Financial Indicators for Different Asset Classes

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Acknoledgements

As it is expected, this report is not the result of my work only. A lot of people have contributed to its contents. I want to thank all of them.

I will begin with David Karim, my tutor during this project. He created the first version of the prototype from which I began my work and guided me during the research phase. Thanks for your support and your kindness!

I also want to thank Christian Wiehenkamp, first user of the tool, for his insights and his ideas.

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Then I also want to thank the University of Paris 13, and especially the Sup' Galilee engineering school. I of course think particularly of Olivier Lafitte who has always encouraged me and had helped me find this internship.

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I will finish by thanking all the people who help me during this experience: from my two flatmates who made my life easier in Germany, to the cafetaria staff always smiling when preparing my hot chocolate. And of course a thought to my family who has always supported me.

Thanks to all of you!

Summary

How to know if an investment is attractive or not today? That's the question I was asked. Of course there is no exact answer, but a lot of indicators exists to help get a feeling about the answer.

Of course some of these indicators are completely absurd, some outdated. For the other ones, some are more commonly used than others. The goal of this project was to create a tool which uses some of these indicators to help the user during the decision process.

Here I only consider four major asset classes: equity, bond, commodity and real estate.

First I introduce some indicators which can be helpful when comparing two different asset classes. A well-known one is the Sharpe ratio which give a risk-adjusted measure of the return. I also consider the different spreads in returns. I finally create a new indicator, close to the Sharpe ratio but which take the liquidity into account too.

Then I look at single asset class. Each of them has a specific behaviour which we can partly explain by looking at the evolution of some indicators. Inside each asset class I encourage to always look at the Sharpe ratio.

For the equity market we obviously begin by introducing the price-to-earnings ratio which is a well-known fundamental indicator, and some other ratios close to this one. I also consider the dividend yield and some technical indicators (RSI, ROC, MACD and Stochastic oscillators).

For the bond market, I first subdivised it in government bonds, corporate bonds and inflation-linked bonds. For all I look at the historical yields and the spreads. I also consider the Macaulay duration and some liquidity measures. For government bonds I encourage to keep an eye on the evolution of the real rate. For corporate bonds two ratios are relevant: the debt-to-ebitda ratio and the interest coverage ratio. Finally for inflation-linked bonds the breakeven rate is the main indicator to look at.

For the commodity market the most relevant information is find in the future and options contracts: the volume, the open interest and the COT index. A few technical indicators seem to be relevant in that market (RSI, ROC, MACD and the Coppock indicator for gold).

For the real estate market the house prices is worth looking at. Two ratio are also commonly used: the price-to-rent ratio and the price-to-income ratio.

Now that we have a list of commonly used indicators another issue appear: getting the data. For the cross asset class there is no problem, but for the single asset class indicators,

some data are not available frequently enough, or for a fee too high compare to the relevance of the indicators. This issue is mostly present in the commodity market and the real estate market.

Summary - French version

Comment déterminer si un investissement est intéressant ou non aujourd'hui? Voici la question qui m'a été posée. Bien sûr, il n'y a pas de réponses exaces, mais une multitude d'indicateurs existent pour permettre d'aider à avoir une idée de la réponse.

Certains de ces indicators sont complétement farefelus, d'autres dépassés. Pour ce qui est des autres, il ne sont pas tous utilisés aussi fréquemment. Le but de ce projet est de créer un outil utilisant certains de ces indicators afin d'aider l'utilisateur pendant la phase de décision.

Dans le cadre de ce projet je ne me suis intéressé qu'à quatre classes d'actifs: les actions, les obligations, les commodités et l'immobilier.

Je commence tout d'abord par introduire plusierus indicateurs utiles pour comparer les classes entre elles. Le plus connu étant le ratio de Sharpe qui est une mesure du rendement ajustée pour prendre en compte le risque. Je considère également la simple différence entre les rendements. J'ai également introduit un nouvel indicateur, sur la même base que le ratio de Sharpe mais dans lequel le risque de liquidité est également considéré.

Ensuite je m'intéresse aux classes d'actifs individuellement. Chacune d'entre elles a un comportement spécifique qui peut être en partie expliquée en regardant l'évolution de certains indicateurs. Dans tous les cas, je conseille de regarder le ratio de Sharpe aussi à l'intérieur de chaque classe.

En ce qui concerne les actions, je considère bien évidemment le PE Ratio qui est un indicateur financier bien connu, ainsi que certains de ces dérivés. Je m'intéresse aussi au taux de dividendes et à plusieurs indicateurs techniques (RSI, ROC, MACD et Oscillateurs stochastiques).

En ce qui concerne les obligations, je commence par faire une subdivision entre les obligations issues par un Etat, celles issues par une entreprise et celles qui sont liées à l'inflation. Pour toutes ces catégories je m'intéresse bien sûr à l'évolution du taux, de la différence de ce taux avec un taux de référence ainsi que la duration de Macaulay et plusieurs mesures de la liquidité. En ce qui concerne les obligations issues par un Etat, je conseille de regarder aussi l'évolution du taux réel. Pour les obligations issues par des entreprises, deux ratios sont pertinents: le ratio dette/EBITDA et le ratio de couverture des intérêts. Enfin pour les obligations dont le taux est lié à l'inflation, le taux breakeven es à regarder de près.

Pour le marché des commodités l'information la plus pertinente se trouve dans les contrats futures et dans les options. Le volume, l'intérêt et l'index COT sont trois indicateurs importants. Quleques indicateurs techniques sont également pertinent ici (RSI, ROC,

MACD et l'indicateur de Coppock pour l'or).

Pour le marché de l'immobilier, l'évolution du prix est un indicateur à suivre. Deux ratios sont également utilisés fréquemment: le ratio prix/loyer et le ratio prix/revenus.

Maintenant que l'on a constitué une liste des indicateurs que l'on souhaite suivre, un autre problème apparaÃ®t: la disponibilité des données. Aucun problème du cÃ´té des indicateurs entre classes d'actifs, par contre lorsque l'on regarde les classes individuellement, certaines données ne sont pas disponibles assez fréquemment, ou alors le prix pour les obtenir est trop élevé commparé à la pertinence de l'information fournie par l'indicateur. Le problème de la disponibilité des données touche particulièrement les marchés des commodités et de l'immobilier.

Contents

1 Introduction

This report is the result of my work at risklab, part of Allianz Global Investors, during my internship organized by the engineering school Sup' Galilee, part of the University of Paris 13. This internship was the final step of my engineering formation in applied mathemactics and scientific computation, specialized in finance.

I will first introduce the work environment with a few words about the company and its activities. Then I will expose the main problematic I have worked on during my time there.

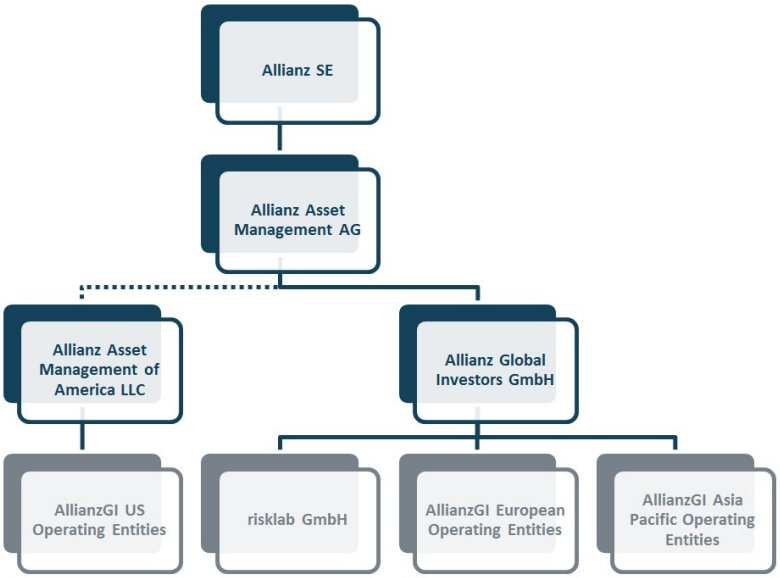

Figure 1: Position of risklab GmbH and Allianz Global Investors in Allianz SE

1.1 The company: Allianz GI

Allianz Global Investors

At Allianz Global Investors, they follow a two-word philosophy: Understand. Act.

It describes how they look at the world and how they behave. they aim to stand out as the investment partner their clients trust by listening closely to understand their challenges, then acting decisively to provide them with solutions that meet their needs.

Diversified active investment manager with a strong parent

Strength and stability are vital in uncertain times. They are an active investment manager with more than EUR 373 billion[1] in assets under management for institutional and retail clients around the world. Their business is diversified across equity, fixed-income and multi-asset strategies and diversified by region.

This solid foundation, together with the support of the world's largest insurer, helps them toward their goal of developing and maintaining long-term relationships with their clients.

Global investment and research capabilities

To create sustainable outperformance, in-depth market knowledge is essential. They have a global research platform that both informs their investment decisions and helps their clients understand the markets. Built around global centers of investment expertise, they can leverage the best talent in a given location while fostering independent thinking across asset classes. They have 525 investment professionals - including portfolio managers averaging more than a decade of experience with their firm - but they don't try to be all things to all people. They focus on distinct areas where they believe they can excel, helping them align their strengths with their clients' goals.

Consultative local delivery

The key to providing excellent service is understanding each client's unique circumstances and acting in their best interests. With their consultative approach and over 395 relationship managers, their goal is to offer solutions that truly address their clients' needs. Their investment teams are located near the markets in which they invest, because they believe that local knowledge is key to creating a sustainable advantage.

With 23 locations in 17 countries, they are well-positioned to deliver key local insights to their clients wherever they are.

A culture of risk management

Risk is both a challenge and an opportunity, which is why risk management is embedded in the way they manage and monitor investments. In fact, their parent company has been doing this successfully for more than 120 years; it is deeply ingrained in what they do. They have more than 70 dedicated specialists who average over 10 years of experience in risk management, and they build on their expertise in partnership with leading universities, supranational organizations and industry associations. This allows them to create portfolios that are risk-optimized, and to offer solutions and perspectives across the risk-return spectrum that aim to bring their clients closer to their goals while managing volatility.

[1] Combined worldwide assets as at 30 June 2014.

1.2 The department: risklab GmbH

Financial engineering meets investment analysis

Financial markets are racing toward globalization. The ever-increasing complexity of questions associated with this globalization is pushing traditional methods of analysis closer and closer to their limits. As pioneers, risklab GmbH has therefore chosen a new path: using innovative methods of financial engineering in investment analysis to yield a completely new, expanded view of its portfolio and investment decisions.

Its proprietary scenario analysis approach allows the company an integrated view and analysis of a variety of different financial instruments - from simple bonds to complex hybrid structures. Along with their individual investment strategy, its clients obtain a realistic assessment of the opportunities and risks of their portfolio, both today and in the future. Because risklab team think in market scenarios, its methodology is clear and easy to understand.

Academia meets practice

Its advice is founded on science. The company relies on a team of highly qualified employees with outstanding academic and practical track records.

With numerous publications in respected journals and teaching activities at renowned universities, these experts have also made a name for themselves internationally.

Through their long-term experience in a variety of consulting projects, especially in the fields of financial engineering, investment analysis and risk management, the company's employees are very well acquainted with the implementation of financial mathematical concepts in the context of applications. The fully developed interplay between theory and practice is the forte of risklab GmbH.

Own excellence meets strong partners

True to its pioneering spirit, risklab GmbH not only incorporates current trends, but also sets new standards again and again with its innovative concepts.

This company has the best conditions for this: within its Competence Center Network it also employs the expertise of external specialists in research and practice for its clients.

risklab GmbH numbers among its partners various national and international universities, research centers and software providers.

It is especially closely linked with the Institute for Mathematical Finance at the Munich

University of Technology and to Algorithmics Inc., one of the world's leading software developers for enterprise-wide risk management. The extensive partnership with Algorithmics Inc. guarantees its clients direct access to innovative technologies such as the "Mark-to-Future" concept that over time has become the industry standard.

From questions to advanced solutions

Good consulting starts with listening. This company delves into the details together, ask questions. Only then it develops, together with its clients, the appropriate solution in the form of:

- ▷ Consultancy Projects: analysis of very specific situation, development of a suitable concept and guidance through the implementation.
- ▷ Investment Services: quantitative analyses on regular basis - tailored to individual situation.
- ▷ Investment Products: availability of existing methods and concepts.

From asset allocation to alternatives

risklab GmbH areas of expertise are derived from centrally questions of the investment process:

- ▷ Asset Allocation,
- ▷ Investment Strategy,
- ▷ Risk Management,
- ▷ Alternatives.

According to risklab GmbH, the basic prerequisite for successful cooperation is a continuous dialogue. Its offering is therefore dynamic: all services are continually developed and adapted in response to new conditions.

With more than 16 years of experience and a strong link to Allianz Global Investors, risklab GmbH has a solid background as a world leading provider of strategic investment and risk solutions. With its team of 35 members including 12 PhDs, this company manages EUR 50 billion[2] assets under advice.

1.3 The problem: Attractiveness of investments

How to spot the most attractive asset? What is the right investing stratagy? That is the question that the investing committee try to answer in its report.

[2] as of January 2014.

As information is the key for smart investment, risklab GmbH wanted to create a software that gives some indications about the different markets and the different assets in order to help the committee during the elaboration of its report.

The idea was to display the most used indicators for asset attractivness in one place, so that in a glance an asset appears attractive or not attractive. That what I was asked to do during my time in risklab GmbH.

First during a research phase of around two months, I selected the indicators that are worth lookingat. Then I created a prototype to have a first idea of what the results were going to look like. Finally I participated in the implementation of the final tool and wrote a small documentation about the different indicators.

2 A few definitions

Before entering the heart of the subject I will introduce some definitions about the notions and concepts I will use later. I will begin by a few words about the financial terminology and then a short introduction of the different kinds of indicators I will use.

2.1 Assets and co

Most probably nothing is surprising in that part. It is just there to clearly define the field of this report and introduce the different instruments I am considering.

Asset

To begin with the beginning, what is an asset? I already use this word quite many times without giving it a clear meaning. Because many different definitions exist depending of the context. Considering the subject studied here it is clear that I am talking about a financial asset, and I have selected the official definition given by the International Accounting Standards Board (IASB)[3] in their International Financial Reporting Standards (IFRS)[4] in 2013:

"An asset is a resource controlled by the entity as a result of past events and from which future economic benefits are expected to flow to the entity."

Quite a large and abstract definition to be honest. To illustrate it I can give you a few examples of assets in our context: a share of Allianz GI, a five year German government bond, 100 barrels of crude oil, ... Assets are much more diverse than these examples let imagine, but it helps have an idea of what we are going to consider here.

Asset class

But of course listing every existing asset and giving a list of specific indicators for each of them is unthinkable and most probably useless. However the behaviour of some assets are very similar. That is why I only work with asset classes. As Robert J. Greer[5] explains in

[3] IASB is an independent and privately funded standard-setting organization for the accounting profession, based in London. The Board, whose members come from nine countries and a variety of backgrounds, is committed to developing a single set of high quality, understandable, and enforceable global standards that require transparent and comparable information in general purpose financial statements. It also works with national accounting standard setters to achieve convergence in accounting standards around the world.

[4] IFRS is a set of rules and guidelines established by the IASB for standardizing the preparation of financial statements so that investors, organizations, and governments have a basis for comparison.

[5] Mr. Greer is an Executive Vice President and Manager of Real Return Products at PIMCO. He is regarded as

his article What is an Asset Class, Anyway? in The Journal of Portfolio Management, Winter 1997:

"An asset class is a set of assets that bear some fundamental economic similarities to each other, and that have characteristics that make them distinct from other assets that are not part of the class."

Given this definition different possibilities exist for sorting all existing assets in a given number of asset classes. Here we are only considering four major asset classes[6]:

- Equity,
- Bond,
- Commodity,
- Real estate.

So now we know what is an asset and an asset class. I have even given a name to the ones I am considering. But what is included in each of them? Of course the asset classes I have listed are well-known, so don't expect any revelation, but I would like to introduce each of them.

Equity

First the equity class. The IASB has a definition for equity also:

"Equity is the residual interest in the assets of the entity after deducting all its liabilities."

The equity is what the owners of an entity have invested in it. It is also a reflexion of the capital left in the entity after its assets are used to pay off any outstanding liabilities. The equity therefore includes share capital contributed by the shareholders along with any profits or surpluses retained in the entity. This is what the owners take home in the event of a liquidation of the entity.

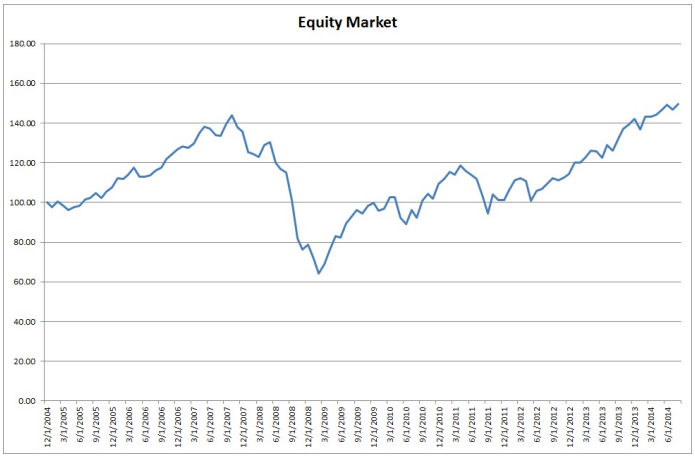

Figure 2: Evolution of the equity returns in the last ten years (calculated from MSCI World Index)

the first person to define an investable commodity index and is a pioneer in explaining why commodity indexes are an asset class distinct from stocks and bonds.

[6] All assets are of course not included in these four asset classes, but only the ones that I am studying here.

The returns of an equity share come from two sources. Of course there is the appreciation (or depreciation) of the value of the entity, and there are also the dividends payed by the entity.

Bond

Considering the bond class I have selected the definition given by the Financial Industry Regulatory Authority (FINRA)[7]:

> *"A bond is a loan that an investor makes to a corporation, government, federal agency or other organization. Consequently, bonds are sometimes referred as debt securities."*

As no entity will loan money for free the issuer of the bond enters into a legal agreement to pay the bondholder interest. The bond issuer also agrees to repay the original sum loaned at the bond's maturity date. Bonds are also called fixed-income securities because many pay you interest based on a regular, predetermined interest rate - also called a coupon rate - that is set when the bond is issued.

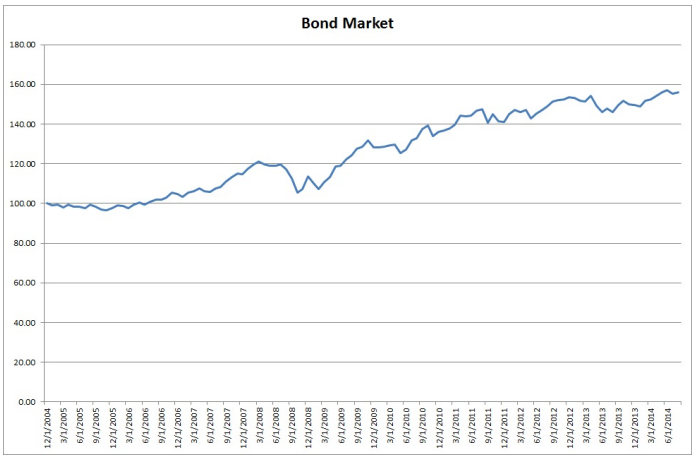

Figure 3: Evolution of the bond returns in the last ten years (calculated from PIMCO Global Advantage Bond Index)

The returns of a bond come from the interest payed. In general the amount of the interest is fixed, but some bonds have their interests linked to another quantity like the inflation for instance.

Here I consider three categories of bonds:

- Government bonds,
- Corporate bonds,
- Inflation-linked bonds.

[7] FINRA is a self-regulatory organization that oversees the activities of member brokerage firms as well as performing market regulation under contract for US stock markets including the New York Stock Exchange and NASDAQ.

Commodity

The commodity class is one of the hardest to define. It is actually quite easy to imagine what is a commodity but putting the concept into words is not an easy task. From the different definitions I encountered I have finally decided to keep that one:

A commodity is a basic good used in commerce that is interchangeable with other commodities of the same type.

The quality of a given commodity may differ slightly but it is essentialy uniform accross producers. When they are traded on a exchange commodities must also meet specified minimum standards, also known as basis grade.

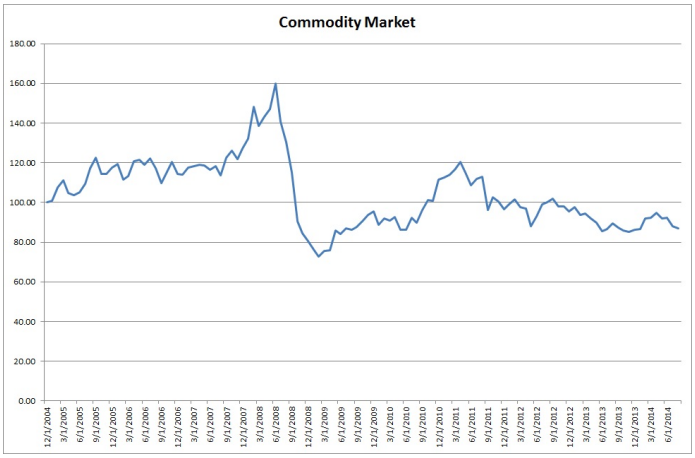

Figure 4: Evolution of the commodity returns in the last ten years (calculated from Dow Jones UBS Commodity Index)

The returns from commodities come only from the prices fluctuations.

The commodity class can be subdivided into five groups:

- Gold,
- Metal,
- Energy,
- Agricultural (soft and grain),
- Livestock and meat.

Real estate

Finally the real estate class. For sure everyone has a idea about what is hiding behind that name. Here is the definition I have selected at the term of my research:

A real estate is a physical land at, above and below the earth's surface with all appartenances, including any structures; any and every interest inland whether corporeal or incorporeal, freehold or non-freehold.

The real estate can then be grouped into three broad categories based on its use:

- ▷ Residential,
- ▷ Commercial,
- ▷ Industrial.

A few examples of real estate include undeveloped land, houses, condominiums, townhomes, office buildings, retail store buildings and factories.

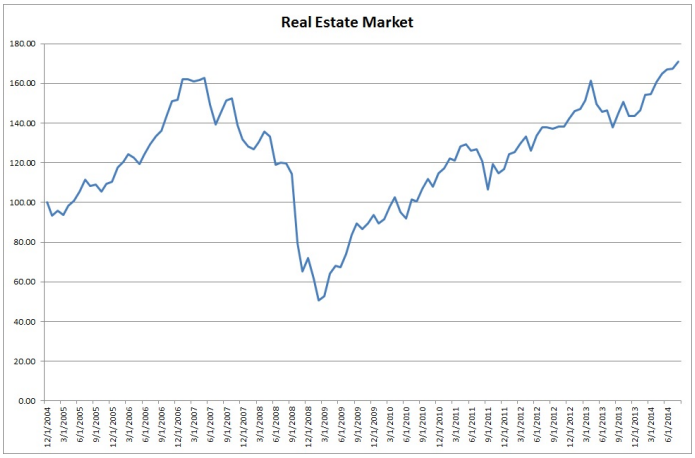

Figure 5: Evolution of the real estate returns in the last ten years (calculated from Dow Jones Global Select REIT Index)

The returns of real estate have two sources: the rent and the price changes.

Here we also consider Real Estate investment Trusts (REITs) which is a security that sells like a stock on the major exchanges and invests in real estate directly, either through properties or mortgages. REITs receive special tax considerations and typically offer investors high yields, as well as a highly liquid method of investing in real estate. As Gregory J. White[8] said:

"REITs smell like real estate, look like bonds and walk like equity."

2.2 Financial indicators

Now that I have described the securities I will study, it is time to say a few words about the tools I will use for examining them.

[8] Gregory J. Whyte heads the REIT group at Morgan Stanley Dean Witter. He has been covering the REIT industry since 1988. He joined Morgan Stanley in 1991 after three years at Lehman Brothers, where he covered real estate and financial services companies.

The different indicators can be sorted in two different groups: the fundamental analysis and the technical analysis. This two analytical models are based on two different methodologies:

- ▷ The fundamental analysis maintains that markets may misprice a security in the short run but that the fair price will eventually be reached. Profits can be made by purchasing the mispriced security and then waiting for the market to recognize its mistake and reprice the security.
- ▷ The technical analysis maintains that all information is reflected already in the stock price. Trends are your friend and sentiment changes predate and predict trend changes. Investors' emotional responses to price movements lead to recognizable price chart patterns. Technical analysis does not care what the value of a security is. Their price predictions are only extrapolations from historical price patterns.

Fundamental analysis

The fundamental analysis is the examination of the underlying forces that affect the well being of the economy, industry groups, and companies. As with most analysis, the goal is to derive a forecast and profit from future price movements. At the company level, the fundamental analysis may involve examination of financial data, management, business concept and competition. At the industry level, there might be an examination of supply and demand forces for the products offered. For the national economy, fundamental analysis might focus on economic data to assess the present and future growth of the economy.

To forecast future asset prices, the fundamental analysis combines economic, industry, and company analysis to derive an asset's current fair value and forecast future value. If fair value is not equal to the current asset price, fundamental analysts believe that the asset is either over or under valued and the market price will ultimately gravitate towards fair value. Fundamentalists do not heed the advice of the random walkers and believe that markets are weak-form efficient. By believing that prices do not accurately reflect all available information, fundamental analysts look to capitalize on perceived price discrepancies.

Technical analysis

The technical analysis is the forecasting of future financial price movements based on an examination of past price movements. Like weather forecasting, the technical analysis does not result in absolute predictions about the future. Instead, the technical analysis can help investors anticipate what is likely to happen to prices over time. The technical analysis uses a wide variety of charts that show price over time.

The technical analysis is applicable to any tradable instrument where the price is influenced by the forces of supply and demand. Price refers to any combination of the open, high, low, or close for a given security over a specific time frame. The time frame can be based on intraday, daily, weekly or monthly price data and last a few hours or many years. In addition, some technical analysts include volume or open interest figures with their study of price action.

3 Cross asset classes studies

Before considering each asset individually, it could be interesting to compare the market of different group of assets with one another. First I will define every categoriesI am considering. Of course the asset classes introduced before will be used, but I wseparate each of them in subcategories. Then I will introduce the selected indicators.

3.1 Considered asset categories

I already introduce the four major categories which are the asset classes : Equity, Bond, Commodity and Real Estate. I just subdivised each ofthese asset classes in relevant group:

- For the Equity, I considered global and regional market. I also look seperately at the small capitalization stocks.
- For the Bond, I separate the class in three categories the government, the corporate and the inflation-linked bonds. I also make a regional decomposition.
- For the Commodity, I just considered the case of gold individually.
- For the Real Estate, I naturally do a regional decomposition.

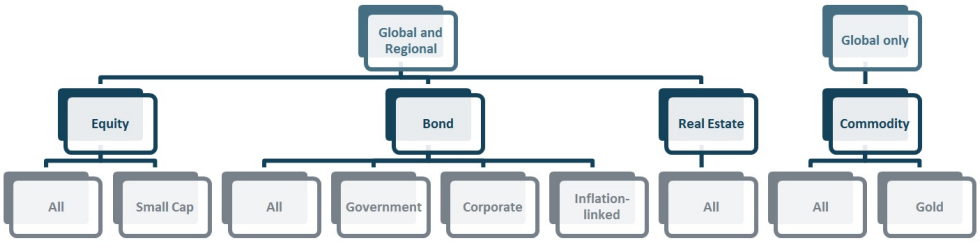

Figure 6: Considered categories of assets

As far as the regional decomposition is concerned, I choose to consider five area:

- World,
- US,
- Europe,

- Asia,
- Emerging market.

ANNEX: List of benchmark

3.2 Cross classes indicators

For the cross classes study I have selected three indicators:

- Spreads in Returns,
- Spreads in Sharpe Ratio,
- Spreads in Risk-Adjusted Ratio.

But first I will introduce the Fed Model which compare the Bond market with the Equity market.

Fed Model

The Fed Model is a theory of equity valuation that is widely used in the investment community. This model compare the earnings yield of the Equity market the yield of the long-term government bonds. In its original form the Fed Model states that both yields should be equal if both market are fair valued and in equilibrium. For the Equity market the S&P 500 Index is used to calculate the earnings yield, while the 10 Year Treasury Note is used for the Bond market.

The Fed model was so named by Ed Yardeni, at Deutsche Morgan Grenfell, based on a statement made in the Humphrey-Hawkins report of July 22, 1997 issued by the Federal Reserve that warned:

"... changes in this ratio [P/E of the S&P 500 Index] have often been inversely related to changes in the long-term Treasury yields, but this year's stock price gains were not matched by a significant net decline in interest rates. As a result, the yield on ten-year Treasury notes now exceeds the ratio of twelve-month-ahead earnings to prices by the largest amount since 1991, when earnings were depressed by the economic slowdown."

The Fed model was never officially endorsed by the Fed, but former Fed chairman Alan Greenspan seemed to make reference to it in his memoirs:

"The decline of real (inflation adjusted) long-term interest rates that has occurred in the last two decades has been associated with rising price-to-earnings ratios for stocks, real estate, and in fact all income-earnings assets."

A bond yield versus equity yield comparison has been used in practice long before the Fed published the graph and Yardeni gave it a name. The original Fed Model is comparing 1 to this ratio:

$$Fed = \frac{Y_E}{Y_B}$$

where Y_E is the earnings yield of the S&P500 Indexand Y_B is theyield of the 10 Year Treasury Note.

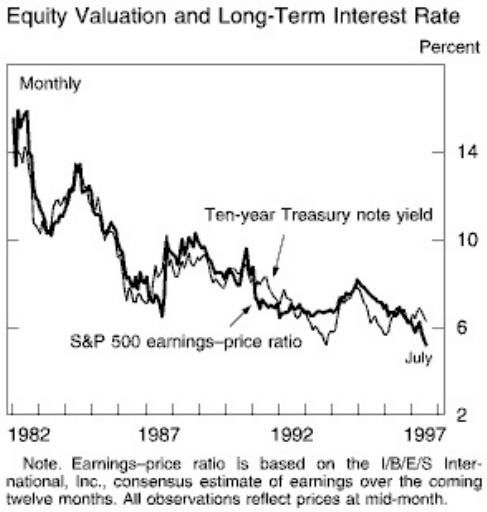

Figure 7: Original graphic from Humphrey-Hawkins report of July 22, 1997

I don't recommand to use the Fed Model as it was originaly described, but with a slightly adjustment. One of the biggest critic against this model is that it does not take into account any risk premium for the Equity market. One easy way to correct this issue is to look at the evolution of the ratio between the earnings yield of the Equity market and the yield of the long-term government bonds, and to compare it with the average of its historical value (10 years average), instead of with 1 as suggested by the Fed Model.

Spreads in Returns

Definitely something everyone will want to take a look at. It seems very reasonable when we want to compare to investment to look at the returns of each of them. Actually the Fed Model that I have just presented can be viewed as a particular case of this indicator: we compare the returns of the Equity market with the returns of the Bond market.

So I will do the same with each asset category. This indicator just calculate the annual return of each asset category using its benchmark. But as for the original version of the Fed Model, there is not a lot of sense in comparing directly the returns with one another, it is more relevant to look at the evolution of the spread between the two and compare it with its historical average.

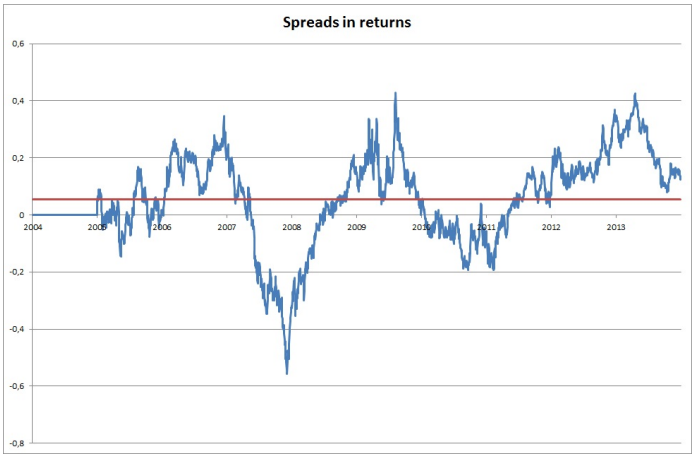

Figure 8: Results of the Spreads in Returns indicators for the Equity and Commodity market

For the average, a ten years period is the most used one. There is not any economic or mathematic reason, but it is long enough to smooth the data but not long enough to be able to follow the trend.

Spreads in Sharpe Ratio

This indicator is a lot similar to the previous one.Except that instead of comparing the returns directly, we compare the Sharpe Ratio. The Sharpe Ratio is a way to examine the performance of an investment by adjusting for its risk.

The first idea of the Sharpe Ratio appears in 1952 when Arthur D. Roy suggested maximizing the ratio $\frac{m-d}{\sigma}$ where m is the expected gross return, d is the minimum acceptable return and σ is the standard deviation of returns. In 1966 William Forsyth Sharpe developped the Reward-to-Variabiliy Ratio:

$$RVR = \frac{E(R - R_f)}{\sqrt{V(R)}}$$

where R is the return of the asset and R_f is a risk-free rate.

He then revised its definition in 1994 to create the actual Sharpe Ratio:

$$Sharpe = \frac{E(R - R_b)}{\sqrt{V(R - R_b)}}$$

where R_b is the return of a benchmark.

The Sharpe Ratio characterizes how well the return of an asset compensates the investor for the risk taken. When comparing two assets versus a common benchmark, the one with a higher Sharpe Ratio provides better return for the same risk (or, equivalently, the same return for lower risk).

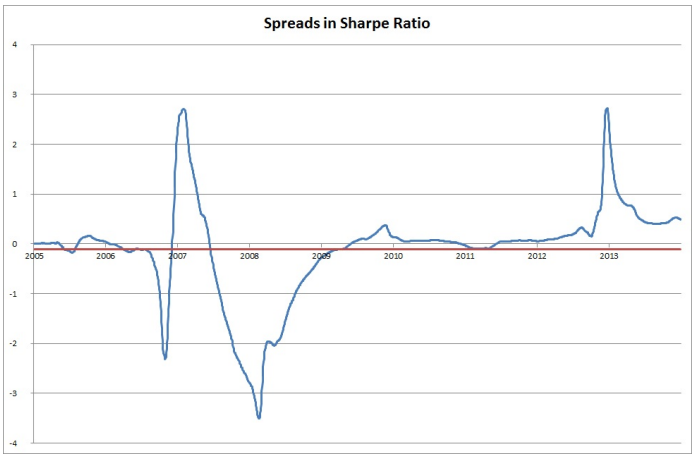

Figure 9: Results of the Spreads in Sharpe Ratio indicators for the Equity and Commodity market

For comparing asset categories with one another, the benchmark used is the EURIBOR 1M. As for the previous indicator we look at the evolution of the spread of the Sharpe Ratio of two different asset categories compared with its ten years average value.

Spreads in Risk-Adjusted Ratio

As I just explained, the Sharpe Ratio can be viewed as an improvment of the first indicator because it takes a risk measure into account. Of course the standard deviation is not the best risk meausre but it is the most common one.

Working on this idea, I wanted to create a new indicator which considers other aspects of the risk of an investment. The standard deviation measure the risk of price changes, and I decided to add a measure of the liquidity risk. Given the differences between the different asset class, I have decided to use a liquidity measure based on the price of the asset: the MEC, for Market Efficiency Coefficient. Sadly the MEC does not take into account every aspects of the liquidity, but only the market resiliency.

The MEC is one of the most widely-used indices in the literature. It measures the impact of execution costs on price volatility over short horizons. The idea behind the construction of this index can be summarized as follows. With high execution costs, asset markets are characterized by price volatility in excess of the theoretical volatility of equilibrium prices. Therefore, a more liquid market implies a smaller variance of transaction prices around the equilibrium price. The reason is that the difference between actual and equilibrium price in a liquid market is smaller than what one should observe in an illiquid market. So this index naturally look at the ratio between the long-term and the short-term variance of the returns. In our case, we use logarithm returns to normalize variances and facili-

tate comparability, since returns and therefore variances could vary substantially between period.

$$MEC = \frac{V(logR_{lt})}{T \times V(logR_{st})}$$

where $V(logR_{lt})$ is the variance of the logarithm of the long-period returns, $V(logR_{st})$ is the variance of the logarithm of the short-period returns and T is the number of short periods in each longer period. In this case, as we are looking at long-term investment, I use one year and five years periods.

The MEC will most of the time be between 0 and 1, 0 for a highly illiquid market, 1 for a very liquid market.

I then combined the MEC with Sharpe Ratio in order to obtain the Risk-Adjusted Ratio:

$$RAR = MEC \times Sharpe$$

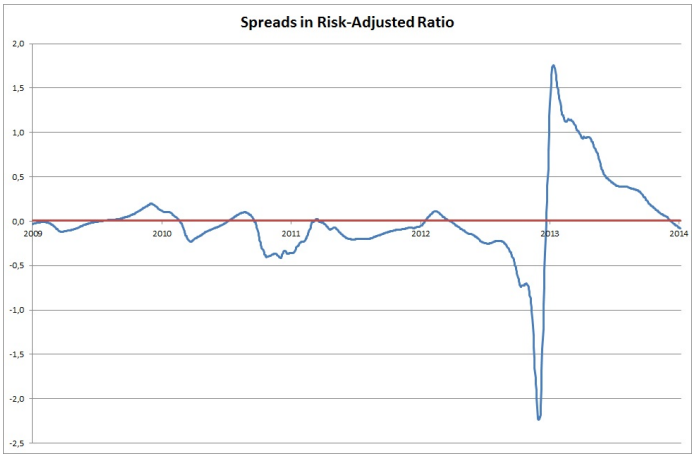

Figure 10: Results of the Spreads in Risk-Adjusted Ratio indicators for the Equity and Commodity market

To calculate the Sharpe Ratio I keep using the EURIBOR 1M as benchmark. And then I look at the evolution of the spread between the Risk-Adjusted Ratio of the two asset categories and its ten years average.

4 Single asset class studies

Now that we have a way of spotting the most attractive asset category, the next question is which particular asset to invest in.

As I already said there is no exact answer in this report,but some indicators that are worth looking at duringthe decision process.

I will begin by wo indicators that are common to all assets. Then I will present a selection of indicators specific to each of the four asset classes that I am considering here.

4.1 Common indicators

I actually will not say much in this part, because I have alreday presented this two indicators previously: the Sharpe Ratio and the RA Ratio.

The only difference with what I introduced before is the benchmark used to calculate these two indicators. Instead of comparing the return of the considered asset with the EURIBOR 1M, I will use a specific benchmark for each asset class, which is the benchmark I used to compare the asset classes with one another.

ANNEX: List of benchmark

4.2 Equity

The literature about indicators for the Equity market is quite long, and number of existing indicators is quite huge. So I won't present all of them here, but just the one I have selected during the research phase.

Given that the only data I had was about the price, I did not consider the indicators based on volume. There is also a lot of economic ratios I did not consider because I did not have access to all the information of the balance sheets.

I finally selected seven indicators:

- Three fundamental indicators:

  - Price-to-Earnings Ratio (PE Ratio),
  - Cyclically Adjusted Price-to-Earnings Ratio (CAPE Ratio),
  - Dividend Yield.

- Four technical indicators:

  - Relative Strength Index (RSI)
  - Rate Of Change (ROC)
  - Moving Average Convergence Divergence (MACD)
  - Stochastic Oscillators (Stochs)

PE Ratio

Chances are the term Price-to-Earnings Ratio is not completely unfamiliar to you. When it comes to valuing equities, the PE Ratio is one of the oldest and most frequently used metrics.

The PE Ratio is the ratio of a company's share price to its per-share earnings:

$$PE = \frac{Equity\ Price}{Earnings\ Per\ Share}$$

The PE Ratio is calculated using the earnings per share (EPS) of the last twelve months. Different variations exist on this point. Some use the estimated earnings for the next twelve months, or even six months of past earnings and six months of expected earnings. There is not a huge difference between these variations. But it is important to realize that in the first calculation, you are using actual historical data. The other two calculations are based on analyst estimates that are not always perfect or precise.

The PE Ratio historically seems to be a mean reverted metrics. However we don't consider the average over the whole history to take into account the underlying trend of the market. So a ten years average seems to be a good compromise, and is in fact often used in practice.

CAPE Ratio

The CAPE Ratio is a variation of the PE Ratio. This metric was developped by Dr. Robert Shiller and Dr. John Campbell in a paper written in 1988 and can be traced to the principles of Graham[9].

Benjamin Graham noted one year earnings were too volatile to offer a good idea of a firm's true earning power. Then the economists Dr. John Campbell and Robert Shiller concluded that a long moving average of real earnings helps to forecast future real dividends which in turn are correlated with returns on stocks. So the idea was to smooth the earnings over

[9] A scholar and financial analyst who is widely recognized as the father of value investing. His famous book, *The Intelligent Investor*, has gained recognition as one of the best and most important investment pieces written illustrating the fundamentals of a value-investing strategy.

a few business cycle by using the average over ten years of the real(inflation-adjusted) earnings. From a mathematical perspective, the CAPE Ratio is calculated as follows:

$$CAPE = \frac{Equity\ Price}{(EPS\ For\ Previous\ 10\ Years \times Inflation\ Multiplier)\ /\ 10}$$

The CAPE Ratio is then interpreted like the PE Ratio. But instead of comparing it with a ten years average, the complete history should be consider.

Dividend Yield

The dividend yield is a financial ratio that show much a company pays out in dividends each year relative to its share price. In the absence of any capital gains, the dividend yield is the return on investment for a stock. It is easy to calculate it:

$$Dividend\ Yield = \frac{Annual\ Dividends\ Per\ Share}{Price\ Per\ Share}$$

Historically, a higher dividend yield has been considered to be desirable among many investors. A high dividend yield can be considered to be evidence that a stock is underpriced or that the company has fallen on hard times and future dividends will not be as high as previous ones. Similarly a low dividend yield can be considered evidence that the stock is overpriced or that future dividends might be higher.

The interpretation of this indicator is easy. The higher the yield the better, so we compare the value today with the average over the last ten years. If it is above then the investment is attractive, otherwise it is not.

RSI

Developed by J. Welles Wilder, the Relative Strength Index (RSI) is a momentum oscillator that measures the speed and change of price movements. RSI oscillates between 0 and 100. Traditionally, and according to Wilder, RSI is considered overbought when above 70 and oversold when below 30.

Wilder features RSI in his 1978 book, *New Concepts in Technical Trading Systems*. Despite being developed before the computer age, Wilder's indicators have stood the test of time and remain extremely popular.

The RSI is a technical indicator that compares the magnitude of recent gains to recent losses in an attempt to determine overbought and oversold conditions of an asset. It is calculated as follows:

$$RSI = 100 \times \frac{Average\ Gain}{Average\ Gain\ +\ Average\ Loss}$$

The way of calculating the average gain or loss can vary. Originally Wilder used a smoothed moving average over fourteen periods. Here I decided to use a simple moving average instead to have a more reactiv indicator. The gain and loss are calculated as follows:

$$\begin{cases} Gain &= max(0, Current\,Close - Previous\,Close) \\ Loss &= max(0, Previous\,Close - Current\,Close) \end{cases}$$

The interpretation of the RSI is typical for a technical indicator.

A buy signal occurs when the RSI declines below 30% and rises above that level, while a sell occurs when it rises above 70% and declines below that level.

Looking for divergences between the RSI and the price can prove to be very effective in identifying potential reversal points in price movement.

ROC

The Rate Of Change (ROC) indicator is a pure momentum oscillator that measures the percent change in price from one period to the next. The ROC calculation compares the current price with the price twenty periods ago. The plot forms an oscillator that fluctuates above and below the zero line as the ROC moves from positive to negative.

The ROC measures the speed at which the price changes over a specific period of time. It is calculated as follow:

$$ROC = 100 \times \frac{Current\,Close - Close\,20\,Periods\,Ago}{Close\,20\,Periods\,Ago}$$

The ROC is the simplest momentum indicator and a widely used one. Its interpretation is simple: a buy signal occurs when the RSI declines below −10% and rises above that level, while a sell occurs when it rises above 10% and declines below that level.

MACD

Developed by Gerald Appel in the late seventies, the Moving Average Convergence Divergence (MACD) is one of the simplest and most effective momentum indicators available. The MACD turns two trend-following indicators, exponantial moving averages, into a momentum oscillator by subtracting the longer moving average from the shorter moving average. As a result, the MACD offers the best of both worlds: trend following and momentum. The MACD fluctuates above and below the zero line as the moving averages converge, cross and diverge. Because the MACD is unbounded, it is not particularly useful for identifying overbought and oversold levels.

The MACD is calculated by substracting the 26 days exponential moving average of the close from its 12 days exponential moving average. We compare the result with 0 and with a signal line which is the 9 days exponential of the MACD.

Crossovers are the most important source of signal for the MACD.A buy signal occurs when the MACD line crosses above the signal line or above 0, while a sell signal occurs when the MACD line crosses below the signal line or below 0.

Like for the RSI, looking for divergences between the MACD and the price can help identifying potential reversal points in price movement.

Stochs

Developed by George C. Lane in the late 1950s, the Stochastic Oscillator is a momentum indicator that shows the location of the close relative to the high-low range over a set number of periods. According to an interview with Lane, the Stochastic Oscillator *doesn't follow price, it doesn't follow volume or anything like that. It follows the speed or the momentum of price. As a rule, the momentum changes direction before price.* As such, bullish and bearish divergences in the Stochastic Oscillator can be used to foreshadow reversals. This was the first, and most important, signal that Lane identified. Lane also used this oscillator to identify bull and bear set-ups to anticipate a future reversal. Because the Stochastic Oscillator is range bound, is also useful for identifying overbought and oversold levels.

There are three different version of the Stochs:

- ▷ Fast,
- ▷ Slow,
- ▷ Full.

I will only explained the fast version as the other two work in the same way. The Stochs are usely plottedas two lines:

- ▷ $\%K$ is the main line,
- ▷ $\%D$ is the signal line.

For the fast version, the Stochs lines are calculated as follow:

$$\begin{cases} \%K &= 100 \times \frac{Current\ Close - Lowest\ Low}{Highest\ High - Lowest\ Low} \\ \%D &= 3\ Periods\ Simple\ Moving\ Average\ Of\ \%K \end{cases}$$

where the highest high and the lowest low are picked in a 14 periods window.

The slow version is very similar: the slow $\%K$ is the fast $\%D$ and the slow $\%D$ is again a 3 periods simple moving average of the slow $\%K$. And the calculations are still made using a 14 periods windows. The full version is a completely customisable version when the lookback window and the average windows can be changed.

Independently of the chosen version, the interpretation has three steps: identifying overbought or oversold conditions, spotting crossovers and looking for divergences.

There is three different ways of getting a buy signal with the Stochs:

- ▷ The Stochs declines below 20% and rises above that level.
- ▷ The $\%K$ line crosses above the $\%D$ line.
- ▷ The $\%K$ line crosses above the 50% line.

Likewise there is three different ways of getting a sell signal with the Stochs:

- ▷ The Stochs rises below 80% and declines above that level.
- ▷ The $\%K$ line crosses below the $\%D$ line.
- ▷ The $\%K$ line crosses below the 50% line.

4.3 Bond

The Bond is another standard asset class that have been studied a lot. I will first introduce some indicators that are common to all bonds. Then I will present some specific indicators to the corporate, the government or the inflation-linked bonds.

I have selected eleven indicators:

- ▷ Five common indicators:
  - Yield,
  - Yield spread,
  - Real Rate,
  - Liquidity measures,
  - Maccaulay duration.
- ▷ Two corporate indicators:
  - Debt/EBITDA Ratio,
  - Interest Coverage Ratio.
- ▷ One Inflation-linked indicator:
  - Breakeven Rate.

Yield

No surprise for this one. The yield represents the annual return of a bond. It does not reflect the total return over the life of the bond. In particular, it takes no account of reinvestment risk (the uncertainty about the rate at which future cashflows can be reinvested) or the fact that bonds usually mature at par value, which can be an important component of a bond's return. It is calculated as follow:

$$Yield = 100 \times \frac{Annual\ Interest\ Payment}{Clean\ Price}$$

As for the PE Ratio concerning the Equity, we compare the Yield with its ten years average value. A higher Yield is more attractive for obvious reason.

Yield Spread

I will be really quick for this one also. It is worth looking at the evolution of the spread between the Yield of the considered bond, and the Yield of a benchmark. This comparison enables to see if the Yield is moving in the same way as the whole market.

A spread that is rising means a more attractive bond. As for the previous indicator, we compare the Spread with its ten years average value.

Real Rate

The Real Rate keep the same idea of the Yield Spread, but instead of comparing the Yield with the Yield of a benchmark, it is compared with the inflation rate.

In fact the Real Rate is the Yield minus the inflation rate. It is particularly worth-looking in the case of a government bond,but it is also useful for a corporate bond. In the case of an inflation-linked bond it is useless because its yield already take the inflation into account.

Liquidity measures

There are a lot of different methods to evaluate the liquidity of a bond, or even an asset in general. It is particularly useful for he bond market to look at the liquidity as it is normally a highly liquid market, so falls in liquidity are a indicator that the market is not doing very well.

I will not present all the liquidity measures. As I do not have access to the data about volume of trading, I only considered two measures. The first one is the MEC that I have already introduced in the cross asset classes studies when I was presenting the risk-adjusted ratio. The other one is a measure based on the credit default swaps (CDS).

This measure is based on the assumption that the theoretical yield of the corporate bond market can be evaluated with the government bond yield and the CDS in a perfectly liquid market. It is already established that:

$$Corporate\ Yield = Government\ Yield + Risk\ Premium$$

This measure says that the risk premium is divided in two parts: one is cover by the CDS premium, the other one is the liquidity premium. So the previous expression can be written:

$$Corporate\ Yield = Government\ Yield + CDS\ Premium + Liquidity\ Risk$$

So the spread between the corporate bond yield and the theoretical yield calculated by adding the CDS premium to the government bond yield is an approximation of the liquidity risk. A widening spread between the two is a sign that the liquidity of the bond market is falling. As for the previous indicator, a ten year windows is appropriate.

Macaulay duration

The duration is a key concept in the bond study. Duration is the most commonly used measure of risk in bond investing. Duration incorporates a bond's yield, coupon, final maturity and call features into one number, expressed in years, that indicates how price-sensitive a bond is to changes in interest rates.

There are a number of ways to calculate duration, but here I will introduce the Macaulay duration which is a frequently used one that is used to measure how sensitive a bond price is to changes in interest rates. The higher the sensitivity, the higher the risk, so a lower duration is preferable.

The Macaulay duration is the weighted average term to maturity of the cash flows from a bond. The weight of each cash flow is determined by dividing the present value of the cash flow by the price, and is a measure of bond price volatility with respect to interest rates. It is calculated as follow:

$$Macaulay\ Duration = \frac{\sum_{t=1}^{n} \frac{tC}{(1+y)^t} + \frac{nN}{(1+y)^n}}{P}$$

where t is the period in which the coupon is received, C is the periodic coupon payment, y is the periodic yield to maturity, n is the number of periods until the maturity, N is the nominal value (received at the maturity) and P is the market price of bond.

As mentioned earlier, a higher duration measures a higher sensitivity to changes in interest rates. Therefor I suggest to look at the current duration compared to its ten year average, with a lower duration as a buy signal.

Debt/EBITDA Ratio

The debt to EBITDA ratio is a measure of a company's ability to pay off its incurred debt. This ratio is worth-looking at when considering a corporate bond. It gives the investor the approximate amount of time that would be needed to pay off all debt, ignoring the factors of interest, taxes, depreciation and amortization. As expected, it is calculated by dividing a company's earnings before interest taxes, depreciation and amorization (EBITDA) of one period by the company's total liabilities:

$$Debt/EBITDA\ Ratio = \frac{Total\ Liabilities}{EBITDA}$$

This ratio is a common metric used by credit rating agencies to assess the probability of

defaulting on issued debt. A high debt/EBITDA ratio suggests that a firm may not be able to service their debt in an appropriate manner and can result in a lowered credit rating. Conversely, a low ratio can suggest that the firm may want take on more debt if needed and it often warrants a relatively high credit rating.

So a lower ratio is a sign of higher attractiveness for the investment. It is useful to compare the actual value with its historical average.

Interest Coverage Ratio

The interest coverage ratio is an other corporate bond indicator. This ratio is used to determine how easily a company can pay interest on outstanding debt. The interest coverage ratio is calculated by dividing a company's earnings before interest and taxes (EBIT) of one period by the company's interest expenses of the same period:

$$Interest\ Coverage\ Ratio = \frac{EBIT}{Interest\ Expense}$$

The lower the ratio, the more the company is burdened by debt expense. When a company's interest coverage ratio is 1.5 or lower, its ability to meet interest expenses may be questionable. An interest coverage ratio below 1 indicates the company is not generating sufficient revenues to satisfy interest expenses. A company that barely manages to cover its interest costs may easily fall into bankruptcy if its earnings suffer for even a single month. Therefor a higher ratio compare to the company's historical average will give a buy signal.

Break Even Rate

The breakeven rate is the key indicator when considering an inflation-linked bond. It is the theoretical inflation rate that makes the returns of a fixed-rate investment and the returns of an inflation-linked investment of similar maturity and credit quality equivalent. If inflation averages more than the breakeven, the inflation-linked investment will outperform the fixed-rate. Conversely, if inflation averages below the breakeven, the fixed-rate will outperform the inflation-linked. These three rates are linked by this expression:

$$(1 + Nominal\ Yield) = (1 + Real\ Yield) \times (1 + Breakeven\ Rate)$$

The breakeven should be co,pare to the actual value of the inflation. If the inflation is higher than the breakeven than the inflation-linked bond is a more attractive investment than the nominal bond.

4.4 Commodity

The commodity is the oldest asset class but its behaviour has not been studied as much as the one of equity or bond. However some indicators are commonly used amongst the

investing community. I have selected eight of them:

- The Sharpe Ratio,
- Four technical indicators:
  - The RSI,
  - The ROC,
  - The MACD,
  - The Modified Coppock Indicator, but for the study of gold only.
- Four indicators concerning future contracts:
  - The Contango or Backwardation market,
  - The Volume,
  - The Open Interest,
  - The COT Index.

For the Sharpe Ratio, the RSI, the ROC and the MACD I will not present them here and simply refer to the previous part about the equity market.

Modified Coppock Indicator

This technical indicator is a modified version of the Coppock indicator. The original indicator was developed by Edwin Coppock for identifying the commencement of bull markets. It was devised for use on the Dow Jones Industrial Average but is suitable for use on other market indices or averages. The version I will present was modified to identify new bull market in the price of gold. It is calculaed as follow:

$$Modified\ Coppock = 10 \times 39\ Weeks\ WMA\ Of(59\ Weeks\ ROC + 49\ Weeks\ ROC)$$

where WMA designed the weighted moving average and ROC the rate of change.

The modified Coppock indicator generates only buy signal that requires two conditions:

- The level of the indicator minus the level of its 16 weeks exponential moving average is greater than 0.07,
- AND the maximum level of the indicator over the previous 39 weeks minus its current level is greater than 0.002.

Volume and Open Interest

When considering a commodity, the study of the futures contracts is a great source of information. The volume and the open interest are two quantities that should be looked at as a pair.

The volume represents the total amount of futures contracts that have changed hands in a given commodity market in a single trading day. The open interest is the total number of outstanding contracts that are held by market participants at the end of each day. A knowledge of volume and open interest can prove useful to give early warning of reversal point.

The relationship between the price, the volume and the open interest can be summarized by the following table:

Price	Volume	Open Interest	Interpretation
Rising	Rising		Trend: bull market
	Falling		Warning: End of bull market
Falling	Rising		Trend: Bear market
	Falling		Warning: End of bear market

Figure 11: Commodity market: Relationship between price, volume and open interest.

COT Index

The Commitment Of Trader (COT) Index is a technical indicator using the information about futures contracts. This indicator watches closely the changes in commercial positions on the futures market, because the commercial traders are supposed to be the one with the most information, so the one to follow. It is calculated as follow:

$$COT_{index} = 100 \times \frac{Current\ Net - Lowest\ Net}{Highest\ Net - Lowest\ Net}$$

where the net is the number of long commercial positions minus the number of short commercial positions. the dafault comparison period is three years. This indicator gives overbought and oversold signal. A sell signal occurs when the COT Index declines below 10% and rises above that level, while a buy signal occurs when it rises above 90% and declines below that level.

4.5 Real Estate

Finally I will finish this part with the indicators for the real estate market. Everyone knows about it, but no one manages to create a model for the real estate market. So many criteria are involved, and the most important ones are of course:

Location, location, location.

However there are some quantities that are worth-looking at. I have selected four of them for the real estate market:

- ▷ The Sharpe Ratio,
- ▷ The House Prices,
- ▷ The price-to-rent ratio,
- ▷ The price-to-income ratio.

I will not introduce the Sharpe ratio again as I already did in the previous parts of this report. However after having presenting the rest of these indicators, I will add a few words about the REITs.

A first remark about real estate is that it is not possible to have data for individual property, so what are studied here are the real estate in each country.

House prices

In this particular case I do not look at the house prices themselves, but at their yearly percentage changes. In fact the changes in the price represents one source of returns for the real estate.

This indicator is really simple, a higher return is preferable, so a higher price change is preferable. I suggest to simply compare the actual value with its ten year average.

Price-to-rent ratio

The name of this indicator is obvious enough. This ratio is simply the average between the price of a real estate investment and the monthly rent that is paid. These two quantities are based on average for each country.

It is worth-looking at this ratio because the rent is the second source of returns for a real estate investment. As expected, the lower the value of this ratio, the more attractive the investment is. Then it is sufficient to compare this value with its ten year average.

Price-to-income ratio

The price-to-income ratio is actually a mix of the two previous indicator. It is the ratio of the price of the investment and the monthly returns it generates. But these returns simply take into account the rent and the monthly price changes.

The interpretation is similar to the price-to-rent ratio, a comparison between the actual value and the ten year average gives an indication about the attractiveness of the investment.

REITs

REITs are traded like equity, so the equity indicators can be used. However, some specificities of the REITs can have an impact on these indicators. I will just present two results.

About the dividend yield, it is even more important to look at it for he REITs as they are forced by laws to give at least 90% of its taxable income in the form of dividends.

The other point is about the PE ratio. The earnings may not be the best quantity to use here as the amortization and depreciation of the real estate is taken into account and have an influence on the PE ratio. However it should not be because the real estate is the product that makes REITs earn money. Therefor the funds from operations (FFO) seems to be a much more appropriate quantity to evaluation the real earnings of the REITs.

5 Tests and Implementation

Now that I have presented all the different indicators that I am considering, it is time to implement them and linked them with the database. Before creating the final tool, I began with a small prototype that I will present, but first of all there is another issue which is the availability of the data.

5.1 Data available?

A good indicator is useless without the data to calculate it. And it was the most important issue for the calculation of the indicator.

There is actually two different problems with the data. First some data are available but not frequently enough It is he case for the real estate market, where the data is only available on an annual basis, or in the best cases every quarters. So for the real estate only the Sharpe ratio is calculated.

The second problem is the fee to access the data. As informaion is valuable, there is a price to get it. It is worth it when the data is needed for different purposes, but paying just to be able to calculate a few indicators need negociations. That is why a lot of the indicators I have previously selected will not be included in the final project for now.

5.2 Prototype: Excel, VBA and Matlab

The implementation was a big part of this project. First I began by making little tests in Excel for each indicators. I just loaded data from a random asset and look at the result, what was the best way of putting it so the user would not have to search for the answer in a pool of information.

Then I created an actual prototype with the user interface in Excel where the user can choose the asset he want to consider, the data period he wants to look at and the parameters he wants to use for each indicators. All the calculations are made in Matlab and I use VBA as an intermediate between the two.

Simply said, the user chooses what he wants to calculate in Excel, then Excel load the appropriate data, VBA send these data to Matlab which uses them to calculate all the indi-

cators, then VBA send the results to Excel which displays them.

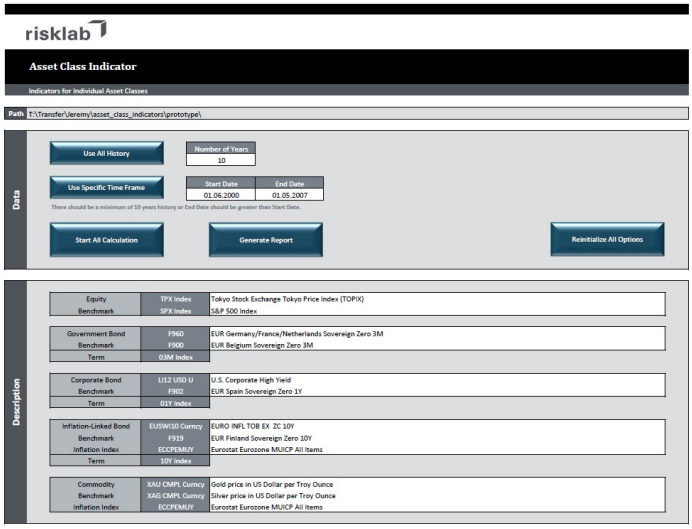

Figure 12: Screen shot of the prototype.

Nothing is optimal in this prototype, the calculations are time consuming, some of the loaded data are not used and the displaying in Excel is time-consuming. But this prototype filled his mission and was really helpful for the implementation of the final tool, and the communication with the programming team concerning the results that are expected.

5.3 Tool: C# with an interface Web

Once the prototype was working, the implementation of the real tool began. I can not say much in this part since it is still under process, I will simply describe the squeleton of the tool, with the different technology used for each part.

The tool is developped as a web application. All the calculations are made on the server side, which stocks the results on a database. Then the web page on the client side just display the corresponding data from this database. The tool is implemented with the framework MVC Web API which is a new technology for creating single page application like this one.

On the server side, all the calculations are made using C#. Different libraries have been created to calculate the different indicators, and then a factory to calculate all of them at once and stock the results in a database. The results are simply stock as a structure composed of array: for each index included in the database, all the indicators are available. To play with all the time series, the Deedle library has been used. It offers an easy solution to manage time series, which is the heart of this project. Concerning the database MongoDb was choosed because it is a very light way of stocking the data in JSON.

On the client side, Angulars JS is used. This framework is specialized in building single page application. It is a powerful technology which made the development HTML really easy. This technology is particularly strong in reading dynamically from JSON ressources which is exactly the case here. Finally for the look of the web page and especially the display of the charts, Kendo UI has been chosen. It gives really nice results and has special features when used in combination with Angular JS.

The implementation is in process for now. Everything is finished on the server side but the client side still needs some work. Finally one important remark is that this tool will not be as flexible as the prototype. As all the calculations are not made on the fly but on a daily basis and stocked on the database, the choices for the parameters are limited. But is should not be a real issue. If needed, a new choice can be added occasionaly. It will be a constant discussion with he users of the tool to see what are their needs.

6 Conclusion

As I already said, this report is the result of my five months internship at risklab GmbH. I will now present in a few words the result of the tool I have worked on, and the personal benefits I got from this experience.

6.1 Results of the tool

Like the prototype, the tool gives the expected results. The only problem now is the graphic interface which is not finished by the time I am writing this report. Once it is completely finished, the user would be able to have quickly some indications about the attractivness of the asset he is considering.

Then the tool could easily be updated to show new indicators that are then available if we have access to more data for example

6.2 Personal perspectives

During these five months, I had the great opportunity of creating a project from scratch. From the research phase to the customization of the user interface, not forgetting the implementation of the calculations.

I was evolving in real autonomy, interacting with different people at different phases of the project. Considering that, I have greatly improved my communication skill because the way of communicating varies given who you want to deliver your message.

The working environment was in English, so I had the opportunity to master my knowneldge of this language. Sadly I did not improve my German as much as I wanted.

For the implementation of the tool, I had the chance to learn a few new languages. I applied what I knew in MATLAB and VBA, but I also get to work with C# and ASP.NET.

So for me this internship has been a very rich experience from which I learned much more than I expected in the financial field, the informatic field and also the human field.

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THESIS

WEBPAGE

WEBSITE