

MIMS – Multi Asset Global Opportunities Fund

Portfolio Management Team

Report – December 2021

Fund description

MIMS – Multi Asset Global Opportunities Fund is an actively-managed fund by Minerva Investment Management Society, based on environmental, social, and governance (ESG) criteria.

The ultimate goal of this portfolio is to achieve long-term growth whilst controlling volatility. To that end, this fund is comprised of a multitude of securities with the possibility, in exceptional cases, to take short term speculative positions. Hedging positions might be implemented through financial derivative instruments. To ensure diversification, this virtual portfolio is spread across geographies, sectors and asset classes, and is built through fundamental analysis, ESG integration and macroeconomic views.

In total, the asset allocation aims to include around 40 different securities with a changing risky component to take advantage of contingent market conditions. The dynamic asset allocation prevents us from using a reference benchmark. The portfolio will be rebalanced every six months, with exceptional reviews to position for market shocks. The holdings only include instruments from the public markets, spread across equity, fixed income, real estate and commodities. ETPs might be considered to take additional exposures to niche markets.



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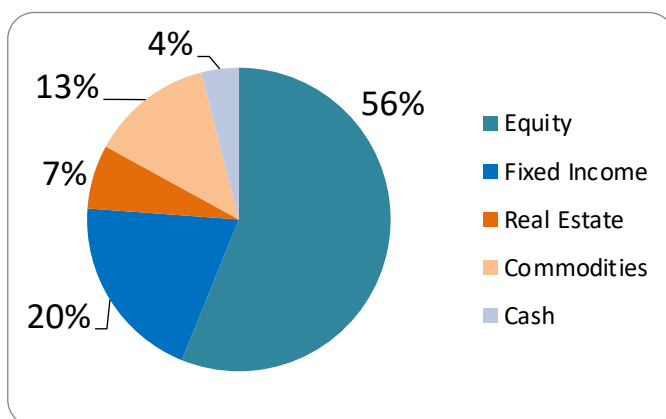
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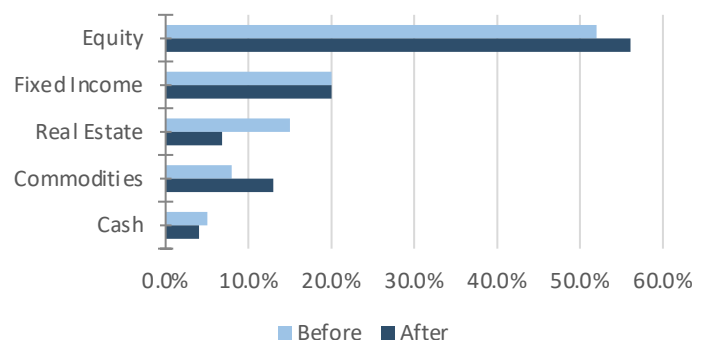
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Asset Allocation



Results of the current rebalancing



Investment Approaches

Top-down approach

Starting from the macroeconomic outlook provided by the Macro Research Team, the Investment Team identifies appealing industries, geographies and asset classes for which the best-performing securities will be analyzed thoroughly.

The Team applies a shared approach to the different asset classes by considering the main return drivers for any holding.

Bottom-up approach

If a security stands out to one of the Investment Analysts, the suggestion is discussed with the Team and further analysis follows.

Long-term growth potential combined with high ESG standards and limited risk downsides both on a micro and macro level are required to consider the investment.

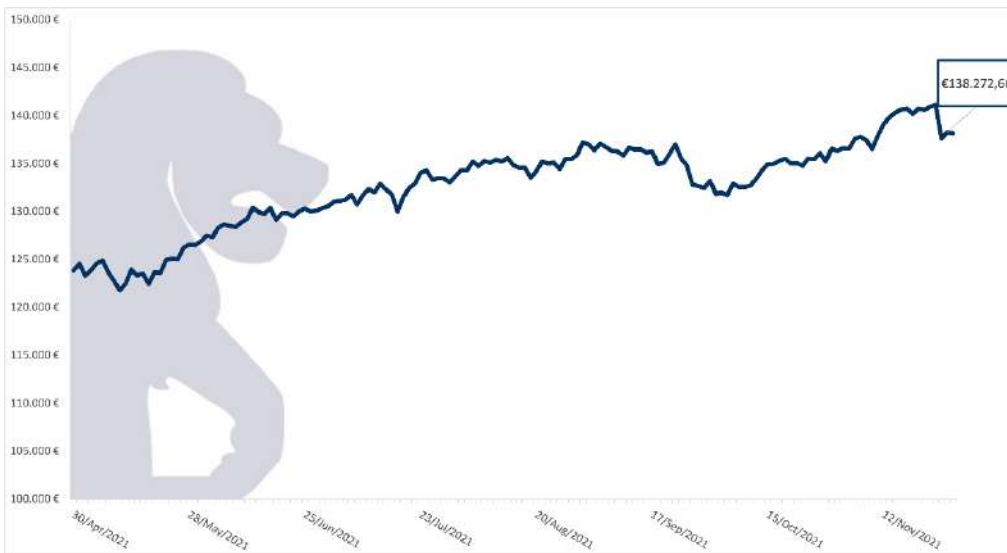
Research contribution

The investment process uses internal research produced by the Research division of Minerva IMS.

The Macro Team provides the outlook underlying the top-down approach. The Equity Team provides recommendations on potential stock holdings. Findings by the Markets and Alternatives Team are used for particular asset classes.

Performance since rebalancing

30.04.2021 - 30.11.2021



Initial holdings have been monitored since 05.12.2019 and additional ones have been introduced on 24.03.2020. The official starting date for the portfolio is 07.04.2020 and a second rebalancing took place on 23.11.2020, a third on 10.05.2021 and the last one on 30.11.2021. The analysis considered the cumulative gain over the entire period since inception. Any security is held only in a discrete number, stock dividends and bond coupons are reinvested at the end of the day in which payments are received.

The fund value is measured at the close of each trading day. Corporate events, dividend reinvestment and fund rebalancing are carried out at the market close.

Considering an initial value of € 100 000 at the market open of 07.04.2020, the portfolio reached a final cumulative value of € 138.272,66 at the close of 31.11.2021.

	1 month	2 months	3 months	Since inception	Daily Volatility	Sharpe Ratio
Multi Asset Fund	2.17%	4.31%	1.69%	38.16%	1.99%	1.42

Top 5 Holdings

Security	Weight
INTESA SAN PAOLO	6.0%
CUMMINS	6.0%
TOYOTA	6.0%
BROOKFIELD	6.0%
NEOENERGIA	6.0%

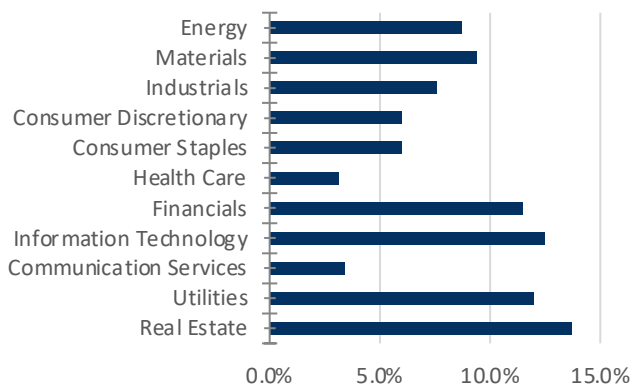
Top 5 Holdings

Country	Weight
USA	33.2%
ITALY	20.1%
GERMANY	9.6%
SWITZERLAND	9.1%
CHINA	5.7%

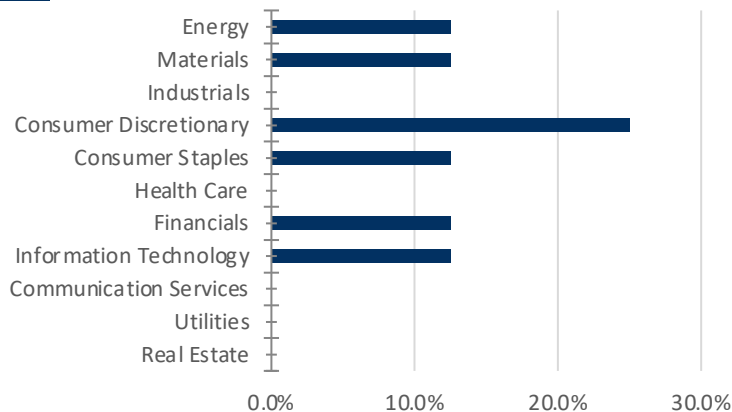
Note: the weights are a product of a Black_litterman mean-variance optimization. Further details in the last part of the report

Sector breakdown

Equity



Bond



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This semester the multi-asset fund has adopted a Mega-Trend Investing strategy based on an in-depth analysis of current opportunities in three booming scenarios. This strategy implies the risk of being incorporated in the mass debate. However, we conducted our analysis having a long-term and critical investing approach dividing current bubbles from real growth opportunities.

For these reasons, the allocation has been focused on three main sectors: Fintech & VR/AR, Green economy & ESG and Infrastructures & Value Stocks.

Starting from new disruptive technologies which are approaching the market, we found in the idea of metaverse the future of social network and digital environments, so we decided to take position in **Matterport (MTTR)** an innovative fast growing tech company operating in this segment. Another interesting investment, which has been suggested us by the Equity research division consists in the Italian digital payment company **NEXI (NEXI.MI)** where future opportunities come from an expanding sector and an external growth strategy based on acquisitions.

In the green economy we have completed, in collaboration with Macro Research division an in-depth research on commodities trying to find out the commodity of the future. The answer to our one million dollar question has been incredibly simple and trivial: Hydrogen. Following the spirit of our research we agreed that it could be better to add to our portfolio a Hydrogen-related stock with high growth potential instead of the commodity itself for several reasons. First, because hydrogen hides many investments risks related with high price volatility and liquidity lack, we preferred to increase to the portfolio a solid business which is working to implement its hydrogen sector and leading the market. **Cummins (CMI)** has been the perfect stock to serve this purposes.

The last investing thematic are infrastructures stocks, the spine of a recovering economy from the pandemic downturn and investments catalyst of mass worldwide governments recovery programs.

Moreover, to have a positive exposure on the high inflation the economy is experimenting, we increase our Value position.

At the end, we took position in **Brookfield Infrastructure Corporation (BIPC)** and **Novartis (NOVN.SWG)**



Disinvestment Cases & Asset Classes Overview

Equity

To finance our current rebalancing strategy, we divest in stocks which eroded their growth opportunities in years or did not confirm their disruptive potential in the last months.

We currently consider **Intel (INTC)** a risk for our cumulative return and diversification purposes since we have heavy exposures on the semiconductors industry and Intel has shown to lose important market shares in the last months.

Moreover, we divest for similar reasons also from **Viacom (VIAC)** and **M3 (2413.T)** since the Japanese company has suffered the high expectation on telehealth which have not been respected by the fact.

Commodities

We maintain our allocation in commodities, including **Crude Oil** which had in our previous rebalancing a relative weight of only 1%. The reason why we decide to maintain this investment despite your green idea is because the transition won't complete in few years being a small steps process. At the end our idea is to balance commodities to track the sustainability evolution process.

Bond & Real Estate

In the last semester we intervened closely on bonds to reduce the duration and on real estate to improve the diversification through residential and industrial REITS. Since the work done has been stable, we decided only to add to our allocation a **Kerry's Sustainability Linked Bond (SLB)** which will be analyzed closely in the last part of the report.

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New Investment Idea: Fintech&VR/AR

MATTERPORT (MTTR)

Product and Sector Introduction

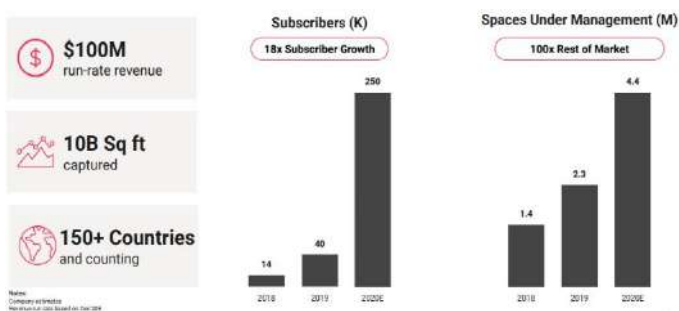
Matterport is the leading spatial data company focused on digitalizing and indexing the built world. Its platform, together with its advanced cameras, enables anyone to turn a physical space into an accurate and immersive digital twin.

In order to fully understand its business, it is necessary to first explain the meaning of “digital twin”.

A digital twin is a digital 3D copy of a real-world place or object. Artificial intelligence and machine learning technologies enable its creation which can be updated quickly to reflect changes with its physical counterpart.

The company’s mission is to allow anyone to experience a physical space without needing to be there. As result there are numerous use cases for the product: Real estate agents can list homes online which their customers can view in a VR headset without conducting multiple house visits. Architects can show their customers progress on a construction site from across the globe. Literally everything from museums, travel destinations, wedding venues, hotel rooms and war zones can be visited virtually. The NYTimes even launched its VR app to put readers in the center of news stories, including showcasing bombed sites and war zones using Matterport cameras.

It is easy to see how and why its revenues have grown significantly during the pandemic along with its subscribers. Here’s an overview on how the company’s numbers changed during last three years:



Business Model Analysis and Future opportunities

Let’s now analyze the business model used by the company: Matterport operates a B2B2C business, enabling its customers to serve their clients more effectively creating immersive content. The company currently runs on Hardwares (its cameras) + SaaS model (its platform) in the form of a monthly subscription. This model provides the company with a fairly stable income even at the most uncertain times and, together with the adaptable products that offers, a prospect of sustainable growth.

Matterport indeed presents high growth opportunities given the size of the target market: there are approximately 4 Billion Buildings around the globe which represent the largest asset class with a value of \$230T in total property and a large part of these are offline. The ambition of the company is to take them virtual.

It is also interesting to look at the future of the company: today Matterport is transforming buildings into data, tomorrow, maybe, their data will increase the value of every building.

Many companies and entrepreneurs (Zuckerberg for example) are now investing in metaverse and augmented reality and Matterport seems well positioned in this field. It could be a great stock to insert in our portfolio also because it is highly diversified with those already present.

However, given the current small size of the company and the high intrinsic risk of this sector, we feel safer to assign to the stock a moderate weight.

NEXI (NEXI.MI)

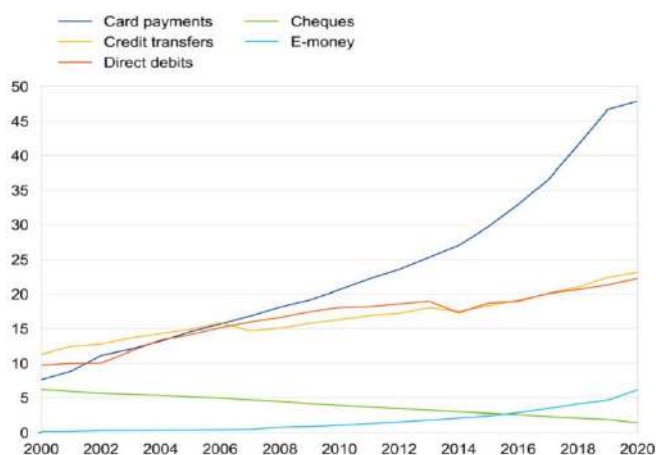
Sector Introduction

Digital Payments and digital banking solutions have grown in volume in recent years and in particular in 2020 due to the Covid-19 pandemic. Latest annual report of the Bank of Italy shows how in the European Union, from 2005 to 2018, digital operations per capita went from 166 to 272 annually while the share of credit cards with respect to the total of transactions went from 30.1% to 52.1%.

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Nexi mainly operates in Italy which remains late with respect to Europe in digital solutions: in 2019 only 125 operations were carried out per capita and this could mean that there is still room for growth and improvement for the sector in this country and, therefore, also for Nexi.

M&A Activity

The company is also carrying out two interesting M&A campaigns aimed at consolidating its leading position in Italy and trying to become the largest pan-European platform for digital payments and solutions.

On 5 October 2020, a memorandum of understanding was signed between Nexi, SIA, CDP Equity, FSIA and Mercury, concerning the integration of the two groups to be realized through the merger by incorporation of SIA in Nexi. The Italian guarantor authority has released its approval in September 2021, giving an important boost to the merger.

This agreement may bring significant benefits to Nexi, allowing it to become a European champion in the sector of digital payments with aggregate revenues pro-forma 2019 for €1.8B and an aggregate EBITDA pro-forma equal to €1B.

Furthermore, the strategic aggregation of SIA into Nexi will allow the achievement of important industrial and financial synergies, initially quantifiable in approximately € 150 million recurring per year when fully operational, and analysts are expecting a double-digit increase of the EPS cash in 2022. Lastly, SIA operates in 50 countries and could be a first step towards the internationalization of Nexi.

Nexi has signed also a binding agreement with Nets on 15 November 2020 concerning the integration of the companies through a merger that will be entirely carried out in stocks. The combination would lead to a leadership in terms of products offered and efficiency, with approximately €2.9B of estimated revenues and approximately €1.5B of EBITDA estimated on pro-forma basis for 2020, including fully operational synergies and assuming the closing of the merger with SIA.

Growth Strategy

A final point supporting our idea is the company's growth strategies until 2023, oriented and supported by great innovation. Latest report highlighted Five pillars on which Nexi's strategy is based:

- Growing through the offer of innovative products with a high technological content in all segments of digital payments;
- Investing in best-in-class technology and development capabilities;
- Develop operational excellence;
- Continue to develop the best skills focused on digital payments at an international level;
- Continue to strengthen Nexi through strategic partnerships and acquisitions aimed at creating additional value for shareholders.

In conclusion, Nexi seems to be a good stock for the future, both for the intrinsic qualities of the company and for the sector's growth opportunities.

New Investment Idea: Infrastructures

Focus: Infrastructure Sector Outlook

The year that is about to end may represent, if it has not already, a turning point for the infrastructure industry which, in turn, could become the driving force of the economy for the short and medium terms. The pandemic has disrupted the industry as it used to be and it boosted several trends that range from technological development to sustainability and affordability of the projects, both in the private and in the public sector. According to PwC, it will take some years for the effects of the pandemic to fully play out, yet in the short term it is still possible to identify four major trends, namely: intensifying the focus on operational resilience, the affordability of infrastructure, the deployment of new technologies and the need for sustainability.

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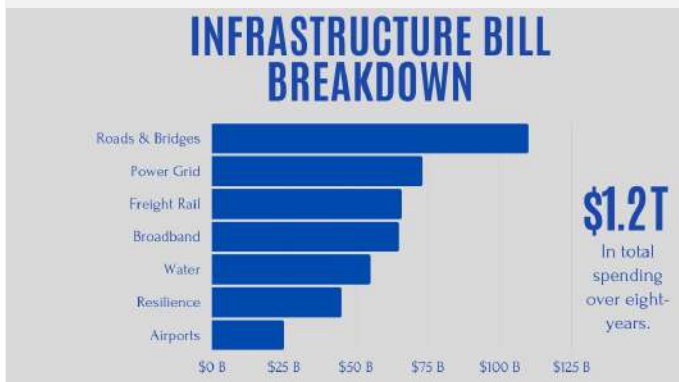
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Starting from operational resilience, the raw material shortage that the whole global economy faced this year showed how it is fundamental to be able to quickly redesign the supply chain in order to keep the production steady and not slow during periods of crisis. When it comes to technology, many studies show how the industry is underinvested in innovative technologies with respect to other capital-intensive industries. Clearly, a wider implementation of technology will result in increased productivity and efficiency of the firms. Finally, it is important to stress that the transition to low-carbon, climate-resilient infrastructure assets remains a key aspect. Estimates show that 70% of the increase in future greenhouse gas emissions will come from infrastructure that haven't even been built yet. Therefore, the key is in providing the stimulus to incentivize the construction of ESG infrastructures.

Under these circumstances, the most important act made by a government must be the Infrastructure Investment and Jobs Act proposed by the Biden Administration and passed into law on November 15th, when the American President signed it. The new infrastructure bill boasts a \$1.2 trillion price tag that includes \$550 billion in new spending that should be a boon to traditional infrastructure stocks.



BROOKFIELD INFRASTRUCTURE CORP. (BIPC)

Company Overview

Together with its sister company Brookfield Infrastructure Partner, BIPC is one of the largest diversified infrastructure stocks in the world, with operations spanning utilities, transportation, energy and even data infrastructure.

The stock appears the perfect fit for someone interested in this attractive industry that looks for well diversified stock that is also highly capitalized. Indeed, with 2.81 billion dollars of market capitalization, BIPC can be classified as mid-cap, and its operations in so many different infrastructure sub-sectors allow to capture the overall boost that the industry is likely to get from everything that is described above. Moreover, its operations are global and not limited to the US market alone.

Market Moves

The dividend policy of the company has always been friendly to investors, with a dividend growth rate always between 5 and 9%, well above the average inflation rate. In addition, the target long-term return on equity is a very strong 12-15%. The current price is slightly below 60 USD, at 59.48, which coincides with an 8% loss with respect to the 52 weeks ago price. However, analysts suggest buying and the average target price for the year-long horizon is set at 70 USD.

Financials

Keeping an eye on the major financial indicators, BIPC was finally able to post positive earnings during the quarter which ended in September 2021 after a struggle which lasted since the beginning of the pandemic. In the last 5 quarters, as reported by the official income statements, the revenues/sales growth was 12.17%, allowing the EBITDA to increase by 432.21 million USD. This means that, even though the firm is capital intensive, its operations are growing and will be able to remunerate the investors. Liquidity ratios still must recover from the pandemic hit, with a current ratio of 0.21 and a cash ratio of 0.07. However, Free Cash Flow has increased by 195.53 million USD while capital expenditures have decreased by 143.68 M dollars over the last 5 quarters, meaning an improving liquidity outlook for the quarters to come.

Overall, we believe that Brookfield can embed all the positive trends and increased investments in the infrastructure industry and will have a positive impact on the overall portfolio, thanks to good growth prospects combined with a well-diversified risk.

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Focus: Inflation & Value Stocks

A value stock refers to shares in a company that appear to be trading at a lower price than its fundamentals, such as dividends, earnings, or sales, which makes it attractive to value investors.

Investor in value stock try to have a profit on the possibility of a wrong market price compared to the company performance.

Usually, stocks that are considered to be Value, have:

- High dividend yield;
- Low price to book ratio;
- Low price to earnings ratio.

A value stock will most likely come from a mature company with a stable dividend issuance that is temporarily experiencing adverse events.

Generally during high inflation periods value stock tend to have a greater performance compared to growth stock because value stock already have strong cash flows which increase with inflation, whereas growth stock have low cash flows, considering that their value is for the potential growth in the future, thus resulting in a poorer performance.

For the above-mentioned reasons in this time of high inflation, value stock may be and investment to be considered.

Novartis (NOV.EB)

Company Overview

Novartis AG is a Switzerland-based pharmaceutical company. The Company develops, manufactures, and markets branded and generic prescription drugs, active pharmaceutical ingredients (APIs), biosimilars and ophthalmic products. The Company uses science and digital technologies for treatments in the disease areas of immunology, dermatology, cancer, ophthalmology, neuroscience, respiratory, cardiovascular, renal and metabolism. The business activities of the Company are divided into two segments: Innovative Medicines, which includes innovative patent-protected prescription medicines for blood pressure, cancer and other ailments, and Sandoz, which includes generic pharmaceuticals and biosimilars.

Financials

Analysts forecast for the future years a slight increase in company earning, as shown in the graph attached.

It is also forecasted a 7% revenue increase in 2021 and a 11% increase in 2022.

Highlights in Fundamentals

- The company's net margin has been higher than its industry group average for each of the past five years;
- NOVN's days sales in receivables of 74.0 is substantially shorter than the Pharmaceuticals industry group average of 139.0;
- In the 10 firms' group within the Pharmaceuticals industry, Novartis is among 3 companies that pay a dividend. The stock's dividend yield is currently 4.0%.

New Investment Idea: Hydrogen

Minerva Macro Division Focus: Proprietary Research

Main Definitions

Hydrogen fuel cells use chemical reactions to generate zero-emission electricity that can be used in transportation and other applications.

Black, brown and grey hydrogen

Grey hydrogen is the most common form and is generated from natural gas, or methane, through a process called "steam reforming".

This process generates just a smaller amount of emissions than black or brown hydrogen, which uses black (bituminous) or brown (lignite) coal in the hydrogen-making process.

Black or brown hydrogen is the most environmentally damaging as both the CO₂ and carbon **monoxide generated during the process are not recaptured.**

Blue hydrogen

Hydrogen is labelled blue whenever the carbon generated from steam reforming is captured and stored underground through industrial carbon capture and storage (CSS).

Blue hydrogen is, therefore, sometimes referred to as carbon neutral as the emissions are not dispersed in the atmosphere.

However, some argue that "low carbon" would be a more accurate description, as 10-20% of the generated carbon cannot be captured.

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Green hydrogen

Green hydrogen – also referred to as “clean hydrogen” – is produced by using clean energy from surplus renewable energy sources, such as solar or wind power, to split water into two hydrogen atoms and one oxygen atom through a process called electrolysis.

Renewables cannot always generate energy at all hours of the day and green hydrogen production could help use the excess generated during peak cycles.

It currently makes up about 0.1% of overall hydrogen production, but this is expected to rise as the cost of renewable energy continues to fall.

Many sectors also now see green hydrogen as the best way of harmonizing the intermittency of renewables – storing excess energy at times of low demand to be fed back into the grid when demand rises – while decarbonizing the chemical, industrial and transportation sectors.

Worldwide Perspective

More than 30 countries have developed hydrogen road maps, and 228 large-scale hydrogen projects were announced across the value chain. Hydrogen could meet 18% of total global energy demand and create a \$2.5 trillion market with more than 30 million jobs by 2050.

Japan is leading in hydrogen fuel cell technology, while the United States is at the forefront of laboratory research. Europe is more focused on upstream hydrogen production, and China has the largest hydrogen market.

Fuel Cell Electric Vehicles (FCEVs), powered by hydrogen, have significantly improved energy efficiency than conventional internal combustion engines or ICE vehicles powered by diesel and petroleum, and produce no exhaust emissions except for water vapors.

Toyota Motor is a leader in hydrogen fuel cell vehicles. The Japanese automaker unveiled the world's first mass-produced hydrogen fuel cell car in 2014 and launched its second-generation Mirai - the Japanese word for "future" - last year. In the first quarter, Toyota sold 2,000 fuel cell vehicles, accounting for half of global sales, according to energy market researcher SNE Research.

Cummins (CMI)

Company Overview

Cummins is an American multinational corporation based in Indiana that specializes in diesel and alternative fuel engines and generators, and related components and technology. Cummins is currently working on three projects that use hydrogen production as a means to store renewable energy, a key issue for proponents of wind, solar, and other low-carbon renewable energy sources. Using renewable sources such as wind to produce hydrogen emits no greenhouse gases. Over the last years, the company has been expanding into the hydrogen production business.

In 2019, Cummins acquired Hydrogenics, a developer and manufacturer of hydrogen generation as means of strengthening its fuel cell capabilities. Since its acquisition two years ago, Cummins has been able to further innovate and scale hydrogen fuel cell technologies across the American and Asian markets. Similarly, the company is also part of a joint venture with NPROXX, a leader and supplier of hydrogen storage technologies. Together with NPROXX, Cummins has been able to begin testing its hydrogen-fueled internal combustion engine. Finally, it is also worth mentioning that the company has most recently been selected by the American Office of Energy Efficiency and Renewable Energy to receive financial support as part of their projects to advance “next-generation clean hydrogen technologies.”

Financials

By analyzing the company's financial statements, it is possible to identify a continuous earnings growth trend, a high ROE, and a strong balance sheet. Last year the company showcased an earnings growth of 39.8%, and over the span of 5 years it has shown an overall 11.1% earnings growth. Moreover, Cummins' 25.3% ROE also demonstrates a profitable usage of the shareholders' money. Finally, a look at the balance sheet allows us to observe how both long-term and short-term assets are greater than the firms' respective debt. When comparing Cummins to competitors like Parker Hannifin (PH), Emerson Electric (EMR), or Eaton Corporation (ETN), it is possible to observe a higher degree of sales growth of 22.7%, a balanced payout ratio of 35.8%.

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Focus: Sustainability-Linked Bond

Main features

Sustainability-Linked bonds are any type of bond instruments for which the financial/structural characteristics can vary depending on whether the issuer achieves predefined Sustainability/ESG objectives. These objectives are:

- measured by Key Performance Indicators (KPIs);
- assessed against predefined Sustainability Performance Targets (SPTs).

Hence, the SLB will need to include some financial/structural impact involving trigger events (e.g., variation of the coupon).

The proceeds of SLBs are intended to be used for general purposes, therefore the use of proceeds can not be considered a determinant in its categorization.

KERRY'S INAUGURAL SUSTAINABILITY-LINKED BOND

Company Overview

Kerry is one of the world's leading Taste and Nutrition company, which supplies food, beverage and pharmaceutical markets with almost 20,000 products. The Group employs over 23,000 people with a presence across Europe, North America, South America, Australia, New Zealand and Asian Markets, serving 150 countries worldwide.

In 1986 the Irish company went public and now it is listed on the Dublin and London Stock Markets.

Credit profile

Rating Agency	Long term	Outlook
S&P	BBB+	Stable
Moody's	Baa2	Stable

Bond outstanding

Outstanding bond instruments	Issue Date	Maturity Date	Nominal Amount
\$ Public Bond – 2023	April 2013	April 2023	\$750 million
€ Public Bond – 2025	Sept 2015	Sept 2025	€950 million
€ Public Bond – 2029	Sept 2019	Sept 2029	€750 million

Inaugural Sustainability-Linked bond highlights

On 24^o November Kerry announced its inaugural €750m 10-year sustainability-linked bond. The instrument is linked to two company's KPIs:

1. Absolute Scope 1 & 2 greenhouse gas emissions reduction;
2. Food Waste reduction across own operations.

Scope 1 emissions refer to all direct emissions from the operations that are owned or controlled by the company. Instead, Scope 2 emissions indicate the ones from the generation of purchased or acquired electricity, steam, heating or cooling consumed by the company.

The Sustainability Performance Targets are set as follow:

By December 2025:

- I. Reduction of 49% in absolute Scope 1 & 2 GHG emissions;
- II. Reduction of 30% in Food Waste.

By December 2030:

- I. Reduction of 55% in absolute Scope 1 & 2 GHG emissions;
- II. Reduction of 50% in Food Waste.

Both the targets are against the 2017 baseline.

The coupon is set at 0.875% while the yield is equal to 0.931%. The final coupon will step up depending on whether each of the condition will be met or not:

- a) +50bps if either of the two step-ups events occur;
- b) +100bps if both step-up events occurs.

The structure described is in line with Kerry's Sustainability-Linked Bond Framework (November 2021), for which ISS ESG provided a Second Party Opinion confirming its alignments with International Capital Market Association (ICMA) SLB principles. In addition, ISS defines Kerry's KPI as "relevant " and "ambitious".

The Group will publish on its website an annual Sustainability-Linked Bond Progress Report, which will be part of the Annual report (Sustainability Review section). The performance of the relevant KPI in the SLB Progress Report will be verified by an independent external reviewer.

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Quantitative Research Team

Risk Report – December 2021

Introduction

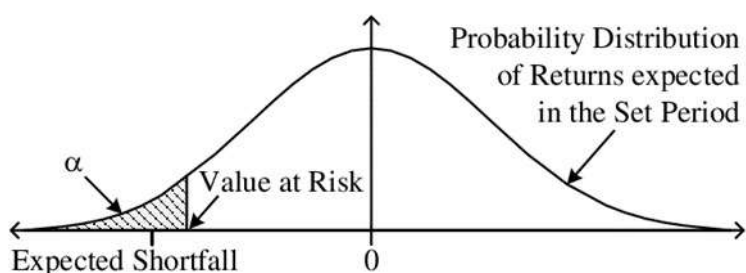
The main objective of this section is to assess and quantify the risk embedded in the Minerva IMS Multi Asset Global Opportunities Fund built by the portfolio team. We use a daily perspective on the potential extreme behavior of a basket of assets selected by the portfolio analysts. The analysis will include three VaR and ES models (two parametric and one non-parametric) and a Black-Litterman model for optimal allocation.

Our focus is the estimation of the two main risk indicators:

- The daily Value at Risk (VaR): the maximum portfolio loss that occurs with $\alpha\%$ of probability over a time horizon of 1 day. For instance, if the VaR ($\alpha=5\%$) = -3.00%, it means that tomorrow there is a 5% probability of encountering a loss in the interval [-100%, -3.00%] potentially;

- The daily Expected Shortfall (ES): the expected return on the portfolio in the worst $\alpha\%$ of cases. So, it is just a mean of the returns lower than the VaR.

A simple technique to estimate these two measure is based on a historical approach: given a time series of returns of a financial security, we can easily compute the desired quantile of the historical distribution to estimate the VaR, and, after that, estimate the ES just by averaging the values below this threshold.



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However, this naive approach is not well suited for our purpose: in fact, by considering our portfolio as a single financial asset, we are losing all the information that comes from all the components; moreover, with this approach we are simply focusing on the past behavior of the fund, while our main goal is to retrieve a risk metric for the future possible trends.

In order to overcome these issues, we propose two alternative techniques that provides better risk estimates:

- Parametric approach (simple approach and time-series modelling approach)
- Bootstrapping

The first method is very well suited for understanding the main vulnerabilities in the portfolio composition, while with the second one it is possible to observe how the metrics varied in the past quarters.

For both pieces of analysis we used daily market prices of portfolio constituents for the period Jul.19 – Apr.21. All the analysis has been conducted with Python.

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In this section we propose to analyze VaR and ES separately for each asset included in the portfolio and then, to estimate the VaR and ES for the whole fund by taking into account the correlation between portfolio constituents.

Parametric approach is based on the assumption that returns of a financial security follow some theoretical distribution. Thus, VaR and ES can be expressed as an α -percentile of the distribution. The crucial step to accurately estimate VaR and ES is to select the appropriate distribution of returns and estimate its parameters.

It is possible to state that stock returns do not follow Gaussian distribution due to the presence of "fat tails": unexpected events might have a huge impact on the stock prices, so it is possible to observe extreme values more frequently than a Normal distribution would predict. For this reason, we assume that stock returns follow a Student-t distribution, thus, the parameters to be estimated are the mean μ , volatility σ and number of degrees of freedom ν .

To obtain more valid and robust results, we proceed with two alternative parameter estimation approaches – (a) simple approach, and (b) time-series modelling approach. For all parts of analysis, we use the last 100 return observations, which correspond almost to 4-months window.

Simple approach

Under the simple approach, we estimate the above-mentioned parameters in the following way:

1. We assume that the mean historical daily return of each security are a good estimate for the expected future return. Thus, μ is estimated as a simple average of daily returns.
2. Volatility of returns σ is calculated as a simple standard deviation of returns.
3. Number of degrees of freedom ν is selected in a way that it best approximates the empirical distribution of returns. In order to do that, we used the Kolmogorov-Smirnov statistic that, for a given empirical cumulative distribution function F and a proposal F_n , is:

$$D_n = \sup x |(F_n - F)|$$

Ideally it should be equal to 0 for a perfect fit, so our goal is to minimize it by proposing different ν for Student-t distribution.

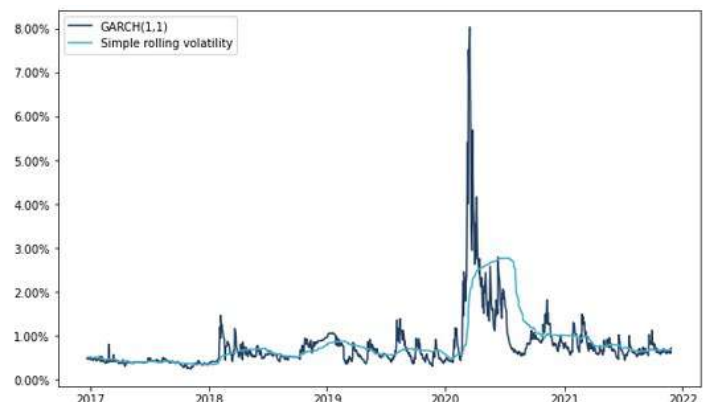
Time-series modelling approach

Because the volatility of returns is not constant over time, it is often modelled by conditional heteroscedasticity processes. The most common way to model volatility is through a Generalized Autoregressive Conditional Heteroscedasticity model GARCH(p,q), where the forecast of the next-period volatility depends on the previous p shocks to stock returns (derived from some mean model) and previous q forecasts of volatility:

$$\sigma_{t+1|t}^2 = \omega + \sum_{i=1}^p \alpha_i \epsilon_{t-i}^2 + \sum_{j=1}^q \beta_j \sigma_{t-j+1|t-j}^2$$

The advantage of GARCH model is that it allows to better estimate the current forecast of return volatility by putting more weight on more recent information. Thus, in the periods of market turbulence GARCH model will produce higher volatility forecasts than the simple average of squared deviations from the mean (see the graph at the bottom).

Because the portfolio is composed exclusively of equity instruments traded on liquid markets, we can assume that prices are efficient, and thus returns can be described by a constant mean model for GARCH(p,q) process, which implies that current mean estimates do not depend on previous returns or shocks. GARCH(p,q) then is estimated by Maximum Likelihood (MLE), which optimizes the distribution parameters. We subsequently use MLE estimates of distribution to derive VaR and ES.



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Parametric approach (continued)

Value-at-risk

Once the parameters of stock returns are known, it is possible to calculate VaR. We estimate the VaR for 95% and 99% confidence level by applying the following formula:

$$VaR_{\alpha} = \sigma * T_{\nu}^{-1}(\alpha) + \mu$$

where σ is the estimated volatility of a security, $T_{\nu}^{-1}(\alpha)$ is the α -percentile of a Student-t distribution with ν degrees of freedom, and μ is the expected return of a stock.

Expected shortfall

Expected shortfall is defined as a conditional expectation of loss, given that the loss occurred. If we introduce the assumption of a continuous distribution of returns of a security, then parametric expected shortfall is simply defined as a tail conditional expectation, and thus can in general be defined by the following formula for any security X :

$$ES_{\alpha}(X) = -\frac{1}{\alpha} \int_0^{\alpha} VaR_{\gamma}(X) d\gamma$$

Under the assumption of Student-t distribution with ν degrees of freedom it can be proven that the expected shortfall would be given as:

$$ES_{\alpha}(X) = \sigma * \frac{\nu + (T_{\nu}^{-1}(\alpha))^2}{\nu - 1} \frac{\tau_{\nu}(T_{\nu}^{-1}(\alpha))}{\alpha} + \mu$$

where σ is the estimated volatility of a security, $T_{\nu}^{-1}(\alpha)$ is the α -percentile of a Student-t distribution with ν degrees of freedom, $\tau_{\nu}(\cdot)$ is the probability density function of Student-t distribution with ν degrees of freedom and μ is the expected return of a stock.

We estimate the ES for 95% and 99% confidence level.

TOP & BOTTOM 5 stocks (simple approach)

	VaR 95	VaR 99	ES 95	ES 99
NVS	-1.53%	-2.17%	-1.92%	-2.50%
IG.MI	-1.09%	-2.44%	-2.15%	-2.82%
PLD	-1.77%	-2.61%	-2.29%	-3.04%
NESTLEIND.NS	-1.86%	-2.67%	-2.36%	-3.09%
EQR	-1.92%	-2.80%	-2.46%	-3.25%
	VaR 95	VaR 99	ES 95	ES 99
AIR.PA	-3.24%	-4.63%	-4.10%	-5.34%
600585.SS	-3.52%	-4.99%	-4.42%	-5.75%
ASML	-3.55%	-5.21%	-4.57%	-6.09%
MU	-3.80%	-5.64%	-4.97%	-6.57%
MTTR	-8.29%	-12.20%	-10.70%	-14.29%

Portfolio VaR and ES

Considering the correlation between the stocks, we estimate the VaR and ES of the whole portfolio for 95% and 99% confidence level by applying the following formulas:

$$VaR_{\alpha,ptf} \approx \sqrt{VaR_{\alpha} * \rho * VaR_{\alpha}'}$$

$$ES_{\alpha,ptf} \approx \sqrt{ES_{\alpha} * \rho * ES_{\alpha}'}$$

where VaR_{α} and ES_{α} are column vectors of individual stock VaR and ES, respectively and ρ is the correlation matrix between securities

The approximation arises because of the assumption of Student-t distribution of returns – the formulas above become an equality the closer the distribution of returns is to the Gaussian.

Results

GARCH results appear to be more conservative than the simple approach ones. Indeed, while simple approach equally weights all observations, GARCH puts more weight on the most recent observations, thus, it better estimates the future volatility and allows to produce more reliable risk metrics.

	Simple approach	GARCH
VaR_{95%}	-1.04%	-1.29%
VaR_{99%}	-1.50%	-2.17%
ES_{95%}	-1.33%	-1.86%
ES_{99%}	-1.74%	-2.92%

TOP & BOTTOM 5 stocks (GARCH)

	VaR 95 (GARCH)	VaR 99 (GARCH)	ES 95 (GARCH)	ES 99 (GARCH)
EQR	-1.47%	-2.15%	-1.89%	-2.49%
NVS	-1.42%	-2.23%	-1.93%	-2.79%
IG.MI	-1.59%	-2.32%	-2.04%	-2.72%
PLD	-1.55%	-2.48%	-2.13%	-3.08%
AAPL	-1.70%	-2.58%	-2.24%	-3.07%
	VaR 95 (GARCH)	VaR 99 (GARCH)	ES 95 (GARCH)	ES 99 (GARCH)
UBSG.SW	-5.07%	-9.02%	-7.69%	-12.64%
AIR.PA	-4.95%	-9.28%	-7.91%	-13.85%
600585.SS	-4.88%	-9.40%	-8.06%	-14.73%
DIS	-5.40%	-11.43%	-9.85%	-19.81%
MTTR	-12.33%	-23.94%	-20.43%	-37.19%

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Bootstrapping

When estimating a certain metric, one of the main problems in Statistics is the lack of the whole population data and the consequent use of only a sample. In our case the population data is the complete historical price data of the securities that are part of our portfolio, in which we only have the data of recent years.

Bootstrapping is a statistical technique that by having only a sample of the population data, provides estimates of statistical metrics that are closer to the ones obtained from the population data.

Given a sample of size n , implementing bootstrap is very simple:

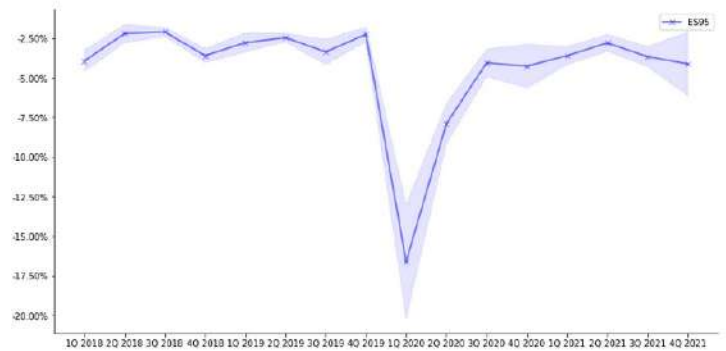
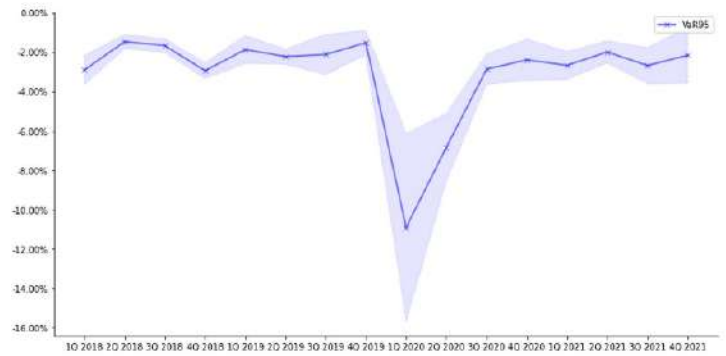
- Sample with replacement n times from the original sample (note that one observation could be selected more than once);
- Compute the metric of interest (in our case the VaR or ES) on this newly created sample and save it;
- Repeat the previous steps M times with $M \rightarrow +\infty$ (we have selected $M=100.000$ for instance);
- Average and compute the standard error of the metrics estimated in each step.

With this method, by estimating the expected shortfall and the standard errors, we can retrieve a more insightful view of our portfolio, but in this case, we are losing the risk contribution of each stock that we had in the previous case.

	Estimate	Standard error
VaR_{95%}	-1.03%	0.20%
VaR_{99%}	-1.91%	0.41%
ES_{95%}	-1.55%	0.22%
ES_{99%}	-2.28%	0.44%

Quarter analysis

Thanks to this method, we can take a look at the evolution of our metrics of interest (Expected Shortfall and VaR) in the past three years:



Black-Litterman weights

UBS	5.5%	AAPL	3,20%
ISP	6,00%	ASML	1,00%
CMI	6,00%	DIS	2,00%
AIR.PA	1.6%	ENI.MI	5,20%
TM	6,00%	IG.MI	6,00%
MONC.MI	3.4%	MU	1,00%
BIPC	6,00%	NEOE3.SA	6,00%
EQUIX	4.6%	NESTLEIND	6,00%
PLD	6,00%	SAP.DE	5,20%
SAFE	1,00%	NEXI.MI	1,00%
EQR	1.1%	NVS	6,00%
CTRE	1,00%	MTTR	1,00%
BAYN.BE	3.2%		
600585.SS	3.4%		
GOOG	1.5%		

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Black–Litterman model

Introduction

The Black-Litterman asset allocation model, created by Fischer Black and Robert Litterman, is a sophisticated portfolio construction method. The main trait that distinguishes the model is the Bayesian approach that is embodied in the inclusion of investors' expectations on future returns in building an optimal portfolio. Unlike the Markowitz optimization, in which return is maximized for a given level of risk, the Black-Litterman model combines the subjective views of an investor regarding the expected returns of one or more assets with the market equilibrium vector of expected returns to form a new estimate of expected returns. The resulting new vector of returns leads to intuitive portfolios with sensible portfolio weights.

Inputs

To compute the portfolio composition, the model requires specific inputs. Some of them are common to other optimization models, like the expected excess returns and the variance-covariance matrix. In addition, we have:

- **VIEWS:** each investor has its own expectations about excess returns, which may deviate from the implied market ones. Views can be expressed in either absolute terms (Disney will have an absolute excess return of 5.25%) or in relative terms (Microsoft will outperform Apple by 2%). On the mathematic perspective, views are represented by a column vector with each element corresponds to a absolute/relative returns.
- **PICKING MATRIX:** this crucial element allows us to link each view to its corresponding asset. Mathematically, we have a matrix whose rows express the different views: absolute views have a single 1 in the column corresponding to the ticker's position, whereas relative views have positive numbers in the nominally outperforming asset columns and negative numbers in the nominally underperforming asset columns. All the other values are set to 0.

Procedure

The Black-Litterman optimization process can be summarized in four parts:

- Estimate the (prior) implied expected returns using relative market capitalization weights and implied risk-aversion;
- Based on the investor views, build the view vector, the picking matrix and the (diagonal) matrix with the variance of each scenario;
- Use all of the previous inputs to compute the (posterior) "Black-Litterman" vector of expected excess returns;
- Use the vector of Black-Litterman posterior returns to compute the new weights for the portfolio.

Key formulas and equations

The starting point is the computation of the implied excess returns via a reverse optimization method:

$$\Pi = \lambda \Sigma w_{\text{market}}$$

Where:

Π is the Implied Excess Equilibrium Return Vector (N x 1 column vector),

Σ represents the covariance matrix of excess returns (N x N matrix),

λ is the risk aversion coefficient,

w_{market} is the market capitalization weight.

The conversion from the prior return vector to the posterior Combined Return Vector ($E[R]$) is done according to:

$$E[R] = [(\tau \Sigma)^{-1} + P' \Omega^{-1} P]^{-1} [(\tau \Sigma)^{-1} \Pi + P' \Omega^{-1} Q]$$

Where:

τ is a scalar,

P is a matrix that identifies the assets involved in the views (K x N matrix),

Ω is a diagonal covariance matrix of error terms from the expressed views representing the uncertainty in each view (K x K matrix),

Q is the View Vector (K x 1 column vector).

This formula can be intuitively interpreted as a weighted average between the (prior) implied returns and our views, with weights that depend on how much we are uncertain regarding every single view.

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