Minerva Investment Management Society
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MIMS – Diversified Passive Selection Fund

Portfolio Management Team

Report – December 2021

Fund description

The Passive Fund is composed by a number of Exchange Traded Funds selected by Minerva Investment Management Society, reflecting the output of the research of the Passive Portfolio Team. These ETFs aim to replicate as closely as possible the performance of a basket of securities with specific common properties, thus being effective instruments for investors who wish to express a certain view on industry sectors or economic trends while capturing as little idiosyncratic risk as possible. Each ETF was carefully chosen in line with the macroeconomic outlook. Our allocation is based on a diversification process achieved among geographies, asset classes and sectors.

Allocation Breakdown

Asset Allocation

In line with the trend of the previous semesters, we have further shifted our portfolio from fixed income (20%) to equity (60%) and commodities (20%). In fact, the low return provided by bonds doesn't justify the two main risks bonds are exposed to: a normalization of monetary policy carried out by tapering the monthly bond-buying program of central banks or by raising interest rates and the risk of negative real yield given the record high inflation since 1990. The risk of persistent inflation, initially underestimated by many investors, is the reason why the weights of commodities in the portfolio is unusually high.

Geographical Allocation

Europe exposure has been increased since its stock market trades as smaller multiples than the US' one which is unquestionably dearly priced even if the historically low interest rates are considered. US exposure is mainly skewed toward high quality, value stocks. As for EM, we believe China is currently surrounded by an excessive pessimism and we believe it offers acceptable returns, provided the risk of contagion of Evergrande liquidity crisis and extra regulation by the Chinese government.

Head of Asset Management
Marco Gortan: +39 3664418518

Head of Portfolio Management
Raffaele De Cicco : +39 3313575076

Portfolio Manager
Daniele Cutini: +39 3315920040

Portfolio Analysts
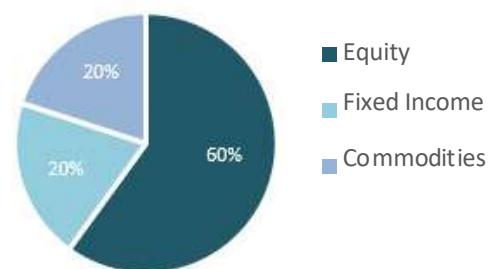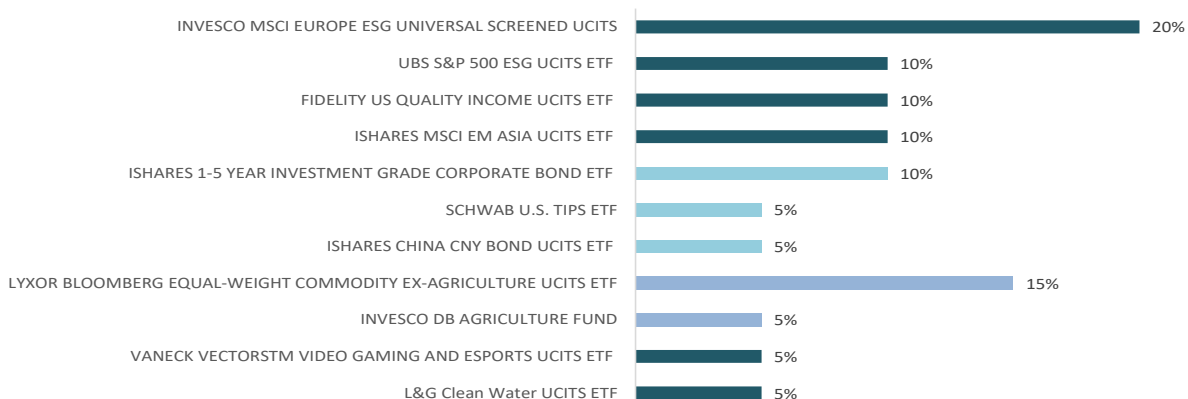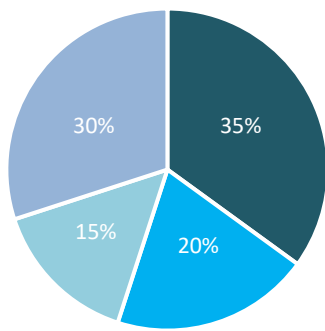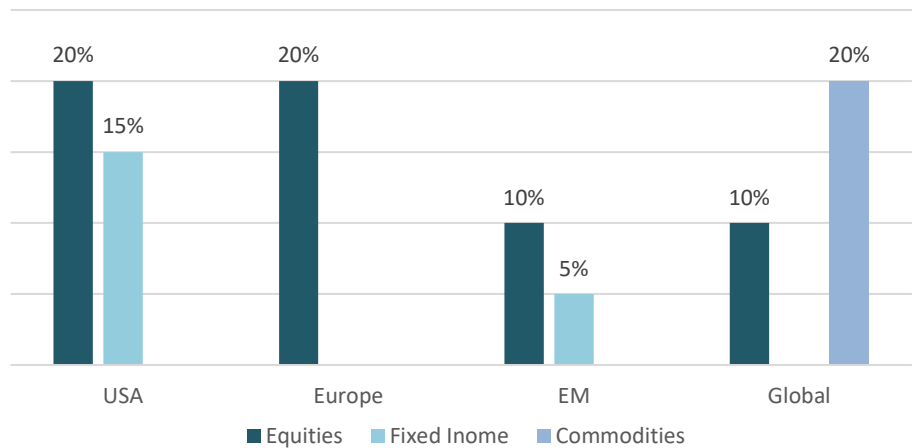Tobia Boselli: +39 3381067611
Diego Castoldi: +39 3315417620
Rogrigo Duarte Silva: +351 969066983
Matilde Zampa: +39 3664015959

Asset Allocation

- Equity 60%
- Fixed Income 20%
- Commodities 20%

ETFs Breakdown

ETF	Weight
INVESCO MSCI EUROPE ESG UNIVERSAL SCREENED UCITS	20%
UBS S&P 500 ESG UCITS ETF	10%
FIDELITY US QUALITY INCOME UCITS ETF	10%
ISHARES MSCI EM ASIA UCITS ETF	10%
ISHARES 1-5 YEAR INVESTMENT GRADE CORPORATE BOND ETF	10%
SCHWAB U.S. TIPS ETF	5%
ISHARES CHINA CNY BOND UCITS ETF	5%
LYXOR BLOOMBERG EQUAL-WEIGHT COMMODITY EX-AGRICULTURE UCITS ETF	15%
INVESCO DB AGRICULTURE FUND	5%
VANECK VECTORSTM VIDEO GAMING AND ESPORTS UCITS ETF	5%
L&G Clean Water UCITS ETF	5%

Geographical Allocation

- USA 35%
- Global 30%
- Europe 20%
- EM 15%

Allocation Breakdown

	USA	Europe	EM	Global
Equities	20%	20%	10%	10%
Fixed Inome	15%		5%	
Commodities				20%

Performance

Period Return	11.28%
02/04/2021 - 23/11/2021	

Daily Expected Return	0.065%
Daily Volatility	0.481%
Annualized Expected Return	16.49%
Annualized Volatility	7.64%
Sharpe Ratio	2.16

Value of the Portfolio

100,000

111,279.3
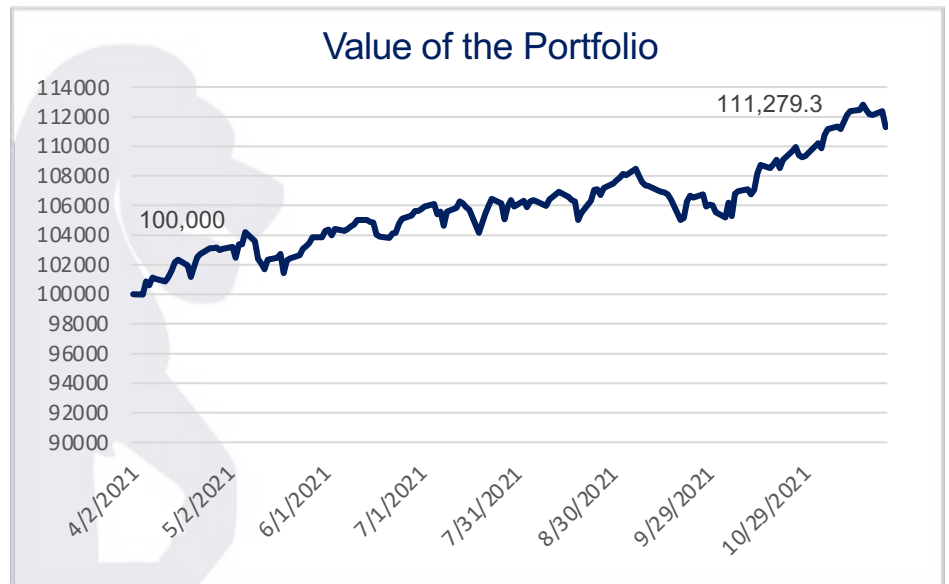
In order to evaluate the performance of our investments, we track the daily value of the portfolio over a period of time stretching from April 2021 to November 2021. At the beginning of the observed period (02/04/2021), we assume an initial investment of €100,000 and calculate the number of shares of each ETF that will be bought and held in portfolio, according to the weights chosen during the asset allocation process. Keeping track of the funds' prices, we can easily determine the value of the portfolio until the end of the period (23/11/2021). We record a final value of €111,279.35, with an overall return of approximately 11.28% in a little less than 8 months. Going into the details, we observe that most of the growth was driven by the equity component of the portfolio as well as by the commodities ETFs we included as an inflation hedge. In the specific the agricultural ETF – that we include to capitalize on the supply chain disruption that eventually affected also agricultural commodities prices - has been the best performer, topping even the performance of the equity's ETFs.

Portfolio Overview

Our portfolio can be ideally divided in 4 main sections:
- "equity indexes ETFs"
- "fixed income ETFs"
- "sector-specific/trend-specific ETFs"
- "commodities (hedging) ETFs"

Equity Indexes ETFs

The first section is the "backbone" of the portfolio. It represents 60% of the total allocation, split across 4 ETFs covering 3 different geographic areas: USA, Europe and Emerging Markets. Equities remain the main driver of the portfolio's overall performance and remain the favorite asset class in most macroeconomic scenarios. However, inflation must be closely monitored in order to promptly manage the portfolio's tech sector exposure which is the most sensitive to the raising of interest rates, used as a tool to tame inflation. US equity exposure accounts for 20% of the total portfolio and we made sure to overweight value stocks in order to correct for the extra weight of tech companies in the S&P500 and in the ETF that replicates it. The benefit of such a choice is a reduction of the duration of the equity component of the portfolio which makes it even less sensitive to persistent higher inflation which will force the central banks to raise interest rates with a negative impact on growth stocks. Europe is set to outperform the US market in the short term given the repositioning of investors towards less expensive markets which are also fundamentally solid. This trend could lead to a reduction in the historical spread of valuation's multiples between American and European stocks. As for EM, we believe the risk-return trade-off is favorable although source of uncertainty on their growth are still present: the Covid-19, not yet under control, and hyperinflation. However, the ETF we picked is mostly exposed to China which we believe might start to attract back some investors.

Fixed Income ETFs

Fixed income role in a portfolio is to lower volatility, and to contribute, although to a small extent to the performance of the portfolio.

The problem of the current macro environment is that investors are not guaranteed to get a positive real return from their fixed income component of the portfolio because of high inflation and record low nominal yield. We dealt with this keeping a TIPS's ETF in the portfolio, reducing the duration of the US corporate bond's ETF and investing in Chinese bonds which offer a sizable yield in a world of historically low one. In our quest for higher yield, we sticked to investing in only investment grade bonds without trading extra-return for quality.

Sector-specific/Trend-specific ETFs

The third section of the portfolio is dedicated to sector-specific and trend-specific equity investments. This section is composed of 2 equity funds, with a weight of 5% each. Confirming a particular emphasis on "green" investments, we have decided to invest in the clean water ETF – that we had already included last semester. Apart from its great performance (36.23% YTD as of 23 November 2021), water companies are set to benefit from the exclusion policy of institutional investors who overweight more ESG-friendly companies therefore they will enjoy less expensive financing and a higher demand for their shares. Besides, the megatrend argument around water is based on the scarcity point which will boost the companies' profit in the near term. We also included a new thematic ETF on Videogames and eSport. The great excitement for the sector during the pandemic and the lockdowns hasn't deflated after the reopening of cities as much as anticipated. We believe the interest in the sector and in its content is here to stay and we positioned our fund to get direct exposure to it. It must be pointed out though that the ETF includes companies which are not profitable yet and therefore the risk contribution of this specific component to the overall portfolio is higher than the other funds' one.

Commodities (Hedging) ETFs

This is the hedge component of the portfolio. The first fund tracks a basket of commodities, including precious metals and energy so it has the common counter-cyclical function of precious metals such as gold, but it is also useful as an inflation hedge because it is more diversified and it also includes industrial metals. The second ETF tracks the performance of agricultural prices. The weight of the ETF is limited because of its high TER and because of the short-term horizon of the investment which we expect to provide a good return just as long as supply-chain disruption persists.

UBS S&P 500 ESG UCITS ETF

Index: S&P500 ESG

Expense Ratio: 0.12% Tracking Error Volatility: 0.51%

ETF overview

The ETF is passively managed and mimics the performance of the S&P500 ESG Index. The sector exposure replicates the one of the respective index and the weights of the single stocks included in the ETF depend on their market cap and ESG rank.

Analysis

This ETF provides exposure to the US market while screening out controversial stocks. The index excludes companies with disqualifying "United Nations Global Compact" scores (tobacco, weapons, etc) and companies within the worst 25% of ESG scores of the GISC. Currently, the ETF is significantly exposed towards the technological sector, reducing the benefit of sector diversification within the American market. Therefore, the weight of the ETF in the total portfolio has been reduced to include another ETF that comprises US companies more sensitive to quality and value factors.

Conclusion

The ETF has returned 33.15% YTD as of 31st October. The momentum provided by strong third-quarter earnings' releases has been the main driver of the strong performance of the ETF. The monetary and fiscal support is still stimulating the developed markets' economies overweighting the problems of supply chain disruptions and the small increase in Covid cases. The outlook on the expected performance of this ETF remains positive although the weight reduction is deemed appropriate considering the past recent rally.

FIDELITY US QUALITY INCOME UCITS ETF

Index: Fidelity US Quality Income

Expense Ratio: 0.25% Tracking Error Volatility: 2.41%

ETF overview

This ETF tracks the performance of high-quality companies based in the US, which offer high dividend yields. The selection process of the companies in the ETF is based on fundamental quality metrics and dividend yield. It tracks the Fidelity US Quality Income Index.

Analysis

The ETF has been included this year to get direct exposure to dividend-paying companies that respect fundamental quality requirements. Historically the standard deviation of the dividend yield of the S&P500 has been close to the 4-5% even during recessions. Therefore, the inclusion of dividend-paying stocks in the portfolio provides a reliable stream of income which is mostly appreciated in high-inflationary macroeconomic scenarios where interest rates could be raised.

The other benefit of the ETF is its sector diversifications. It inevitably has a sizeable exposure towards tech stocks which however have been screened out using quality metrics meaning there is not direct exposure to companies with the largest market cap as in the case of the S&P500 that by construction is a cap-weighted index. As a result, the ETF should add stability to the overall portfolio thanks to the accumulation of the dividends paid out at a time of dare valuation of the US stock market.
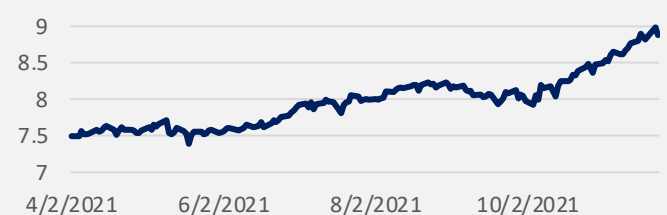
Conclusion

The ETF has returned 26.62% YTD as of 31st October. It is a lower return compared to the S&P500's one. However, the risk-return profile of the fund is very attractive especially taking into account the current economic environment of inflation above the central banks' 2% target and dare equity market valuations. In the end, the ETF provides equity-like returns but mitigated risk.

INVESCO MSCI EUROPE ESG UNIVERSAL SCREENED UCITS

Index: MSCI Europe ESG Universal Select Business Screens

**Expense Ratio:** 0.12% **Tracking Error Volatility:** 0.41%

Overview
This ETF invests in large-cap European companies with a high ESG score and aims to track the performance of the MSCI Europe ESG Universal Select Business Screens Index net of commissions.

Analysis
Equity exposure to the old continent is achieved thanks to this ETF. After the strong rally of the tech sector in America supported by the low interest rates environments and significant profit growth during the pandemic, the portfolio rotation towards value sectors with lower rates of growth but higher dividend yield is still in place. European indexes by construction are more skewed towards value than American ones and this ETF might benefit both from such a rotation and from the geographical repositioning of investors who look for less expensive markets than the American one. In fact, Europe historically trades at smaller multiples than the US and may have more room to run compared to US equities currently trading close to all-time highs.
The screening of stocks based on ESG ratings, first, excludes controversial sectors such as thermal coal and weapons. Secondly, it affects the weight of the security in the ETF alongside its market cap. The attention to the ESG ratings of the companies in the ETF makes it consistent with the increasing attention of investors and stakeholders to non-financial information and disclosure.
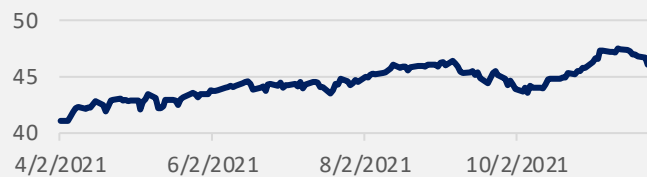
Conclusion
The ETF has returned 21.14% YTD as of 31st October. Although the performance is above the long-term average equity return, the historically low interest rates make equities still attractive on a risk-adjusted basis. Besides the current stance of the ECB compared with the more hawkish FED sets a positive environment for near-term equity returns.

ISHARES MSCI EM ASIA UCITS ETF

Index: MSCI Emerging Markets Asia

**Expense Ratio:** 0.20% **Tracking Error Volatility:** 0.84%

Overview
The ETF provides exposure to Asian emerging markets equities, namely to China, Taiwan, South Korea, India, Hong Kong. It tracks the performance of the MSCI Emerging Markets Asia index which includes large and mid-cap companies.

Analysis
The estimate of the growth premium of emerging markets over developed ones is currently at 1.4% which is lower than the historical average because of the strong GDP growth of developed countries on their way out of the Covid-19 recession. The biggest threat to future growth in developing countries is the delta variant. The still high contagion rate might hinder economic activities and cause further lockdowns. As for inflation, it remains elevated, however the disappearance of base effects and the progressive easing of supply chain bottlenecks are likely to lift some pressure on rising prices in the next months.
China is set to grow at an 8% rate in 2021 although the risk associated with the credit tightening and the possible contagion of the liquidity crisis of Evergrande represents real sources of uncertainty whose developments must be closely monitored by investors. All in all, the base case scenario for the emerging markets is positive and their relative price compared to developed countries is attractive.
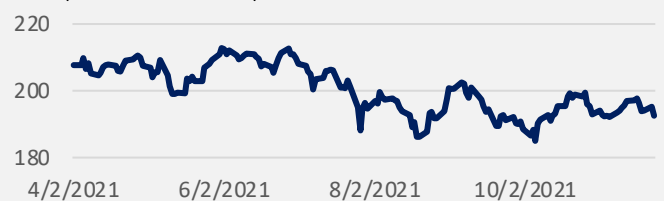
Conclusion
The ETF has returned 2.69% YTD as of 31st October. The weak performance is explained by the risk-aversion of investors towards developing countries. Indeed, the persistence of Covid cases paired with the significant tightening of regulation in China – with an impact primarily on technological and educational companies – have discouraged investors from investing in developing countries crowding the American and the European ones.

SCHWAB U.S. TIPS ETF

Index: Bloomberg Barclays US Treasury Inflation-Linked Bond

Expense Ratio: 0.05% Tracking Error Volatility: 0.01%

Overview
The fund aims to track, before fees and expenses, the total return of the Bloomberg Barclays US Treasury Inflation-Linked Bond Index, which measures the performance of the US Treasury Inflation-Protected Securities (TIPS) market.

Analysis
The biggest theme of 2021 in financial markets has been the global inflation surge, visible not only in EM economies but also in the DM. As revealed by the latest CPI report, the annual US rate of inflation from 2020 to October 2021 was 6.2 percent, and even after excluding the most volatile categories of food and energy prices, prices are running higher than they have been in years.
Central Banks are expected to tighten the pandemic-induced monetary stimulus, the FED has announced a 15bn reduction in its bond-buying program starting from November 2021, and the normalization process is expected to continue in the following months for all the major CBs. Given this perspective, we think fixed income should be underweighted since bonds usually suffer in a high inflation environment. To partially hedge our position, the Inflation-protected US treasury is one of the best options available. This ETF is by definition less sensitive to higher rates of inflation and shall overperform in periods of rising prices contributing to the overall portfolio performance.
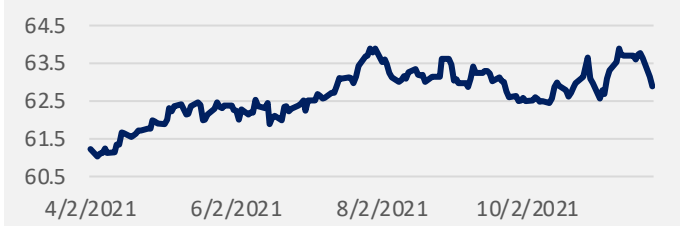
Conclusion
Given the 3.5 year-to-date return, the very low cost of 0.05%, the relative safety of this ETF and the potential protection against higher-than-expected inflation, the fund has been included in the portfolio.

ISHARES 1-5 YEAR INVESTMENT GRADE CORPORATE BOND ETF

Index: ICE BofA 1-5 Year US Corporate

Expense Ratio: 0.06% Tracking Error Volatility: 0.36%

Overview
The iShares 1-5 Year Investment Grade Corporate Bond ETF seeks to track the returns of the ICE BofA 1-5 Year US Corporate Index, which is composed of USD denominated investment-grade corporate bonds with maturities between one and five years.

Analysis
The main driver of this choice is the short duration that characterizes the investment horizon of this ETF, indeed shorter duration bonds are less affected by an unexpected rise in interest rates. As stated before, during 2022 the markets expect rising inflation and as a consequence an increase in interest rates implemented by Central Banks to reduce the pressure of rising prices.
Exploiting the inverse relationship between bonds' prices and interest rates we think reducing the duration of a fixed-income investment is the right way to minimize our exposure to this outlook.
With an effective duration of 2.79 years and convexity of 0.08 (a different measure to describe how much prices are affected by interest rates), this ETF provides an optimal opportunity in terms of risk-adjusted return.
Additionally, the focus of this ETF is on US blue chips investment-grade companies, with easy access to credit and a high level of creditworthiness, ensuring a smooth transition through higher-interest rates period.
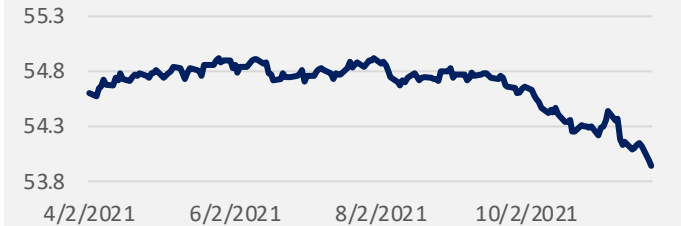
Conclusion
The YTD return of the ETF has been negative, however considering that interest rates are close to 0 we are not worried by such a performance, especially because the inclusion of this fund is mainly focused on reducing the duration of the portfolio. The liquidity of the short-term bond market and the low expense ratio of the ETF make it a satisfying option.

ISHARES CHINA CNY BOND UCITS ETF

Index: Bloomberg Barclays China Treasury + Policy Bank Total Return

Expense Ratio: 0.35% Tracking Error Volatility: 0.36%

Overview

The iShares China CNY Bond ETF Fund aims at tracking the performance of Bloomberg Barclays China Treasury + Policy Bank Total Return Index that replicates investment-grade bonds issued by the Chinese treasury.

Analysis

We decided to include this ETF in the portfolio primarily because of the returns offered by Chinese yields. The Chinese market offers attractive yields delivered by A-rated sovereign bonds. Geographical diversification was also one of the rationales behind this choice.

In recent months, the Chinese economy has been exposed to a difficult period that was mainly policy-driven. Since markets expect the reasons for this slowdown to be due to government regulation changes, and the Chinese economy is expected to recover, we decided to include this ETF.

Additionally, the concerns about the Evergrande situation and the property sector have been monitored and put under control.

Since we decided to reduce the weight of fixed income ETFs in this portfolio, we are confident that this fund could be a great opportunity for an appealing return even if the Chinese economy it is not in a booming period.

Conclusion

The fund performed 9.55% in 2020, the effective duration is 5.78 and the Chinese economy is expected to grow at a 5.5% consensus rate. In this environment, the inclusion of this fund seems an optimal choice to diversify geographically our exposure.

LYXOR BLOOMBERG EQUAL-WEIGHT COMMODITY EX-AGRICULTURE UCITS ETF

Index: Bloomberg Energy and Metals Equal-Weighted Total Return

Expense Ratio: 0.30% Tracking Error Volatility: 2.46%

Overview

This ETF aims to track the benchmark Bloomberg Energy and Metals Equal-Weighted Total Return Index, which tracks the performance of an equal-weighted basket of 12 energy and metal commodity futures contracts. The weights are reset to their target weights quarterly and derivative contracts are "rolled" to a new contract to maintain exposure.

Analysis

In the context of rising inflation, we have decided to include an ETF that provides exposure to several non-agricultural commodities, such as gold, silver, and oil. This ETF benefits from a good level of diversification, and from providing exposure to commodities that tend to outperform the market in times of high inflation, such as gold and silver. It also provides exposure to oil and metals that are mainly used in industrial production, such as copper and aluminum. Over the last year, the Lyxor Bloomberg Equal-weight Commodity ex-Agriculture UCITS ETF has risen by 32.56%.

Conclusion

We believe that this ETF will help shield the portfolio from inflation, by providing diversification. It may also benefit from the potential rise in industrial metals' prices. Finally, the expense ratio is relatively low, which is always to take into consideration, when picking an ETF.

INVESCO DB AGRICULTURE FUND

Index: DBIQ Diversified Agriculture Index Total Return

Expense Ratio: 0.93% Tracking Error Volatility: 2.46%

Overview
This ETF intends to track the benchmark DBIQ Diversified Agriculture Index Total Return plus the interest income from the fund's holdings of primarily US Treasury securities and money market income less the fund's expenses.

Analysis
The growing inflation in the US and Europe, particularly in agricultural commodities has prompted us to include an ETF that tracks an index composed of several agricultural commodity futures contracts, such as wheat, coffee, and soybeans, among others. During the last month alone, wheat futures have gone up 11.03%, while coffee futures have increased by 15.38%. If we look at the yearly change, the numbers are even more pronounced, with wheat futures increasing 47.44% and coffee futures soaring by 112.97%.
As we anticipate inflation to continue the rise, we expect food prices to increase even more, as they tend to be particularly volatile, because of its inelastic demand. For this reason, we believe that the relatively high expense ratio of 0.93% is not enough to make us pass on this ETF. Besides, the Invesco DB Agriculture Fund is one of the most liquid agricultural commodity ETFs on the market.

Conclusion
Despite the relatively high expense ratio of 0.93%, we believe that agricultural commodity prices are going to continue going up, due to its typically inelastic demand, along with the increasingly unpredictable weather.

L&G Clean Water UCITS ETF

Index: Solactive Clean Water

Expense Ratio: 0.49% Tracking Error Volatility: 1.98%

Overview
The fund aims to replicate the performance of the Solactive Clean Water Index NTR. The ETF comprises companies that have expertise in providing services in areas such as "technology", "digital", "utility", and/or "engineering" for the global clean water industry (the "Water Related Services"). Companies are firstly selected on the basis of their market cap and ESG rating. In fact the companies in the ETF contribute to environmental and social objectives, and follow good governance practices.

Analysis
This is the greenest ETF in the portfolio. A direct benefit of its inclusion in the portfolio is the increasing demand by institutional investors of ESG-friendly companies. Also, we strongly believe in the long-term financial performance of companies which take into consideration also nonfinancial metrics such as their environmental impact and which share an inclusive view in terms of who are their shareholders. That said, we believe that water scarcity and increasing demand from developing countries will lead to a consolidation in the industry with an improvements in profitability as a result. Furthermore, most of the companies included in the ETF are utilities and therefore are stable, dividend-paying companies. Hence the ETF smooths out the volatility of the portfolio while providing good and stable return (dividends are reinvested since all the ETFs we pick are accumulating).
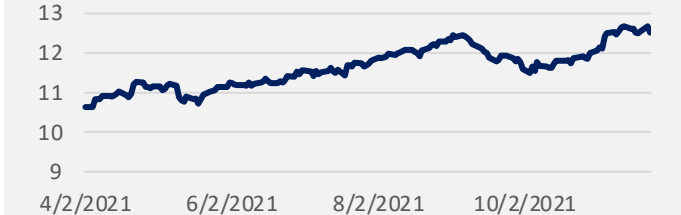
Conclusion
The ETF has returned 36% YTD as of 23rd November. Its performance beats all the main equity benchmarks such as the S&P500 and our outlook for the future remains significantly positive.

VANECK VECTORSTM VIDEO GAMING AND ESPORTS UCITS ETF

Index: MVIS Global Video Gaming and eSports Index

Expense Ratio: 0.55% Tracking Error Volatility: 3.39%

Overview
The fund aims to replicate the MVIS Global Video Gaming and eSports Index. The ETF undertakes investment in equity securities of companies whose predominant economic activity is in developing video games and related software or hardware such as computer processors and graphics cards used in video gaming systems and related hardware such as controllers, headsets and video gaming consoles.

Analysis
The global market for video game reached $155B and is expected to grow steadily in the coming years reaching $268B by 2025. What is significant nowadays is that the first generation of gamers is now grown up and has significant spending power at its disposal. Despite the high average daily time spent playing games among kids, the hobby can no longer be considered solely child's play. In fact, it was found that video gaming is gaining popularity among parents across the world as well, with an even split in terms of the gender distribution of video gaming parents worldwide. Companies involved in the production of graphic cards have also experienced a significant increase in demand given the application of GPUs in the mining process of cryptocurrencies.

Global video game market value from 2020 to 2025 (in billions U.S. dollars)
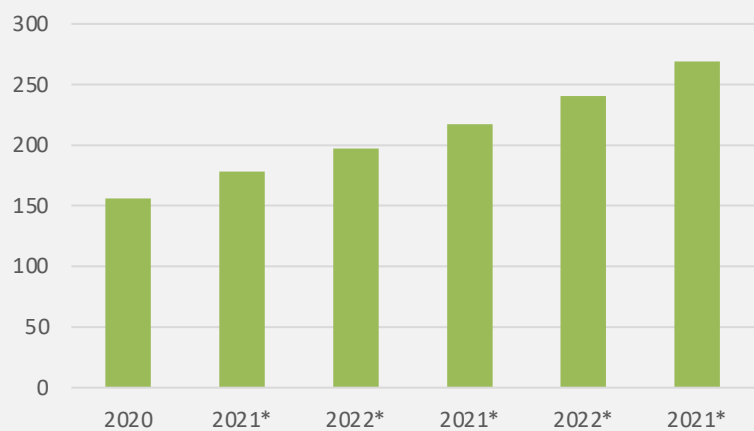
Source: Statista & Juniper research

Conclusion
The ETF was launched in 2019 and has reached AUM of $881.7M. The total expense ratio is set at 0.55%. The geographical exposure is very equally balanced between US and Asian countries such as Japan, China, Taiwan and South Korea offering a unique country diversification. Considering the current trends, we believe there is a huge upside potential in this ETF and on the industry as a whole.

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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 diversified passive selection 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 the Black-Litterman optimization algorithm to inform the choice of component's weights.

As the Investment Risk division, our focus is the estimation of the two main risk indicators:

- The daily Value at Risk (VaR): the maximum portfolio loss that occurs with α% of probability over a time horizon of 1 day. For instance, if the VaR (α=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 α% 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.
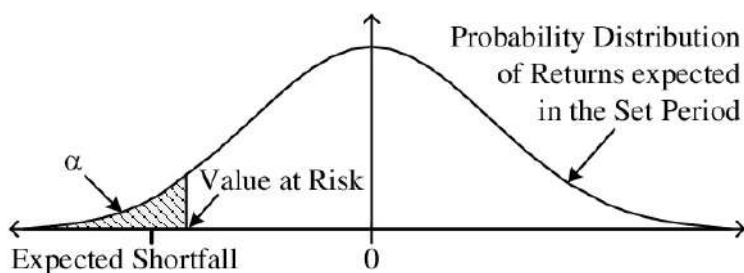
Head of Asset Management
Marco Gortan: +39 3664418518

Head of Quantitative Research
Emanuele Chiarini: +39 3478383128

Analyst
Mohamed Akhatar : +39 3516350606
Umberto Barbieri : +39 3332558188
Anna Vlastova :+7 9150040845
Francesco Zanettin: +39 3357257891

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.

All the analysis has been conducted with Python.

Parametric approach

In this section we propose to analyze VaR and ES separately for each ETF 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 it's 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.

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 Fn, is:

$$Dn = \sup x \,|(Fn - F)|$$

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.
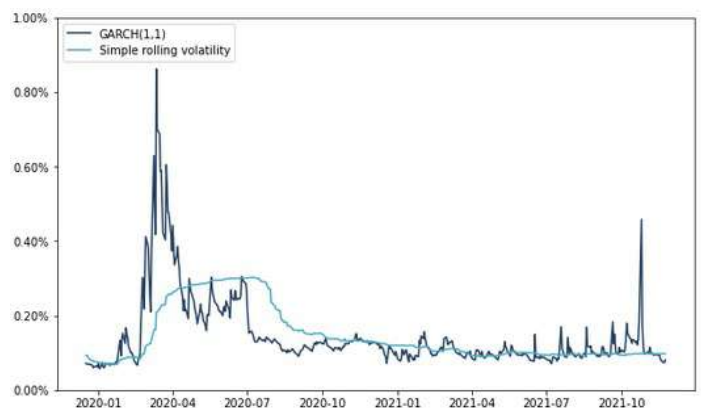
Time-series modelling approach

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 passive 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.

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:

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

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.

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 slightly higher 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
VaR95%	-1.39%	-1.20%
VaR99%	-2.00%	-2.08%
ES95%	-1.76%	-1.77%%
ES99%	-2.31%	-2.81%%

Simple approach

	VaR 95	VaR 99	ES 95	ES 99
ISHARES CHIN.GVT. BD.1- 10YR ACC	-0.55%	-0.81%	-0.71%	-0.96%
ISHARES 1-5 YR.INV. GDE. CPRT.BD ETF	-0.59%	-0.85%	-0.75%	-0.99%
SCHWAB US.TIPS ETF	-0.65%	-0.93%	-0.82%	-1.07%
INVESCO DB AGRICULTURE FUND	-1.42%	-2.05%	-1.81%	-2.36%
IVS.MSCI EU.ESG UNIV SCND.UCITS ETF	-1.88%	-2.70%	-2.38%	-3.12%
L&G CLEAN WATER UCITS ETF USD ACC	-1.98%	-2.85%	-2.51%	-3.29%
LYXOR BLOOMBERG EQ WEIGHT COMMOD EX-AGR	-2.03%	-2.91%	-2.57%	-3.37%
FIDELITY US QUALITY INCOME UCITS ETF USD ACC	-2.08%	-2.99%	-2.64%	-3.47%
UBS (IRL) ETF SP5. ESG UCITS ETF A ACC USD	-2.19%	-3.17%	-2.79%	-3.67%
ISHARES MSCI EM (SWX) ASIA UCITS ETF USD (ACC)	-2.36%	-3.39%	-2.99%	-3.91%
VANV. VIDEOGAMING&ESPORTS	-2.43%	-3.53%	-3.11%	-4.09%

GARCH

	VaR 95 (GARCH)	VaR 99 (GARCH)	ES 95 (GARCH)	ES 99 (GARCH)
ISHARES 1-5 YR.INV. GDE. CPRT.BD ETF	-0.31%	-0.55%	-0.47%	-0.77%
ISHARES CHIN.GVT. BD.1- 10YR ACC	-0.56%	-1.03%	-0.87%	-1.47%
SCHWAB US.TIPS ETF	-0.79%	-1.32%	-1.14%	-1.74%
INVESCO DB AGRICULTURE FUND	-1.31%	-2.20%	-1.89%	-2.89%
IVS.MSCI EU.ESG UNIV SCND.UCITS ETF	-1.41%	-2.32%	-1.99%	-2.98%
L&G CLEAN WATER UCITS ETF USD ACC	-1.61%	-2.65%	-2.28%	-3.41%
ISHARES MSCI EM (SWX) ASIA UCITS ETF USD (ACC)	-1.92%	-3.27%	-2.80%	-4.36%
LYXOR BLOOMBERG EQ WEIGHT COMMOD EX-AGR	-1.94%	-3.29%	-2.81%	-4.36%
UBS (IRL) ETF SP5. ESG UCITS ETF A ACC USD	-1.79%	-3.39%	-2.87%	-4.98%
FIDELITY US QUALITY INCOME UCITS ETF USD ACC	-1.98%	-3.03%	-3.08%	-5.19%
VANV. VIDEOGAMING&ESPORTS	-2.83%	-4.70%	-4.03%	-6.09%

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→+∞ (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. Here, you can find the following estimates:

	Estimate	Standard error
VaR$_{95\%}$	-1.22%	0.13%
VaR$_{99\%}$	-2.80%	0.34%
ES$_{95\%}$	-2.30%	0.30%
ES$_{99\%}$	-4.13%	0.83%

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:

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

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 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.