.0181019428
0.3	2009-01-04 - 2009-01-10	ibm	9	9	0.0239867156
0.3	2009-01-04 - 2009-01-10	aa	3	3	0.0333508696
0.3	2009-01-04 - 2009-01-10	t	6	6	0.0270893238
0.3	2009-01-04 - 2009-01-10	ba	4	0.8	0.0495811439
0.3	2009-01-04 - 2009-01-10	bac	18	3.6	0.0315756856
0.3	2009-01-11 - 2009-01-17	hpq	1	1	0.0464748932
0.3	2009-01-11 - 2009-01-17	ge	26	26	0.0174874464
0.3	2009-01-11 - 2009-01-17	ibm	8	8	0.0249052786
0.3	2009-01-11 - 2009-01-17	aa	2	2	0.0377493434
0.3	2009-01-11 - 2009-01-17	t	5	5	0.0286765829
0.3	2009-01-11 - 2009-01-17	ba	6	1.2	0.04400115
0.3	2009-01-11 - 2009-01-17	bac	34	6.8	0.0261496408
0.3	2009-01-18 - 2009-01-24	hpq	1	1	0.0451550204
0.3	2009-01-18 - 2009-01-24	ge	30	30	0.016276824
0.3	2009-01-18 - 2009-01-24	ibm	13	13	0.0209181386
0.3	2009-01-18 - 2009-01-24	aa	2	2	0.0366772735
0.3	2009-01-18 - 2009-01-24	t	6	6	0.0263791421
0.3	2009-01-18 - 2009-01-24	ba	5	1	0.0451550204
0.3	2009-01-18 - 2009-01-24	bac	48	9.6	0.022909978
0.3	2009-01-25 - 2009-01-31	hpq	1	1	0.0474571481

0.3	2009-01-25 - 2009-01-31	ge	32	32	0.0167786356
0.3	2009-01-25 - 2009-01-31	ibm	10	10	0.0237849168
0.3	2009-01-25 - 2009-01-31	aa	2	2	0.0385471823
0.3	2009-01-25 - 2009-01-31	t	6	6	0.0277240237
0.3	2009-01-25 - 2009-01-31	ba	4	0.8	0.0507428247
0.3	2009-01-25 - 2009-01-31	bac	42	8.4	0.0250621226
0.3	2009-02-01 - 2009-02-07	hpq	1	1	0.0460447423
0.3	2009-02-01 - 2009-02-07	ge	33	33	0.0161296842
0.3	2009-02-01 - 2009-02-07	ibm	10	10	0.023077037
0.3	2009-02-01 - 2009-02-07	aa	2	2	0.0373999522
0.3	2009-02-01 - 2009-02-07	t	6	6	0.0268989093
0.3	2009-02-01 - 2009-02-07	ba	4	0.8	0.0492326316
0.3	2009-02-01 - 2009-02-07	bac	54	10.8	0.0225503309
0.3	2009-02-08 - 2009-02-14	hpq	1	1	0.0454778554
0.3	2009-02-08 - 2009-02-14	ge	34	34	0.015789061
0.3	2009-02-08 - 2009-02-14	ibm	9	9	0.0235248695
0.3	2009-02-08 - 2009-02-14	aa	3	3	0.0327087238
0.3	2009-02-08 - 2009-02-14	t	7	7	0.025367085
0.3	2009-02-08 - 2009-02-14	ba	4	0.8	0.0486264965
0.3	2009-02-08 - 2009-02-14	bac	59	11.8	0.0216887925
0.3	2009-02-15 - 2009-02-21	hpq	1	1	0.0455549486
0.3	2009-02-15 - 2009-02-21	ge	38	38	0.0152967963
0.3	2009-02-15 - 2009-02-21	ibm	10	10	0.0228315587
0.3	2009-02-15 - 2009-02-21	aa	2	2	0.0370021162
0.3	2009-02-15 - 2009-02-21	t	5	5	0.0281089459
0.3	2009-02-15 - 2009-02-21	ba	4	0.8	0.0487089273
0.3	2009-02-15 - 2009-02-21	bac	55	11	0.0221879795
0.3	2009-02-22 - 2009-02-28	hpq	1	1	0.0485930025
0.3	2009-02-22 - 2009-02-28	ge	57	57	0.0144481179
0.3	2009-02-22 - 2009-02-28	ibm	10	10	0.0243541925
0.3	2009-02-22 - 2009-02-28	aa	2	2	0.0394697828
0.3	2009-02-22 - 2009-02-28	t	8	8	0.0260403453
0.3	2009-02-22 - 2009-02-28	ba	3	0.6	0.0566406671
0.3	2009-02-22 - 2009-02-28	bac	67	13.4	0.0223070579
0.3	2009-03-01 - 2009-03-07	hpq	1	1	0.0484388144
0.3	2009-03-01 - 2009-03-07	ge	89	89	0.0126001729
0.3	2009-03-01 - 2009-03-07	ibm	12	12	0.0229847154
0.3	2009-03-01 - 2009-03-07	aa	3	3	0.034838314
0.3	2009-03-01 - 2009-03-07	t	7	7	0.0270186778
0.3	2009-03-01 - 2009-03-07	ba	5	1	0.0484388144
0.3	2009-03-01 - 2009-03-07	bac	60	12	0.0229847154
0.3	2009-03-08 - 2009-03-14	hpq	1	1	0.0507568897
0.3	2009-03-08 - 2009-03-14	ge	100	100	0.0127495543
0.3	2009-03-08 - 2009-03-14	ibm	12	12	0.024084666
0.3	2009-03-08 - 2009-03-14	aa	3	3	0.0365055272
0.3	2009-03-08 - 2009-03-14	t	7	7	0.0283116766
0.3	2009-03-08 - 2009-03-14	ba	5	1	0.0507568897
0.3	2009-03-08 - 2009-03-14	bac	80	16	0.0220932195
0.3	2009-03-15 - 2009-03-21	hpq	2	2	0.040106032
0.3	2009-03-15 - 2009-03-21	ge	82	82	0.0131635958
0.3	2009-03-15 - 2009-03-21	ibm	17	17	0.021104935
0.3	2009-03-15 - 2009-03-21	aa	3	3	0.0355125876

0.3	2009-03-15 - 2009-03-21	t	7	7	0.0275416074
0.3	2009-03-15 - 2009-03-21	ba	5	1	0.0493763173
0.3	2009-03-15 - 2009-03-21	bac	90	18	0.0207461228
0.3	2009-03-22 - 2009-03-28	hpq	1	1	0.0496209543
0.3	2009-03-22 - 2009-03-28	ge	74	74	0.0136425513
0.3	2009-03-22 - 2009-03-28	ibm	17	17	0.0212095003
0.3	2009-03-22 - 2009-03-28	aa	3	3	0.0356885362
0.3	2009-03-22 - 2009-03-28	t	7	7	0.0276780634
0.3	2009-03-22 - 2009-03-28	ba	5	1	0.0496209543
0.3	2009-03-22 - 2009-03-28	bac	90	18	0.0208489103
0.3	2009-03-29 - 2009-04-04	hpq	2	2	0.0386270795
0.3	2009-03-29 - 2009-04-04	ge	61	61	0.013854853
0.3	2009-03-29 - 2009-04-04	ibm	13	13	0.0220301709
0.3	2009-03-29 - 2009-04-04	aa	3	3	0.0342030233
0.3	2009-03-29 - 2009-04-04	t	5	5	0.029343362
0.3	2009-03-29 - 2009-04-04	ba	6	1.2	0.0450242512
0.3	2009-03-29 - 2009-04-04	bac	70	14	0.0215457919
0.3	2009-04-05 - 2009-04-11	hpq	2	2	0.0404602675
0.3	2009-04-05 - 2009-04-11	ge	57	57	0.01481069
0.3	2009-04-05 - 2009-04-11	ibm	12	12	0.0236365112
0.3	2009-04-05 - 2009-04-11	aa	4	4	0.0328639493
0.3	2009-04-05 - 2009-04-11	t	6	6	0.0290999588
0.3	2009-04-05 - 2009-04-11	ba	6	1.2	0.0471610401
0.3	2009-04-05 - 2009-04-11	bac	66	13.2	0.0229702419
0.3	2009-04-12 - 2009-04-18	hpq	2	2	0.0402678389
0.3	2009-04-12 - 2009-04-18	ge	62	62	0.0143730791
0.3	2009-04-12 - 2009-04-18	ibm	9	9	0.0256445196
0.3	2009-04-12 - 2009-04-18	aa	3	3	0.0356558624
0.3	2009-04-12 - 2009-04-18	t	7	7	0.0276527234
0.3	2009-04-12 - 2009-04-18	ba	6	1.2	0.0469367427
0.3	2009-04-12 - 2009-04-18	bac	95	19	0.0204946847
0.3	2009-04-19 - 2009-04-25	hpq	1	1	0.0484399325
0.3	2009-04-19 - 2009-04-25	ge	54	54	0.0146381233
0.3	2009-04-19 - 2009-04-25	ibm	12	12	0.0229852459
0.3	2009-04-19 - 2009-04-25	aa	3	3	0.0348391181
0.3	2009-04-19 - 2009-04-25	t	6	6	0.0282981571
0.3	2009-04-19 - 2009-04-25	ba	4	0.8	0.0517936518
0.3	2009-04-19 - 2009-04-25	bac	91	18.2	0.0202853317
0.3	2009-04-26 - 2009-05-02	hpq	1	1	0.0476345646
0.3	2009-04-26 - 2009-05-02	ge	46	46	0.0151040999
0.3	2009-04-26 - 2009-05-02	ibm	9	9	0.0246404961
0.3	2009-04-26 - 2009-05-02	aa	3	3	0.0342598789
0.3	2009-04-26 - 2009-05-02	t	6	6	0.0278276687
0.3	2009-04-26 - 2009-05-02	ba	5	1	0.0476345646
0.3	2009-04-26 - 2009-05-02	bac	74	14.8	0.0212248038
0.3	2009-05-03 - 2009-05-09	hpq	2	2	0.040638273
0.3	2009-05-03 - 2009-05-09	ge	50	50	0.0154722417
0.3	2009-05-03 - 2009-05-09	ibm	10	10	0.0250751905
0.3	2009-05-03 - 2009-05-09	aa	3	3	0.0359838697
0.3	2009-05-03 - 2009-05-09	t	7	7	0.0279071078
0.3	2009-05-03 - 2009-05-09	ba	6	1.2	0.0473685257
0.3	2009-05-03 - 2009-05-09	bac	100	20	0.0203673836

0.3	2009-05-10 - 2009-05-16	hpq	1	1	0.0466247481
0.3	2009-05-10 - 2009-05-16	ge	46	46	0.0147839045
0.3	2009-05-10 - 2009-05-16	ibm	8	8	0.0249855838
0.3	2009-05-10 - 2009-05-16	aa	3	3	0.0335335955
0.3	2009-05-10 - 2009-05-16	t	5	5	0.0287690484
0.3	2009-05-10 - 2009-05-16	ba	4	0.8	0.0498527938
0.3	2009-05-10 - 2009-05-16	bac	83	16.6	0.020071696
0.3	2009-05-17 - 2009-05-23	hpq	2	2	0.0377829431
0.3	2009-05-17 - 2009-05-23	ge	42	42	0.0151575844
0.3	2009-05-17 - 2009-05-23	ibm	8	8	0.0249274461
0.3	2009-05-17 - 2009-05-23	aa	3	3	0.0334555679
0.3	2009-05-17 - 2009-05-23	t	6	6	0.0271743652
0.3	2009-05-17 - 2009-05-23	ba	4	0.8	0.0497367939
0.3	2009-05-17 - 2009-05-23	bac	71	14.2	0.0209854496
0.3	2009-05-24 - 2009-05-30	hpq	1	1	0.042637942
0.3	2009-05-24 - 2009-05-30	ge	32	32	0.015074789
0.3	2009-05-24 - 2009-05-30	ibm	7	7	0.0237830102
0.3	2009-05-24 - 2009-05-30	aa	2	2	0.0346327706
0.3	2009-05-24 - 2009-05-30	t	5	5	0.026309054
0.3	2009-05-24 - 2009-05-30	ba	2	0.4	0.0561278281
0.3	2009-05-24 - 2009-05-30	bac	57	11.4	0.0205458815
0.3	2009-05-31 - 2009-06-06	hpq	1	1	0.0475807057
0.3	2009-05-31 - 2009-06-06	ge	36	36	0.0162382838
0.3	2009-05-31 - 2009-06-06	ibm	9	9	0.0246126358
0.3	2009-05-31 - 2009-06-06	aa	2	2	0.0386475422
0.3	2009-05-31 - 2009-06-06	t	6	6	0.0277962049
0.3	2009-05-31 - 2009-06-06	ba	5	1	0.0475807057
0.3	2009-05-31 - 2009-06-06	bac	51	10.2	0.0237055932
0.3	2009-06-07 - 2009-06-13	hpq	1	1	0.045533973
0.3	2009-06-07 - 2009-06-13	ge	29	29	0.0165812072
0.3	2009-06-07 - 2009-06-13	ibm	8	8	0.0244010519
0.3	2009-06-07 - 2009-06-13	aa	2	2	0.0369850787
0.3	2009-06-07 - 2009-06-13	t	6	6	0.0266005227
0.3	2009-06-07 - 2009-06-13	ba	4	0.8	0.0486864994
0.3	2009-06-07 - 2009-06-13	bac	60	12	0.0216063383
0.3	2009-06-14 - 2009-06-20	hpq	1	1	0.0440857833
0.3	2009-06-14 - 2009-06-20	ge	30	30	0.0158914009
0.3	2009-06-14 - 2009-06-20	ibm	8	8	0.0236249863
0.3	2009-06-14 - 2009-06-20	aa	2	2	0.0358087831
0.3	2009-06-14 - 2009-06-20	t	4	4	0.0290857699
0.3	2009-06-14 - 2009-06-20	ba	6	1.2	0.0417392064
0.3	2009-06-14 - 2009-06-20	bac	56	11.2	0.0213566512
0.3	2009-06-21 - 2009-06-27	hpq	1	1	0.0413395043
0.3	2009-06-21 - 2009-06-27	ge	28	28	0.0152131047
0.3	2009-06-21 - 2009-06-27	ibm	7	7	0.0230587549
0.3	2009-06-21 - 2009-06-27	aa	2	2	0.0335781115
0.3	2009-06-21 - 2009-06-27	t	5	5	0.025507874
0.3	2009-06-21 - 2009-06-27	ba	4	0.8	0.0442016284
0.3	2009-06-21 - 2009-06-27	bac	54	10.8	0.020245949
0.3	2009-06-28 - 2009-07-04	hpq	1	1	0.0419116019
0.3	2009-06-28 - 2009-07-04	ge	26	26	0.0157703835
0.3	2009-06-28 - 2009-07-04	ibm	6	6	0.0244843672

0.3	2009-06-28 - 2009-07-04	aa	2	2	0.034042799
0.3	2009-06-28 - 2009-07-04	t	4	4	0.0276513451
0.3	2009-06-28 - 2009-07-04	ba	4	0.8	0.0448133349
0.3	2009-06-28 - 2009-07-04	bac	44	8.8	0.0218267693
0.3	2009-07-05 - 2009-07-11	hpq	1	1	0.0418720555
0.3	2009-07-05 - 2009-07-11	ge	26	26	0.0157555031
0.3	2009-07-05 - 2009-07-11	ibm	6	6	0.0244612646
0.3	2009-07-05 - 2009-07-11	aa	3	3	0.0301153493
0.3	2009-07-05 - 2009-07-11	t	5	5	0.0258364762
0.3	2009-07-05 - 2009-07-11	ba	2	0.4	0.0551196288
0.3	2009-07-05 - 2009-07-11	bac	47	9.4	0.021378928
0.3	2009-07-12 - 2009-07-18	hpq	1	1	0.0452043914
0.3	2009-07-12 - 2009-07-18	ge	34	34	0.0156941194
0.3	2009-07-12 - 2009-07-18	ibm	11	11	0.0220172372
0.3	2009-07-12 - 2009-07-18	aa	3	3	0.0325120422
0.3	2009-07-12 - 2009-07-18	t	6	6	0.0264079842
0.3	2009-07-12 - 2009-07-18	ba	4	0.8	0.0483340994
0.3	2009-07-12 - 2009-07-18	bac	60	12	0.0214499485
0.3	2009-07-19 - 2009-07-25	hpq	1	1	0.0472044053
0.3	2009-07-19 - 2009-07-25	ge	31	31	0.0168489958
0.3	2009-07-19 - 2009-07-25	ibm	12	12	0.0223989756
0.3	2009-07-19 - 2009-07-25	aa	3	3	0.0339504984
0.3	2009-07-19 - 2009-07-25	t	6	6	0.0275763737
0.3	2009-07-19 - 2009-07-25	ba	5	1	0.0472044053
0.3	2009-07-19 - 2009-07-25	bac	48	9.6	0.0239497597
0.3	2009-07-26 - 2009-08-01	hpq	2	2	0.0375683215
0.3	2009-07-26 - 2009-08-01	ge	33	33	0.0162022977
0.3	2009-07-26 - 2009-08-01	ibm	9	9	0.0239253355
0.3	2009-07-26 - 2009-08-01	aa	2	2	0.0375683215
0.3	2009-07-26 - 2009-08-01	t	6	6	0.0270200044
0.3	2009-07-26 - 2009-08-01	ba	5	1	0.0462520291
0.3	2009-07-26 - 2009-08-01	bac	53	10.6	0.0227792295
0.3	2009-08-02 - 2009-08-08	hpq	1	1	0.0467323533
0.3	2009-08-02 - 2009-08-08	ge	38	38	0.0156921544
0.3	2009-08-02 - 2009-08-08	ibm	10	10	0.0234216589
0.3	2009-08-02 - 2009-08-08	aa	3	3	0.0336109877
0.3	2009-08-02 - 2009-08-08	t	6	6	0.0273006053
0.3	2009-08-02 - 2009-08-08	ba	4	0.8	0.049967849
0.3	2009-08-02 - 2009-08-08	bac	73	14.6	0.0209079664
0.3	2009-08-09 - 2009-08-15	hpq	1	1	0.0449462472
0.3	2009-08-09 - 2009-08-15	ge	34	34	0.0156044965
0.3	2009-08-09 - 2009-08-15	ibm	8	8	0.0240860975
0.3	2009-08-09 - 2009-08-15	aa	3	3	0.032326379
0.3	2009-08-09 - 2009-08-15	t	5	5	0.0277333566
0.3	2009-08-09 - 2009-08-15	ba	6	1.2	0.04255387
0.3	2009-08-09 - 2009-08-15	bac	62	12.4	0.0211186878
0.3	2009-08-16 - 2009-08-22	hpq	2	2	0.0354705775
0.3	2009-08-16 - 2009-08-22	ge	30	30	0.0157413104
0.3	2009-08-16 - 2009-08-22	ibm	8	8	0.0234018538
0.3	2009-08-16 - 2009-08-22	aa	2	2	0.0354705775
0.3	2009-08-16 - 2009-08-22	t	5	5	0.0269455006
0.3	2009-08-16 - 2009-08-22	ba	4	0.8	0.046692837

0.3	2009-08-16 - 2009-08-22	bac	59	11.8	0.0208263257
0.3	2009-08-23 - 2009-08-29	hpq	1	1	0.0435658951
0.3	2009-08-23 - 2009-08-29	ge	30	30	0.0157039992
0.3	2009-08-23 - 2009-08-29	ibm	8	8	0.0233463851
0.3	2009-08-23 - 2009-08-29	aa	2	2	0.0353865027
0.3	2009-08-23 - 2009-08-29	t	4	4	0.0287427716
0.3	2009-08-23 - 2009-08-29	ba	5	1	0.0435658951
0.3	2009-08-23 - 2009-08-29	bac	55	11	0.0212191917
0.3	2009-08-30 - 2009-09-05	hpq	1	1	0.0438601984
0.3	2009-08-30 - 2009-09-05	ge	23	23	0.0171219112
0.3	2009-08-30 - 2009-09-05	ibm	8	8	0.0235040984
0.3	2009-08-30 - 2009-09-05	aa	2	2	0.0356255513
0.3	2009-08-30 - 2009-09-05	t	6	6	0.0256227192
0.3	2009-08-30 - 2009-09-05	ba	4	0.8	0.0468968417
0.3	2009-08-30 - 2009-09-05	bac	49	9.8	0.0221158059
0.3	2009-09-06 - 2009-09-12	hpq	1	1	0.0417911831
0.3	2009-09-06 - 2009-09-12	ge	23	23	0.01631422
0.3	2009-09-06 - 2009-09-12	ibm	6	6	0.0244140197
0.3	2009-09-06 - 2009-09-12	aa	2	2	0.0339449886
0.3	2009-09-06 - 2009-09-12	t	6	6	0.0244140197
0.3	2009-09-06 - 2009-09-12	ba	4	0.8	0.044684579
0.3	2009-09-06 - 2009-09-12	bac	40	8	0.0223953405
0.3	2009-09-13 - 2009-09-19	hpq	2	2	0.0372107386
0.3	2009-09-13 - 2009-09-19	ge	38	38	0.0153830415
0.3	2009-09-13 - 2009-09-19	ibm	9	9	0.0236976094
0.3	2009-09-13 - 2009-09-19	aa	3	3	0.0329488995
0.3	2009-09-13 - 2009-09-19	t	7	7	0.025553352
0.3	2009-09-13 - 2009-09-19	ba	4	0.8	0.0489835541
0.3	2009-09-13 - 2009-09-19	bac	41	8.2	0.0243687433
0.3	2009-09-20 - 2009-09-26	hpq	2	2	0.0365500357
0.3	2009-09-20 - 2009-09-26	ge	28	28	0.0165595829
0.3	2009-09-20 - 2009-09-26	ibm	8	8	0.0241140306
0.3	2009-09-20 - 2009-09-26	aa	2	2	0.0365500357
0.3	2009-09-20 - 2009-09-26	t	7	7	0.0250996342
0.3	2009-09-20 - 2009-09-26	ba	4	0.8	0.0481138166
0.3	2009-09-20 - 2009-09-26	bac	38	7.6	0.0244879667
0.3	2009-09-27 - 2009-10-03	hpq	1	1	0.0432198602
0.3	2009-09-27 - 2009-10-03	ge	26	26	0.0162626514
0.3	2009-09-27 - 2009-10-03	ibm	8	8	0.0231609496
0.3	2009-09-27 - 2009-10-03	aa	2	2	0.035105435
0.3	2009-09-27 - 2009-10-03	t	6	6	0.0252486396
0.3	2009-09-27 - 2009-10-03	ba	4	0.8	0.0462121699
0.3	2009-09-27 - 2009-10-03	bac	37	7.4	0.023709033
0.3	2009-10-04 - 2009-10-10	hpq	2	2	0.037749885
0.3	2009-10-04 - 2009-10-10	ge	25	25	0.0176946766
0.3	2009-10-04 - 2009-10-10	ibm	8	8	0.0249056359
0.3	2009-10-04 - 2009-10-10	aa	4	4	0.0306624345
0.3	2009-10-04 - 2009-10-10	t	6	6	0.027150589
0.3	2009-10-04 - 2009-10-10	ba	4	0.8	0.0496932768
0.3	2009-10-04 - 2009-10-10	bac	29	5.8	0.0274281321
0.3	2009-10-11 - 2009-10-17	hpq	2	2	0.0406901778
0.3	2009-10-11 - 2009-10-17	ge	30	30	0.0180576907

0.3	2009-10-11 - 2009-10-17	ibm	14	14	0.0226965672
0.3	2009-10-11 - 2009-10-17	aa	2	2	0.0406901778
0.3	2009-10-11 - 2009-10-17	t	8	8	0.0268455058
0.3	2009-10-11 - 2009-10-17	ba	5	1	0.0500954851
0.3	2009-10-11 - 2009-10-17	bac	44	8.8	0.0260887809
0.3	2009-10-18 - 2009-10-24	hpq	1	1	0.0493661132
0.3	2009-10-18 - 2009-10-24	ge	27	27	0.018366221
0.3	2009-10-18 - 2009-10-24	ibm	10	10	0.0247416657
0.3	2009-10-18 - 2009-10-24	aa	2	2	0.0400977438
0.3	2009-10-18 - 2009-10-24	t	6	6	0.0288392233
0.3	2009-10-18 - 2009-10-24	ba	5	1	0.0493661132
0.3	2009-10-18 - 2009-10-24	bac	34	6.8	0.0277764194
0.3	2009-10-25 - 2009-10-31	hpq	2	2	0.0377465142
0.3	2009-10-25 - 2009-10-31	ge	21	21	0.018643183
0.3	2009-10-25 - 2009-10-31	ibm	9	9	0.0240388173
0.3	2009-10-25 - 2009-10-31	aa	2	2	0.0377465142
0.3	2009-10-25 - 2009-10-31	t	6	6	0.0271481647
0.3	2009-10-25 - 2009-10-31	ba	6	1.2	0.0439978522
0.3	2009-10-25 - 2009-10-31	bac	39	7.8	0.0250932821
0.3	2009-11-01 - 2009-11-07	hpq	1	1	0.0429736302
0.3	2009-11-01 - 2009-11-07	ge	22	22	0.0170010302
0.3	2009-11-01 - 2009-11-07	ibm	7	7	0.0239702537
0.3	2009-11-01 - 2009-11-07	aa	2	2	0.0349054341
0.3	2009-11-01 - 2009-11-07	t	6	6	0.0251047943
0.3	2009-11-01 - 2009-11-07	ba	4	0.8	0.0459488923
0.3	2009-11-01 - 2009-11-07	bac	34	6.8	0.0241796143
0.3	2009-11-08 - 2009-11-14	hpq	2	2	0.036242128
0.3	2009-11-08 - 2009-11-14	ge	22	22	0.0176520799
0.3	2009-11-08 - 2009-11-14	ibm	9	9	0.023080751
0.3	2009-11-08 - 2009-11-14	aa	2	2	0.036242128
0.3	2009-11-08 - 2009-11-14	t	5	5	0.027531615
0.3	2009-11-08 - 2009-11-14	ba	4	0.8	0.0477084924
0.3	2009-11-08 - 2009-11-14	bac	29	5.8	0.0263326333
0.3	2009-11-15 - 2009-11-21	hpq	2	2	0.0357104826
0.3	2009-11-15 - 2009-11-21	ge	20	20	0.017897638
0.3	2009-11-15 - 2009-11-21	ibm	8	8	0.0235601321
0.3	2009-11-15 - 2009-11-21	aa	1	1	0.0439647611
0.3	2009-11-15 - 2009-11-21	t	5	5	0.0271277464
0.3	2009-11-15 - 2009-11-21	ba	4	0.8	0.0470086437
0.3	2009-11-15 - 2009-11-21	bac	29	5.8	0.0259463528
0.3	2009-11-22 - 2009-11-28	hpq	2	2	0.0336434452
0.3	2009-11-22 - 2009-11-28	ge	16	16	0.0180290759
0.3	2009-11-22 - 2009-11-28	ibm	7	7	0.0231036209
0.3	2009-11-22 - 2009-11-28	aa	1	1	0.0414199397
0.3	2009-11-22 - 2009-11-28	t	4	4	0.027326969
0.3	2009-11-22 - 2009-11-28	ba	2	0.4	0.0545244715
0.3	2009-11-22 - 2009-11-28	bac	21	4.2	0.0269298959
0.3	2009-11-29 - 2009-12-05	hpq	1	1	0.0438342088
0.3	2009-11-29 - 2009-12-05	ge	21	21	0.0175852029
0.3	2009-11-29 - 2009-12-05	ibm	7	7	0.0244502757
0.3	2009-11-29 - 2009-12-05	aa	2	2	0.0356044411
0.3	2009-11-29 - 2009-12-05	t	6	6	0.0256075363

0.3	2009-11-29 - 2009-12-05	ba	4	0.8	0.0468690527
0.3	2009-11-29 - 2009-12-05	bac	31	6.2	0.0253568712
0.3	2009-12-06 - 2009-12-12	hpq	1	1	0.0430962173
0.3	2009-12-06 - 2009-12-12	ge	18	18	0.0181074544
0.3	2009-12-06 - 2009-12-12	ibm	6	6	0.0251764086
0.3	2009-12-06 - 2009-12-12	aa	2	2	0.0350050058
0.3	2009-12-06 - 2009-12-12	t	5	5	0.0265918254
0.3	2009-12-06 - 2009-12-12	ba	3	0.6	0.0502335392
0.3	2009-12-06 - 2009-12-12	bac	29	5.8	0.0254337709
0.3	2009-12-13 - 2009-12-19	hpq	1	1	0.0421655851
0.3	2009-12-13 - 2009-12-19	ge	17	17	0.0180228494
0.3	2009-12-13 - 2009-12-19	ibm	6	6	0.0246327419
0.3	2009-12-13 - 2009-12-19	aa	2	2	0.0342490975
0.3	2009-12-13 - 2009-12-19	t	5	5	0.0260175938
0.3	2009-12-13 - 2009-12-19	ba	7	1.4	0.0381170884
0.3	2009-12-13 - 2009-12-19	bac	29	5.8	0.0248845466
0.3	2009-12-20 - 2009-12-26	hpq	1	1	0.0402459132
0.3	2009-12-20 - 2009-12-26	ge	14	14	0.0182340598
0.3	2009-12-20 - 2009-12-26	ibm	6	6	0.0235112874
0.3	2009-12-20 - 2009-12-26	aa	3	3	0.0289457902
0.3	2009-12-20 - 2009-12-26	t	4	4	0.0265524004
0.3	2009-12-20 - 2009-12-26	ba	3	0.6	0.0469111858
0.3	2009-12-20 - 2009-12-26	bac	24	4.8	0.025139082
0.3	2009-12-27 - 2010-01-02	hpq	1	1	0.0414178867
0.3	2009-12-27 - 2010-01-02	ge	14	14	0.0187650413
0.3	2009-12-27 - 2010-01-02	ibm	7	7	0.0231024758
0.3	2009-12-27 - 2010-01-02	aa	2	2	0.0336417777
0.3	2009-12-27 - 2010-01-02	t	5	5	0.0255562386
0.3	2009-12-27 - 2010-01-02	ba	3	0.6	0.0482772541
0.3	2009-12-27 - 2010-01-02	bac	24	4.8	0.0258711399

table 6

The reference keyword used here is "hpq" that belongs to each scaling keyword group corresponds to the tick symbol of the company Hewlett-Packard. The five first keywords including "hpq" belong to the same group. The two other keywords are the first two of the secong group after "hpq", which is always the first keyword in each group.

We can see big names like ibm" and "ge" worthing respectively 9 and 23 times "hpq" in terms of search volume the first week. This is confirmed in the rescaled volume figure.However even if "bac" gets 18 as a search volume in the first week, this does not double of "ibm"; because its reference value simply worths less than the value 1 of "hpq" here.This is confirmed reading its absolute search volume percentage in the rescaled volume column.

11 The Google Trends Buy And Hold Strategy

Here, we develop a new product. This product beats all the techniques implemented in the previous section. It is based on the Google trading strategy. It consists in buying the DJIA assets and trading them following the Google trends trading strategy. This strategy worths its money management. In order to succeed, we choose to hold the shares instead of selling them all at the sell signal. Only one tenth of the current shares are actually sold at each selling signal. We also avoid to buy shares for all the available liquid asset. In turn, only half of the money is used. In addition,we use the keyword "stock price". This keyword gets comparable but better results than the keyword "debt".

We show the corresponding returns on investment in the following picture including the former implemented strategy results.

11.1 Algorithm

The following algorithm has been applied as a new model based upon the Google Trends based trading explained in section 6. The particularity of this is that in trading the DJIA, we opt not to sell all the assets and re-buy them at each trading opportunity. In turn we buy for one fraction of the available liquid asset when stated by the trading signal and we sell one tenth of the available shares in the case of a sell signal.

Buy and sell signal are all triggered according to the same mechanism than the original method. Only the key word is changed here in "stock price" instead of "debt" to have better results.

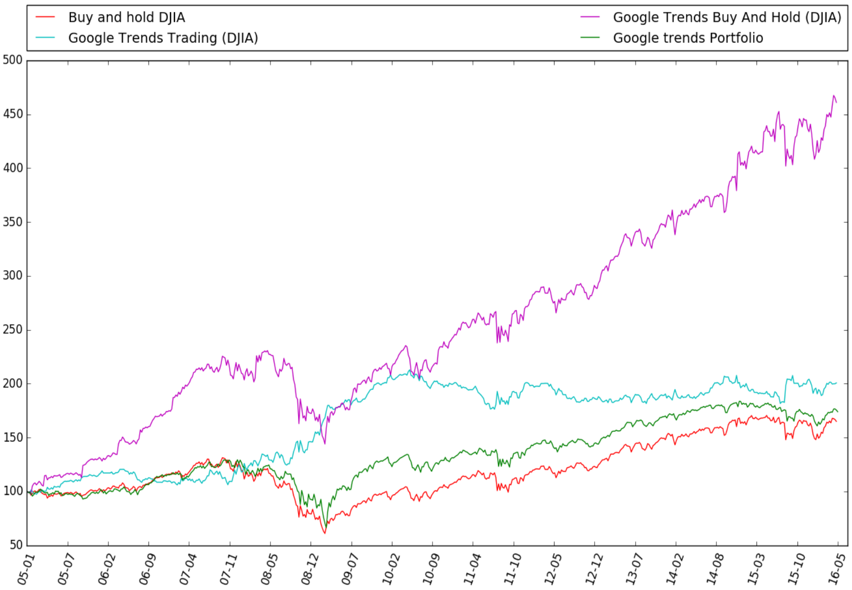
1 - Get DJIA close prices of first day of the week on Yahoo Finance
2 - Initialize z the initial investment amount
3 - For each time value t: calculate $\Delta n(t, \Delta t) = (n(t) - N(t-1, \Delta t))$
$with\ N(t-1, \Delta t) = (n(t-1) + n(t-2) + ... + n(t - \Delta t))/\Delta t$ and $n(t)$ the relative search volume percentage.
4 - For starting time t_0, if $\Delta n(t_0 - 3, \Delta t) > 0$ for $\Delta t = 3$, buy shares for the amount of $min(z, \lceil z/2 \rceil)$ at close price at $p(t_0)$
5 - If $\Delta n(t0 - 3, \Delta t) < 0$, sell shares for the amount of $min(z, \lceil z/2 \rceil)$ at close price $p(t_0)$ and buy them back at $p(t_0 + 1)$
6 - update z
7 - For each time t, if $\Delta n(t-3, \Delta t) > 0$, buy shares for the amount of of $min(z, \lceil z/2 \rceil)$ at $p(t)$
8 - For each time t, if $\Delta n(t-3, \Delta t) < 0$, sell one tenth of total number of shares at close price $p(t)$ and sell shares for the same amount at close price $p(t)$ and buy them back at $p(t+1)$
9 - Calculate Portfolio evolution

11.2 Results

11.2.1 First Experiment - Without Transaction Costs

Firstly, we show the result of the experiments without transaction cost.

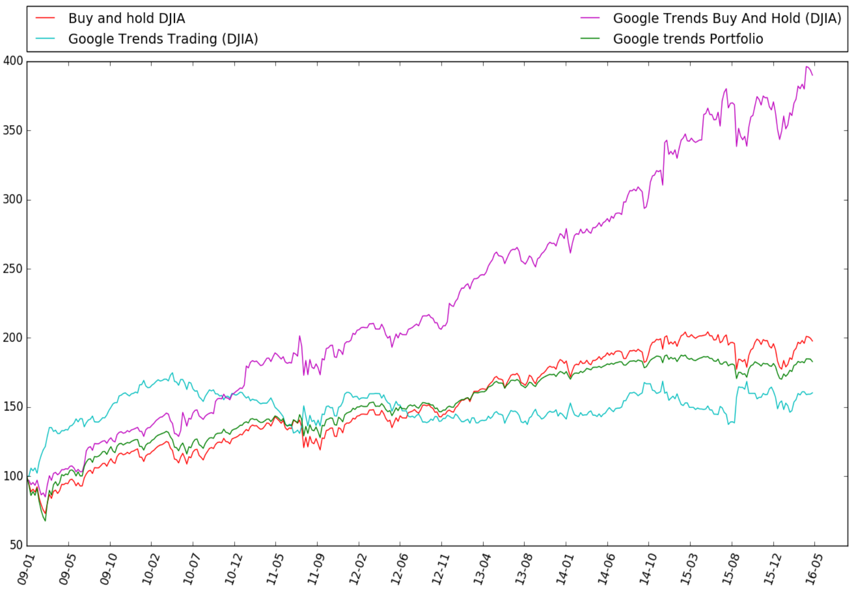
The conditions of the experiment are the same than this of section 9.1.



Without the transaction costs, the Google Trends buy and hold strategy peaks at 460% after 10 years of trading. This strategy outperforms the other competing strategies practically over all the trading period. It is the second strategy in terms of resistance to financial shock.

11.2.2 Second Experiment - Without Transaction Costs

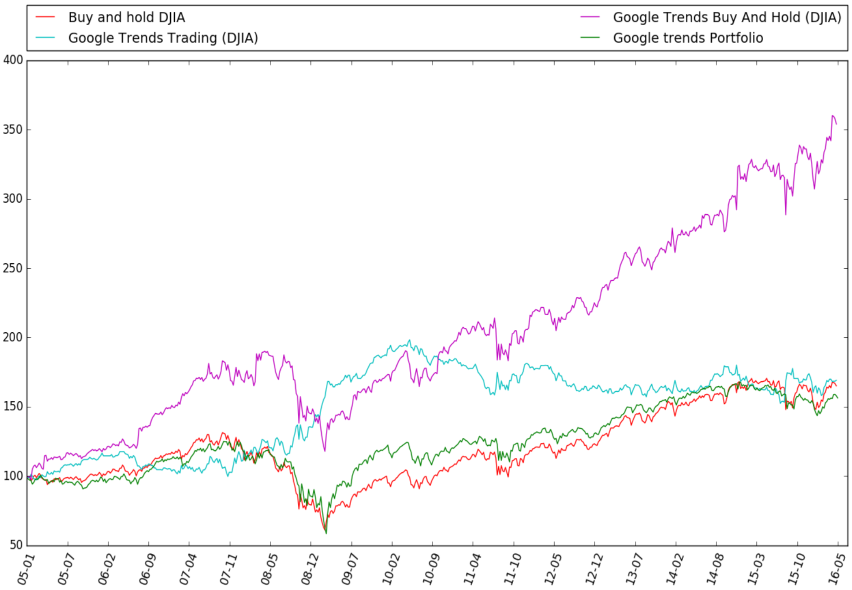
The conditions of the experiments are the same than this of section 10.1.



The Google Trends Buy and hold strategy also outclasses the Google Trends portfolio strategy for the second experiment. The Google Trends Hold and buy strategy almost peaks at almost 400% at the end of the trading period.

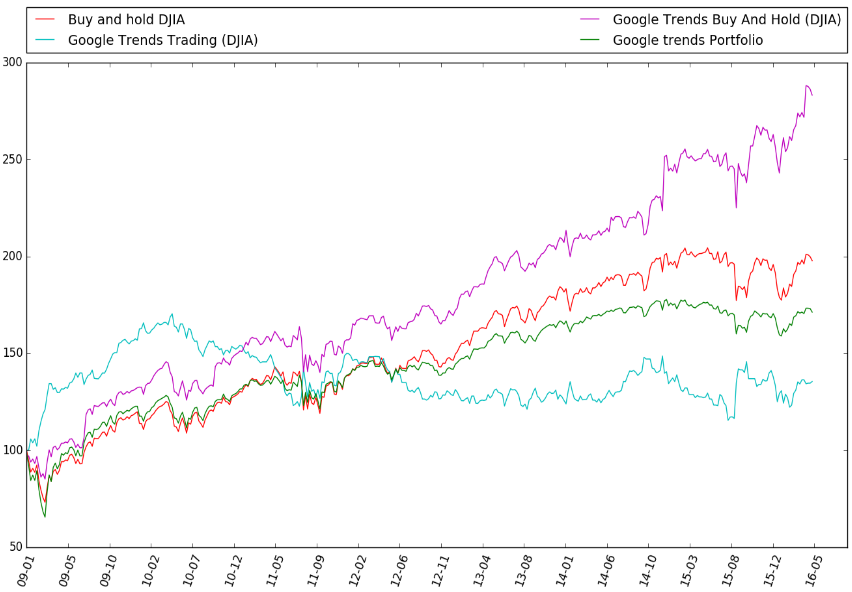
Here, we show the result of the experiments with the transaction costs.

11.2.3 First Experiment - With Transaction Costs



The Google Trends Buy and Hold peaks at almost 350% at the end of the trading period. It outperforms all the other strategies except this of the Google Trends trading in the time of financial crisis. It outdistances the classical DJIA Buy and hold strategy from near 200% points.

11.2.4 Second Experiment - With Transaction Costs



The Google Trends Buy and hold strategy competes with both the DJIA Buy and hold strategy and the Google trends strategy over the increasing period from february 2009 to January 2015. But it outperformed both strategy during the mini krash of 2015 and the uncertain period that followed. The Google Trading strategy outpasses the Google Trends Buy and hold strategy after during the period which follows the 2008 financial crisis but is outdistanced later.

11.3 Relation Price, Signal: Google Trends Trading

The following table shows the performance of the original trading algorithm before crisis. The performance reads 0 when the wrong action has been taken. That means when we sold shares while thinking that prices were going to fall but things do not happen as expected and in turn price goes up. Such behavior shows a mistake in the original concept of the procedure. We then count number of mistakes over number of occurrences to establish the performance of the corresponding keyword.

Relation signal,price evolution			
Time	**Price**	**Signal**	**Performance**
2005-01-02 - 2005-01-08	up	sell	0
2005-01-09 - 2005-01-15	down	sell	1
2005-01-16 - 2005-01-22	up	sell	0
2005-01-23 - 2005-01-29	up	sell	0
2005-01-30 - 2005-02-05	up	sell	0
2005-02-13 - 2005-02-19	up	buy	1
2005-02-20 - 2005-02-26	up	buy	1
2005-02-27 - 2005-03-05	down	buy	0
2005-03-06 - 2005-03-12	down	sell	1
2005-03-13 - 2005-03-19	down	buy	0
2005-03-20 - 2005-03-26	down	buy	0
2005-03-27 - 2005-04-02	up	buy	1
2005-04-03 - 2005-04-09	down	sell	1
2005-04-10 - 2005-04-16	up	sell	0
2005-04-17 - 2005-04-23	up	sell	0
2005-04-24 - 2005-04-30	up	buy	1
2005-05-01 - 2005-05-07	down	buy	0
2005-05-08 - 2005-05-14	up	buy	1
2005-05-15 - 2005-05-21	down	buy	0
2005-05-22 - 2005-05-28	down	buy	0
2005-05-29 - 2005-06-04	up	buy	1
2005-06-05 - 2005-06-11	up	sell	0
2005-06-12 - 2005-06-18	down	sell	1
2005-06-19 - 2005-06-25	up	buy	1
2005-06-26 - 2005-07-02	up	buy	1
2005-07-03 - 2005-07-09	up	buy	1
2005-07-10 - 2005-07-16	up	sell	0
2005-07-17 - 2005-07-23	up	buy	1
2005-07-24 - 2005-07-30	down	sell	1
2005-08-07 - 2005-08-13	down	buy	0
2005-08-14 - 2005-08-20	down	buy	0
2005-08-21 - 2005-08-27	up	buy	1
2005-08-28 - 2005-09-03	up	buy	1
2005-09-04 - 2005-09-10	down	buy	0
2005-09-11 - 2005-09-17	down	sell	1
2005-09-18 - 2005-09-24	up	sell	0
2005-09-25 - 2005-10-01	down	sell	1
2005-10-02 - 2005-10-08	up	buy	1
2005-10-09 - 2005-10-15	up	buy	1
2005-10-16 - 2005-10-22	up	buy	1
2005-11-06 - 2005-11-12	up	buy	1
2005-11-13 - 2005-11-19	up	sell	0

2005-11-20 - 2005-11-26	down	buy	0
2005-11-27 - 2005-12-03	down	sell	1
2005-12-04 - 2005-12-10	up	sell	0
2005-12-11 - 2005-12-17	down	buy	0
2005-12-18 - 2005-12-24	up	buy	1
2005-12-25 - 2005-12-31	up	buy	1
2006-01-01 - 2006-01-07	down	sell	1
2006-01-08 - 2006-01-14	down	sell	1
2006-01-15 - 2006-01-21	up	sell	0
2006-01-22 - 2006-01-28	down	sell	1
2006-03-05 - 2006-03-11	up	sell	0
2006-03-12 - 2006-03-18	down	sell	1
2006-03-19 - 2006-03-25	down	sell	1
2006-03-26 - 2006-04-01	down	buy	0
2006-04-02 - 2006-04-08	down	sell	1
2006-04-09 - 2006-04-15	up	buy	1
2006-04-16 - 2006-04-22	up	buy	1
2006-04-30 - 2006-05-06	down	buy	0
2006-05-14 - 2006-05-20	down	buy	0
2006-05-21 - 2006-05-27	down	buy	0
2006-05-28 - 2006-06-03	down	buy	0
2006-06-04 - 2006-06-10	up	buy	1
2006-06-11 - 2006-06-17	up	sell	0
2006-06-18 - 2006-06-24	up	buy	1
2006-06-25 - 2006-07-01	down	buy	0
2006-07-02 - 2006-07-08	down	buy	0
2006-07-09 - 2006-07-15	up	sell	0
2006-07-16 - 2006-07-22	up	sell	0
2006-07-30 - 2006-08-05	down	buy	0
2006-08-06 - 2006-08-12	up	buy	1
2006-08-13 - 2006-08-19	up	buy	1
2006-08-20 - 2006-08-26	up	buy	1
2006-08-27 - 2006-09-02	down	buy	0
2006-09-03 - 2006-09-09	up	buy	1
2006-09-10 - 2006-09-16	up	sell	0
2006-09-17 - 2006-09-23	up	sell	0
2006-09-24 - 2006-09-30	up	sell	0
2006-10-08 - 2006-10-14	up	sell	0
2006-10-22 - 2006-10-28	up	sell	0
2006-11-19 - 2006-11-25	up	buy	1
2006-11-26 - 2006-12-02	up	sell	0
2006-12-10 - 2006-12-16	down	buy	0
2006-12-17 - 2006-12-23	up	buy	1
2006-12-24 - 2006-12-30	down	buy	0
2006-12-31 - 2007-01-06	up	sell	0

table 7

For this first case, the overall performance is 48%. What appears to be deceiving but this result is really confirmed by the portfolio evolution in that period. Technically having a performance around 51% insure the method to be random and any certainty of return on investment is impossible. In turn, a 60% performance is a good figure for this purpose.

In the following table, we can see the performance of the keyword during crisis. This actually proves fairly better as it output a bit more than 57%. Such interesting results are confirmed by increase of portfolio return during that period.

Relation signal,price evolution			
Time	**Price**	**Signal**	**Performance**
2008-01-06 - 2008-01-12	down	sell	1
2008-01-13 - 2008-01-19	up	sell	0
2008-01-20 - 2008-01-26	up	sell	0
2008-01-27 - 2008-02-02	down	sell	1
2008-02-03 - 2008-02-09	up	buy	1
2008-02-10 - 2008-02-16	up	buy	1
2008-02-17 - 2008-02-23	down	buy	0
2008-02-24 - 2008-03-01	down	sell	1
2008-03-02 - 2008-03-08	up	sell	0
2008-03-16 - 2008-03-22	down	buy	0
2008-03-23 - 2008-03-29	up	buy	1
2008-03-30 - 2008-04-05	down	sell	1
2008-04-06 - 2008-04-12	up	buy	1
2008-04-13 - 2008-04-19	up	sell	0
2008-04-20 - 2008-04-26	up	sell	0
2008-04-27 - 2008-05-03	down	buy	0
2008-05-04 - 2008-05-10	up	buy	1
2008-05-11 - 2008-05-17	down	buy	0
2008-05-18 - 2008-05-24	down	buy	0
2008-05-25 - 2008-05-31	down	buy	0
2008-06-08 - 2008-06-14	down	sell	1
2008-06-15 - 2008-06-21	down	sell	1
2008-06-22 - 2008-06-28	down	sell	1
2008-06-29 - 2008-07-05	down	buy	0
2008-07-06 - 2008-07-12	up	sell	0
2008-07-13 - 2008-07-19	down	sell	1
2008-07-20 - 2008-07-26	up	sell	0
2008-07-27 - 2008-08-02	up	sell	0
2008-08-03 - 2008-08-09	down	buy	0
2008-08-10 - 2008-08-16	down	buy	0
2008-08-17 - 2008-08-23	up	buy	1
2008-08-24 - 2008-08-30	down	sell	1
2008-08-31 - 2008-09-06	down	sell	1
2008-09-07 - 2008-09-13	up	sell	0
2008-09-14 - 2008-09-20	down	sell	1
2008-09-21 - 2008-09-27	down	sell	1
2008-09-28 - 2008-10-04	down	sell	1
2008-10-05 - 2008-10-11	down	sell	1
2008-10-12 - 2008-10-18	down	buy	0
2008-10-19 - 2008-10-25	up	buy	1
2008-10-26 - 2008-11-01	down	buy	0
2008-11-02 - 2008-11-08	down	buy	0
2008-11-09 - 2008-11-15	up	sell	0
2008-11-16 - 2008-11-22	down	sell	1
2008-11-23 - 2008-11-29	up	buy	1
2008-12-07 - 2008-12-13	down	sell	1

2008-12-14 - 2008-12-20	down	buy	0
2008-12-21 - 2008-12-27	up	buy	1
2009-01-04 - 2009-01-10	down	sell	1
2009-01-11 - 2009-01-17	up	sell	0
2009-01-18 - 2009-01-24	down	sell	1
2009-01-25 - 2009-01-31	up	sell	0
2009-02-01 - 2009-02-07	down	sell	1
2009-02-08 - 2009-02-14	down	sell	1
2009-02-15 - 2009-02-21	down	sell	1
2009-02-22 - 2009-02-28	down	sell	1
2009-03-01 - 2009-03-07	up	buy	1
2009-03-08 - 2009-03-14	up	buy	1
2009-03-15 - 2009-03-21	down	buy	0
2009-03-29 - 2009-04-04	up	buy	1
2009-04-05 - 2009-04-11	down	buy	0
2009-04-12 - 2009-04-18	up	buy	1
2009-04-26 - 2009-05-02	down	buy	0
2009-05-03 - 2009-05-09	up	buy	1
2009-05-10 - 2009-05-16	down	buy	0
2009-05-17 - 2009-05-23	up	buy	1
2009-05-24 - 2009-05-30	up	buy	1
2009-05-31 - 2009-06-06	down	sell	1
2009-06-07 - 2009-06-13	down	sell	1
2009-06-14 - 2009-06-20	up	sell	0
2009-06-21 - 2009-06-27	down	sell	1
2009-06-28 - 2009-07-04	up	sell	0
2009-07-05 - 2009-07-11	up	sell	0
2009-07-12 - 2009-07-18	up	buy	1
2009-07-19 - 2009-07-25	up	buy	1
2009-07-26 - 2009-08-01	up	buy	1
2009-08-02 - 2009-08-08	down	sell	1
2009-08-09 - 2009-08-15	up	sell	0
2009-08-16 - 2009-08-22	down	buy	0
2009-08-23 - 2009-08-29	up	sell	0
2009-08-30 - 2009-09-05	up	buy	1
2009-09-06 - 2009-09-12	up	buy	1
2009-09-13 - 2009-09-19	up	sell	0
2009-09-20 - 2009-09-26	down	sell	1
2009-09-27 - 2009-10-03	up	buy	1
2009-10-04 - 2009-10-10	up	buy	1
2009-10-11 - 2009-10-17	down	sell	1
2009-10-18 - 2009-10-24	down	sell	1
2009-10-25 - 2009-10-31	up	buy	1
2009-11-08 - 2009-11-14	up	buy	1
2009-11-15 - 2009-11-21	down	sell	1
2009-11-22 - 2009-11-28	up	buy	1
2009-11-29 - 2009-12-05	up	sell	0
2009-12-06 - 2009-12-12	down	buy	0
2009-12-13 - 2009-12-19	up	buy	1
2009-12-20 - 2009-12-26	up	buy	1
2009-12-27 - 2010-01-02	up	buy	1
2010-01-03 - 2010-01-09	up	sell	0

2010-01-10 - 2010-01-16	down	sell	1
2010-01-17 - 2010-01-23	down	sell	1
2010-01-24 - 2010-01-30	down	sell	1
2010-01-31 - 2010-02-06	up	sell	0
2010-02-07 - 2010-02-13	up	sell	0
2010-02-14 - 2010-02-20	up	buy	1
2010-02-21 - 2010-02-27	up	buy	1
2010-02-28 - 2010-03-06	up	buy	1
2010-03-07 - 2010-03-13	up	buy	1
2010-03-14 - 2010-03-20	up	buy	1
2010-03-21 - 2010-03-27	up	sell	0
2010-03-28 - 2010-04-03	up	buy	1
2010-04-04 - 2010-04-10	up	buy	1
2010-04-11 - 2010-04-17	up	sell	0
2010-04-25 - 2010-05-01	down	sell	1
2010-05-02 - 2010-05-08	down	sell	1
2010-05-09 - 2010-05-15	down	buy	0
2010-05-16 - 2010-05-22	down	buy	0
2010-05-23 - 2010-05-29	down	buy	0
2010-05-30 - 2010-06-05	up	buy	1
2010-06-06 - 2010-06-12	up	sell	0
2010-06-20 - 2010-06-26	down	buy	0
2010-06-27 - 2010-07-03	up	buy	1
2010-07-04 - 2010-07-10	down	buy	0
2010-07-11 - 2010-07-17	up	sell	0
2010-07-18 - 2010-07-24	up	sell	0
2010-07-25 - 2010-07-31	up	buy	1
2010-08-01 - 2010-08-07	down	buy	0
2010-08-08 - 2010-08-14	down	buy	0
2010-08-15 - 2010-08-21	down	buy	0
2010-08-22 - 2010-08-28	up	buy	1
2010-08-29 - 2010-09-04	up	buy	1
2010-09-05 - 2010-09-11	up	buy	1
2010-09-12 - 2010-09-18	up	sell	0
2010-09-19 - 2010-09-25	down	sell	1
2010-09-26 - 2010-10-02	up	sell	0
2010-10-03 - 2010-10-09	up	sell	0
2010-10-17 - 2010-10-23	down	sell	1
2010-10-24 - 2010-10-30	up	sell	0
2010-10-31 - 2010-11-06	down	sell	1
2010-11-07 - 2010-11-13	down	sell	1
2010-11-14 - 2010-11-20	down	buy	0
2010-11-21 - 2010-11-27	up	buy	1
2010-11-28 - 2010-12-04	up	sell	0
2010-12-05 - 2010-12-11	up	sell	0
2010-12-12 - 2010-12-18	up	buy	1
2010-12-19 - 2010-12-25	up	buy	1
2010-12-26 - 2011-01-01	down	buy	0

table 8

In the following table the results are as deceiving as the first period as overall performance stagnates at 50% what suggests than the method works randomly and only a null log return could be expected from any investment based on it.

Relation signal,price evolution			
Time	**Price**	**Signal**	**Performance**
2015-01-04 - 2015-01-10	down	sell	1
2015-01-11 - 2015-01-17	up	sell	0
2015-01-18 - 2015-01-24	down	sell	1
2015-01-25 - 2015-01-31	up	sell	0
2015-02-01 - 2015-02-07	up	sell	0
2015-02-08 - 2015-02-14	up	sell	0
2015-02-15 - 2015-02-21	up	buy	1
2015-02-22 - 2015-02-28	down	buy	0
2015-03-08 - 2015-03-14	up	sell	0
2015-03-29 - 2015-04-04	up	buy	1
2015-04-05 - 2015-04-11	up	sell	0
2015-04-12 - 2015-04-18	up	sell	0
2015-04-19 - 2015-04-25	up	sell	0
2015-04-26 - 2015-05-02	up	buy	1
2015-05-03 - 2015-05-09	up	buy	1
2015-05-10 - 2015-05-16	down	buy	0
2015-05-17 - 2015-05-23	down	buy	0
2015-05-24 - 2015-05-30	down	buy	0
2015-05-31 - 2015-06-06	up	sell	0
2015-06-14 - 2015-06-20	down	sell	1
2015-06-21 - 2015-06-27	up	sell	0
2015-06-28 - 2015-07-04	up	sell	0
2015-07-05 - 2015-07-11	up	sell	0
2015-07-12 - 2015-07-18	down	buy	0
2015-07-19 - 2015-07-25	up	buy	1
2015-07-26 - 2015-08-01	up	buy	1
2015-08-02 - 2015-08-08	down	buy	0
2015-08-09 - 2015-08-15	down	sell	1
2015-08-16 - 2015-08-22	up	buy	1
2015-08-23 - 2015-08-29	down	buy	0
2015-08-30 - 2015-09-05	down	buy	0
2015-09-13 - 2015-09-19	down	sell	1
2015-09-20 - 2015-09-26	up	sell	0
2015-09-27 - 2015-10-03	up	sell	0
2015-10-25 - 2015-10-31	down	sell	1
2015-11-01 - 2015-11-07	down	sell	1
2015-11-15 - 2015-11-21	down	buy	0
2015-11-22 - 2015-11-28	up	buy	1
2015-11-29 - 2015-12-05	down	sell	1
2015-12-06 - 2015-12-12	down	sell	1
2015-12-13 - 2015-12-19	up	sell	0
2015-12-20 - 2015-12-26	down	buy	0
2015-12-27 - 2016-01-02	down	buy	0
2016-01-03 - 2016-01-09	down	sell	1
2016-01-10 - 2016-01-16	down	sell	1
2016-01-17 - 2016-01-23	up	sell	0
2016-01-24 - 2016-01-30	down	sell	1
2016-01-31 - 2016-02-06	up	sell	0

2016-02-07 - 2016-02-13	up	sell	0
2016-02-14 - 2016-02-20	down	sell	1
2016-02-21 - 2016-02-27	up	buy	1
2016-02-28 - 2016-03-05	up	buy	1
2016-03-06 - 2016-03-12	up	buy	1
2016-03-13 - 2016-03-19	down	buy	0
2016-03-20 - 2016-03-26	up	buy	1
2016-03-27 - 2016-04-02	down	buy	0
2016-04-10 - 2016-04-16	down	sell	1
2016-04-17 - 2016-04-23	down	sell	1
2016-05-01 - 2016-05-07	up	buy	1

table 9

11.4 Relation Price, Signal: Google Trends Buy And Hold

We show here, the performance of the keyword "stock price" used in the program we created. This is seen as a competing "keyword" because the process of elaboration for the trading signal is identical in both the Google Trends trading method and the Google Trends Buy and hold method. It will be shown that both methods works conversely in the outlined periods.

The first following table shows an overall performance of 54% on that period and is far good and also proved better than the former technique in terms of keywords performance.

Relation signal,price evolution			
Time	**Price**	**Signal**	**Performance**
2005-01-02 - 2005-01-08	up	buy	1
2005-01-09 - 2005-01-15	down	buy	0
2005-01-16 - 2005-01-22	up	buy	1
2005-01-23 - 2005-01-29	up	buy	1
2005-01-30 - 2005-02-05	up	buy	1
2005-02-06 - 2005-02-12	down	buy	0
2005-02-13 - 2005-02-19	up	buy	1
2005-02-20 - 2005-02-26	up	sell	0
2005-02-27 - 2005-03-05	down	buy	0
2005-03-06 - 2005-03-12	down	buy	0
2005-03-13 - 2005-03-19	down	sell	1
2005-03-20 - 2005-03-26	down	buy	0
2005-03-27 - 2005-04-02	up	buy	1
2005-04-03 - 2005-04-09	down	buy	0
2005-04-10 - 2005-04-16	up	buy	1
2005-04-17 - 2005-04-23	up	sell	0
2005-04-24 - 2005-04-30	up	sell	0
2005-05-01 - 2005-05-07	down	sell	1
2005-05-08 - 2005-05-14	up	sell	0
2005-05-15 - 2005-05-21	down	sell	1
2005-05-22 - 2005-05-28	down	buy	0
2005-05-29 - 2005-06-04	up	sell	0
2005-06-05 - 2005-06-11	up	buy	1
2005-06-12 - 2005-06-18	down	sell	1
2005-06-19 - 2005-06-25	up	buy	1
2005-06-26 - 2005-07-02	up	sell	0

2005-07-03 - 2005-07-09	up	sell	0
2005-07-10 - 2005-07-16	up	buy	1
2005-07-17 - 2005-07-23	up	buy	1
2005-07-24 - 2005-07-30	down	buy	0
2005-07-31 - 2005-08-06	up	sell	0
2005-08-07 - 2005-08-13	down	sell	1
2005-08-14 - 2005-08-20	down	sell	1
2005-08-21 - 2005-08-27	up	sell	0
2005-08-28 - 2005-09-03	up	buy	1
2005-09-04 - 2005-09-10	down	sell	1
2005-09-11 - 2005-09-17	down	buy	0
2005-09-18 - 2005-09-24	up	sell	0
2005-09-25 - 2005-10-01	down	buy	0
2005-10-02 - 2005-10-08	up	buy	1
2005-10-09 - 2005-10-15	up	buy	1
2005-10-16 - 2005-10-22	up	buy	1
2005-10-23 - 2005-10-29	up	sell	0
2005-10-30 - 2005-11-05	up	sell	0
2005-11-06 - 2005-11-12	up	sell	0
2005-11-13 - 2005-11-19	up	buy	1
2005-11-20 - 2005-11-26	down	buy	0
2005-11-27 - 2005-12-03	down	buy	0
2005-12-04 - 2005-12-10	up	buy	1
2005-12-11 - 2005-12-17	down	sell	1
2005-12-18 - 2005-12-24	up	sell	0
2005-12-25 - 2005-12-31	up	sell	0
2006-01-01 - 2006-01-07	down	buy	0
2006-01-08 - 2006-01-14	down	buy	0
2006-01-15 - 2006-01-21	up	buy	1
2006-01-22 - 2006-01-28	down	buy	0
2006-01-29 - 2006-02-04	up	buy	1
2006-02-05 - 2006-02-11	up	sell	0
2006-02-12 - 2006-02-18	up	sell	0
2006-02-19 - 2006-02-25	down	sell	1
2006-02-26 - 2006-03-04	up	buy	1
2006-03-05 - 2006-03-11	up	buy	1
2006-03-12 - 2006-03-18	down	sell	1
2006-03-19 - 2006-03-25	down	sell	1
2006-03-26 - 2006-04-01	down	buy	0
2006-04-02 - 2006-04-08	down	buy	0
2006-04-09 - 2006-04-15	up	buy	1
2006-04-16 - 2006-04-22	up	buy	1
2006-04-23 - 2006-04-29	up	sell	0
2006-04-30 - 2006-05-06	down	sell	1
2006-05-07 - 2006-05-13	down	sell	1
2006-05-14 - 2006-05-20	down	sell	1
2006-05-21 - 2006-05-27	down	sell	1
2006-05-28 - 2006-06-03	down	sell	1
2006-06-04 - 2006-06-10	up	sell	0
2006-06-11 - 2006-06-17	up	buy	1
2006-06-18 - 2006-06-24	up	sell	0
2006-06-25 - 2006-07-01	down	sell	1

2006-07-02 - 2006-07-08	down	sell	1
2006-07-09 - 2006-07-15	up	buy	1
2006-07-16 - 2006-07-22	up	buy	1
2006-07-23 - 2006-07-29	up	buy	1
2006-07-30 - 2006-08-05	down	buy	0
2006-08-06 - 2006-08-12	up	sell	0
2006-08-13 - 2006-08-19	up	sell	0
2006-08-20 - 2006-08-26	up	sell	0
2006-08-27 - 2006-09-02	down	sell	1
2006-09-03 - 2006-09-09	up	sell	0
2006-09-10 - 2006-09-16	up	buy	1
2006-09-17 - 2006-09-23	up	buy	1
2006-09-24 - 2006-09-30	up	buy	1
2006-10-01 - 2006-10-07	up	buy	1
2006-10-08 - 2006-10-14	up	buy	1
2006-10-15 - 2006-10-21	down	sell	1
2006-10-22 - 2006-10-28	up	buy	1
2006-10-29 - 2006-11-04	up	sell	0
2006-11-05 - 2006-11-11	up	sell	0
2006-11-12 - 2006-11-18	down	buy	0
2006-11-19 - 2006-11-25	up	sell	0
2006-11-26 - 2006-12-02	up	buy	1
2006-12-03 - 2006-12-09	up	buy	1
2006-12-10 - 2006-12-16	down	buy	0
2006-12-17 - 2006-12-23	up	sell	0
2006-12-24 - 2006-12-30	down	sell	1
2006-12-31 - 2007-01-06	up	buy	1

table 10

This relative good can be seen in the returns on investment figure for the corresponding period. On this first period far from any crisis, the economy state is good and even if ”buy” signals compete with ”sell” signals in numbers, we do not sell all the shares what could raise transaction costs and could be very costly in the case we mistook in our price direction forecast. So forecasting errors here are minimized by the relative mere value of our trading amount.

In the following table we see performance during crisis. The performance is lower than the competing technique as it could not be better than 48%.

Relation signal,price evolution			
Time	**Price**	**Signal**	**Performance**
2008-01-06 - 2008-01-12	down	buy	0
2008-01-13 - 2008-01-19	up	buy	1
2008-01-20 - 2008-01-26	up	buy	1
2008-01-27 - 2008-02-02	down	sell	1
2008-02-03 - 2008-02-09	up	sell	0
2008-02-10 - 2008-02-16	up	sell	0
2008-02-17 - 2008-02-23	down	sell	1
2008-02-24 - 2008-03-01	down	buy	0
2008-03-02 - 2008-03-08	up	buy	1
2008-03-09 - 2008-03-15	up	buy	1
2008-03-16 - 2008-03-22	down	buy	0
2008-03-23 - 2008-03-29	up	sell	0

2008-03-30 - 2008-04-05	down	sell	1
2008-04-06 - 2008-04-12	up	sell	0
2008-04-13 - 2008-04-19	up	sell	0
2008-04-20 - 2008-04-26	up	sell	0
2008-04-27 - 2008-05-03	down	sell	1
2008-05-04 - 2008-05-10	up	sell	0
2008-05-11 - 2008-05-17	down	sell	1
2008-05-18 - 2008-05-24	down	sell	1
2008-05-25 - 2008-05-31	down	sell	1
2008-06-01 - 2008-06-07	down	buy	0
2008-06-08 - 2008-06-14	down	buy	0
2008-06-15 - 2008-06-21	down	sell	1
2008-06-22 - 2008-06-28	down	buy	0
2008-06-29 - 2008-07-05	down	sell	1
2008-07-06 - 2008-07-12	up	buy	1
2008-07-13 - 2008-07-19	down	buy	0
2008-07-20 - 2008-07-26	up	buy	1
2008-07-27 - 2008-08-02	up	sell	0
2008-08-03 - 2008-08-09	down	sell	1
2008-08-10 - 2008-08-16	down	sell	1
2008-08-17 - 2008-08-23	up	sell	0
2008-08-24 - 2008-08-30	down	sell	1
2008-08-31 - 2008-09-06	down	sell	1
2008-09-07 - 2008-09-13	up	buy	1
2008-09-14 - 2008-09-20	down	buy	0
2008-09-21 - 2008-09-27	down	buy	0
2008-09-28 - 2008-10-04	down	buy	0
2008-10-05 - 2008-10-11	down	buy	0
2008-10-12 - 2008-10-18	down	buy	0
2008-10-19 - 2008-10-25	up	sell	0
2008-10-26 - 2008-11-01	down	sell	1
2008-11-02 - 2008-11-08	down	sell	1
2008-11-09 - 2008-11-15	up	sell	0
2008-11-16 - 2008-11-22	down	buy	0
2008-11-23 - 2008-11-29	up	sell	0
2008-11-30 - 2008-12-06	down	sell	1
2008-12-07 - 2008-12-13	down	sell	1
2008-12-14 - 2008-12-20	down	sell	1
2008-12-21 - 2008-12-27	up	sell	0
2008-12-28 - 2009-01-03	down	sell	1
2009-01-04 - 2009-01-10	down	buy	0
2009-01-11 - 2009-01-17	up	buy	1
2009-01-18 - 2009-01-24	down	buy	0
2009-01-25 - 2009-01-31	up	sell	0
2009-02-01 - 2009-02-07	down	sell	1
2009-02-08 - 2009-02-14	down	buy	0
2009-02-15 - 2009-02-21	down	buy	0
2009-02-22 - 2009-02-28	down	buy	0
2009-03-01 - 2009-03-07	up	buy	1
2009-03-08 - 2009-03-14	up	buy	1
2009-03-15 - 2009-03-21	down	sell	1
2009-03-22 - 2009-03-28	up	sell	0

2009-03-29 - 2009-04-04	up	sell	0
2009-04-05 - 2009-04-11	down	sell	1
2009-04-12 - 2009-04-18	up	sell	0
2009-04-19 - 2009-04-25	up	sell	0
2009-04-26 - 2009-05-02	down	sell	1
2009-05-03 - 2009-05-09	up	buy	1
2009-05-10 - 2009-05-16	down	sell	1
2009-05-17 - 2009-05-23	up	sell	0
2009-05-24 - 2009-05-30	up	sell	0
2009-05-31 - 2009-06-06	down	buy	0
2009-06-07 - 2009-06-13	down	sell	1
2009-06-14 - 2009-06-20	up	sell	0
2009-06-21 - 2009-06-27	down	sell	1
2009-06-28 - 2009-07-04	up	sell	0
2009-07-05 - 2009-07-11	up	buy	1
2009-07-12 - 2009-07-18	up	buy	1
2009-07-19 - 2009-07-25	up	buy	1
2009-07-26 - 2009-08-01	up	buy	1
2009-08-02 - 2009-08-08	down	buy	0
2009-08-09 - 2009-08-15	up	sell	0
2009-08-16 - 2009-08-22	down	sell	1
2009-08-23 - 2009-08-29	up	sell	0
2009-08-30 - 2009-09-05	up	sell	0
2009-09-06 - 2009-09-12	up	sell	0
2009-09-13 - 2009-09-19	up	buy	1
2009-09-20 - 2009-09-26	down	sell	1
2009-09-27 - 2009-10-03	up	sell	0
2009-10-04 - 2009-10-10	up	sell	0
2009-10-11 - 2009-10-17	down	buy	0
2009-10-18 - 2009-10-24	down	buy	0
2009-10-25 - 2009-10-31	up	sell	0
2009-11-01 - 2009-11-07	up	sell	0
2009-11-08 - 2009-11-14	up	buy	1
2009-11-15 - 2009-11-21	down	buy	0
2009-11-22 - 2009-11-28	up	sell	0
2009-11-29 - 2009-12-05	up	buy	1
2009-12-06 - 2009-12-12	down	sell	1
2009-12-13 - 2009-12-19	up	buy	1
2009-12-20 - 2009-12-26	up	sell	0
2009-12-27 - 2010-01-02	up	sell	0
2010-01-03 - 2010-01-09	up	buy	1
2010-01-10 - 2010-01-16	down	buy	0
2010-01-17 - 2010-01-23	down	buy	0
2010-01-24 - 2010-01-30	down	buy	0
2010-01-31 - 2010-02-06	up	buy	1
2010-02-07 - 2010-02-13	up	sell	0
2010-02-14 - 2010-02-20	up	sell	0
2010-02-21 - 2010-02-27	up	buy	1
2010-02-28 - 2010-03-06	up	buy	1
2010-03-07 - 2010-03-13	up	buy	1
2010-03-14 - 2010-03-20	up	sell	0
2010-03-21 - 2010-03-27	up	buy	1

2010-03-28 - 2010-04-03	up	sell	0
2010-04-04 - 2010-04-10	up	buy	1
2010-04-11 - 2010-04-17	up	buy	1
2010-04-18 - 2010-04-24	down	buy	0
2010-04-25 - 2010-05-01	down	buy	0
2010-05-02 - 2010-05-08	down	buy	0
2010-05-09 - 2010-05-15	down	sell	1
2010-05-16 - 2010-05-22	down	sell	1
2010-05-23 - 2010-05-29	down	sell	1
2010-05-30 - 2010-06-05	up	buy	1
2010-06-06 - 2010-06-12	up	buy	1
2010-06-13 - 2010-06-19	down	buy	0
2010-06-20 - 2010-06-26	down	sell	1
2010-06-27 - 2010-07-03	up	sell	0
2010-07-04 - 2010-07-10	down	sell	1
2010-07-11 - 2010-07-17	up	buy	1
2010-07-18 - 2010-07-24	up	buy	1
2010-07-25 - 2010-07-31	up	sell	0
2010-08-01 - 2010-08-07	down	sell	1
2010-08-08 - 2010-08-14	down	sell	1
2010-08-15 - 2010-08-21	down	sell	1
2010-08-22 - 2010-08-28	up	sell	0
2010-08-29 - 2010-09-04	up	sell	0
2010-09-05 - 2010-09-11	up	sell	0
2010-09-12 - 2010-09-18	up	buy	1
2010-09-19 - 2010-09-25	down	buy	0
2010-09-26 - 2010-10-02	up	buy	1
2010-10-03 - 2010-10-09	up	buy	1
2010-10-10 - 2010-10-16	up	buy	1
2010-10-17 - 2010-10-23	down	buy	0
2010-10-24 - 2010-10-30	up	sell	0
2010-10-31 - 2010-11-06	down	buy	0
2010-11-07 - 2010-11-13	down	buy	0
2010-11-14 - 2010-11-20	down	buy	0
2010-11-21 - 2010-11-27	up	sell	0
2010-11-28 - 2010-12-04	up	buy	1
2010-12-05 - 2010-12-11	up	buy	1
2010-12-12 - 2010-12-18	up	sell	0
2010-12-19 - 2010-12-25	up	sell	0
2010-12-26 - 2011-01-01	down	sell	1

table 11

We are relatively not surprised by this performance by being the worst ever shows that in time of crisis one could not gain profit in trading over the advice of that method. But the return on investment in barely negative here. We take advantage of the accumulation of wealth made during the good period and we wait patiently for better times. Here comes the performance in better times.

As expected, the technique establishes performance records here toping at 57%. This prove that good period is definitely its favorite ground of expression. We can rely on the created technique to serve desirable returns in current economic health and the economy to remain good otherwise just a few of the accumulated wealth would be cut off.

Relation signal,price evolution			
Time	**Price**	**Signal**	**Performance**
2015-01-04 - 2015-01-10	down	buy	0
2015-01-11 - 2015-01-17	up	buy	1
2015-01-18 - 2015-01-24	down	buy	0
2015-01-25 - 2015-01-31	up	buy	1
2015-02-01 - 2015-02-07	up	buy	1
2015-02-08 - 2015-02-14	up	buy	1
2015-02-15 - 2015-02-21	up	sell	0
2015-02-22 - 2015-02-28	down	buy	0
2015-03-01 - 2015-03-07	down	sell	1
2015-03-08 - 2015-03-14	up	sell	0
2015-03-15 - 2015-03-21	down	sell	1
2015-03-22 - 2015-03-28	down	sell	1
2015-03-29 - 2015-04-04	up	sell	0
2015-04-05 - 2015-04-11	up	buy	1
2015-04-12 - 2015-04-18	up	buy	1
2015-04-19 - 2015-04-25	up	buy	1
2015-04-26 - 2015-05-02	up	buy	1
2015-05-03 - 2015-05-09	up	sell	0
2015-05-10 - 2015-05-16	down	sell	1
2015-05-17 - 2015-05-23	down	sell	1
2015-05-24 - 2015-05-30	down	sell	1
2015-05-31 - 2015-06-06	up	sell	0
2015-06-07 - 2015-06-13	up	buy	1
2015-06-14 - 2015-06-20	down	buy	0
2015-06-21 - 2015-06-27	up	buy	1
2015-06-28 - 2015-07-04	up	buy	1
2015-07-05 - 2015-07-11	up	buy	1
2015-07-12 - 2015-07-18	down	buy	0
2015-07-19 - 2015-07-25	up	buy	1
2015-07-26 - 2015-08-01	up	buy	1
2015-08-02 - 2015-08-08	down	buy	0
2015-08-09 - 2015-08-15	down	sell	1
2015-08-16 - 2015-08-22	up	buy	1
2015-08-23 - 2015-08-29	down	buy	0
2015-08-30 - 2015-09-05	down	sell	1
2015-09-06 - 2015-09-12	up	sell	0
2015-09-13 - 2015-09-19	down	sell	1
2015-09-20 - 2015-09-26	up	buy	1
2015-09-27 - 2015-10-03	up	buy	1
2015-10-04 - 2015-10-10	up	buy	1
2015-10-11 - 2015-10-17	up	sell	0
2015-10-18 - 2015-10-24	up	buy	1
2015-10-25 - 2015-10-31	down	buy	0
2015-11-01 - 2015-11-07	down	buy	0
2015-11-08 - 2015-11-14	up	sell	0
2015-11-15 - 2015-11-21	down	sell	1
2015-11-22 - 2015-11-28	up	sell	0
2015-11-29 - 2015-12-05	down	buy	0
2015-12-06 - 2015-12-12	down	buy	0

2015-12-13 - 2015-12-19	up	buy	1
2015-12-20 - 2015-12-26	down	sell	1
2015-12-27 - 2016-01-02	down	sell	1
2016-01-03 - 2016-01-09	down	buy	0
2016-01-10 - 2016-01-16	down	buy	0
2016-01-17 - 2016-01-23	up	buy	1
2016-01-24 - 2016-01-30	down	sell	1
2016-01-31 - 2016-02-06	up	sell	0
2016-02-07 - 2016-02-13	up	buy	1
2016-02-14 - 2016-02-20	down	sell	1
2016-02-21 - 2016-02-27	up	sell	0
2016-02-28 - 2016-03-05	up	buy	1
2016-03-06 - 2016-03-12	up	buy	1
2016-03-13 - 2016-03-19	down	sell	1
2016-03-20 - 2016-03-26	up	sell	0
2016-03-27 - 2016-04-02	down	buy	0
2016-04-03 - 2016-04-09	up	buy	1
2016-04-10 - 2016-04-16	down	buy	0
2016-04-17 - 2016-04-23	down	buy	0
2016-04-24 - 2016-04-30	down	buy	0
2016-05-01 - 2016-05-07	up	sell	0

table 12

12 Conclusion

In conclusion, we can say that this thesis was a good way to have a global view on what stock market is. We have provided basics, definitions and knowledge of the business; its importance in today world.
We then developed a new product which consists in holding the DJIA portfolio and trade part of them according to the evolution of the number of searched terms got from Google Trends. We benchmarked the method with two other methods also based on Google Trends. We thus showed its worth given that this beat the other former methods in terms of return on investment.

This shows us that even if historic methods were only based on data from the past, today, we can rely on a new set of methods that forecast the future of trading trends. These are tools that can lead to interesting results if very well managed. Today, the Google trends Buy and Hold DJIA strategy was proved worthy but we can imagine very well a similar technique based on an other compound portfolio.

In any case, the field of finance has been a very good ground for the expression of the capabilities of Google Trends and we expect greater results in the future with the coming up of new features on this application as well as from other collective applications.

References

[1] http://www.stat.cmu.edu/~abrock/algotrading/.

[2] http://www.columbia.edu/~ks20/FE-Notes/4700-07-Notes-CAPM.pdf.

[3] http://www.kellogg.northwestern.edu/faculty/papanikolaou/htm/finc460/ln/lecture1.pdf.

[4] https://www.quora.com/How-Exactly-do-Stock-Prices-Get-Determined.

[5] http://www.nasdaq.com/investing/glossary/a/algo-trading.

[6] Carol Alexander. Quantitative methods in finance, 2008.

[7] Ilaria Bordino, Stefano Battiston, Guido Caldarelli, Matthieu Cristelli, Antti Ukkonen, and Ingmar Weber. Web Search Queries Can Predict Stock Market Volumes. *PLoS ONE*, 7(7):e40014–, July 2012.

[8] Yan Carrière-Swallow and Felipe Labbé. Nowcasting with google trends in an emerging market. *Journal of Forecasting*, 32(4):289–298, 2013.

[9] Hyunyoung Choi and Hal Varian. Predicting the present with google trends. *The Economic Record*, 88(s1):2–9, 2012.

[10] Michael S. Drake, Darren T. Roulstone, and Jacob R. Thornock. Investor information demand: Evidence from google searches around earnings announcements. *Journal of Accounting Research*, 50(4):1001–1040, 2012.

[11] Nathan Kallus. Predicting crowd behavior with big public data. In *Proceedings of the 23rd International Conference on World Wide Web*, WWW '14 Companion, pages 625–630, New York, NY, USA, 2014. ACM.

[12] Ladislav Krištoufek. Can google trends search queries contribute to risk diversification? Papers, arXiv.org, 2013.

[13] Pawel Lachowicz. Applied Portfolio Optimization with Risk Management using Matlab, 2014.

[14] Renato Di Lorenzo. Basic Technical Analysis of Financial Markets, 2013.

[15] Harry M. Markowitz. FOUNDATIONS OF PORTFOLIO THEORY, December 1990.

[16] Jordi Mondria, Thomas Wu, and Yi Zhang. The determinants of international investment and attention allocation: Using internet search query data. Working papers, University of Toronto, Department of Economics, 2008.

[17] Tobias Preis, Helen S. Moat, and H. Eugene Stanley. Quantifying Trading Behavior in Financial Markets Using Google Trends. *Scientific Reports*, 3, April 2013.

[18] Tobias Preis, Helen S. Moat, H. Eugene Stanley, and Steven R. Bishop. Quantifying the Advantage of Looking Forward. *Scientific Reports*, 2, April 2012.

[19] Torsten Schmidt and Simeon Vosen. Forecasting private consumption: Survey-based indicators vs. google trends. Ruhr Economic Papers 155, Rheinisch-Westfälisches Institut für Wirtschaftsforschung (RWI), Ruhr-University Bochum, TU Dortmund University, University of Duisburg-Essen, 2009.

[20] Herbert A. Simon. A Behavioral Model of Rational Choice. *The Quarterly Journal of Economics*, 69(1):99–118, February 1955.

[21] Lieven Vandenberghe Stephen Boyd. Convex OPtimization.