The 2020s: An Era of Uncertainty and Opportunity

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In this paper, I am attempting to identify the factors that inform the performance over time of a portfolio via its returns and volatility. I will do so by examining the impact and relationship between geopolitical crises, the federal reserve decision making and the overall impact of innovation on market creation. However, the impact of each will be primarily related to a specific market, as follows: geopolitical crises on commodities, the federal reserve decision making on treasuries, and market creating innovation on equities.

The model used to compute the performance parameters needed for the study is the Modern Portfolio Theory. Even though it was introduced back in 1952 and has shown multiple limitations (especially in regards to accounting for downside risk), its simplicity allows for a straight-forward understanding of the parameters and their derivation as well as provides general insights that remain valid. The model was coded as a python script (accessible here) that only requires the asset names, start and end date of the analysis and iterations needed for a representative "efficient frontier" (risk-minimizing portfolio options).

The timeframe of the analysis is restricted to the current decade as it contains enough shock-inducing events to provide insights into each of the factors suggested. However, we will encounter a direct correlation that we will highlight. It is a unique occurrence in modern world history but the 2020s have, in the span of 4 years only, seen a once in a century global pandemic (since the 1918-1920 Spanish flu), in addition to a first hot war on the European continent since World War II started by the Russian Invasion of Ukraine, and Artificial Intelligence becoming a revenue driver for companies with the highest current capitalization on the public markets. We endeavor to view these events from the standpoint of the investor and how he ought to manage a basic portfolio with only 3 asset classes. We will use indices to represent the variation in the value of each as constructing a portfolio based on individual subcomponents is beyond the detail level intended by this paper.

Russia and Ukraine have long been producers and exporters of the most consumed agricultural and energy products on the planet. Ukraine, for instance, was referred to as the breadbasket of the Soviet Union during the 20th century and transitioned to hold that label for the wider world after the fall of the USSR. The country is the fifth largest wheat exporter and fourth largest corn exporter, accounting for 12% and 15% of global exports respectively, the destinations of which span heavily populated Mediterranean and east Asian countries. Russia, on the other hand, is equally as consequential on the agricultural global market, with 20% of the global wheat trade, but even more so when it comes to energy products as the second largest global exporter of natural gas and crude oil. We will thus narrow our focus to the a priori mentioned commodities: wheat - corn - natural gas - crude oil. These assets are represented in the indices tradable on

the public markets and weighted differently according to each provider. We will assess the impact of each subcomponent on the indices at large but only evaluate the portfolio performance based on the indices themselves. The agricultural and energy products impacted by the conflict represent around a third in value of the Bloomberg Commodity Index (BCOM) and just above half in value of the S&P Global Commodity Index (SPGSCI). To identify the signals that constitute the start and end of our analysis, we will refer to the escalation in tone on the international stage by the Russian government in December 2021 (first mention of military action in an official communique) and the annexation of Donetsk and Luhansk in late September 2022 as the two limit points. The latter is not an indication of any geopolitical reality but only a mark at which the markets can be assumed to have stabilized by, establishing supply alternatives to accommodate the demand equilibrium. We confirm the validity of our selection by plotting the time series data which highlights the timing of the shock induced by the initial signal, as seen in fig.1. Both indices examined track comparably over the interval, with a slow but consistent increase in the lead-up and a spike following the invasion, maintaining that level for the following 4 months before coming back down even though prices remain relatively high.

Fig. 1 The S&P and Bloomberg Commodity Price Indices over the leadup and initial phase of the conflict in Ukraine.

Table 1 - The boundary values of both indices over the period specified.

Date	^BCOM	^SPGSCI
12-01-2021	95.2 $	521.3 $
03-08-2022	132.6 $	822.3 $
09-30-2022	111.5 $	608.8 $

We mentioned that the constitution of each index is different which is reflected by our volatility plots (shown on figure 2), generated based on the standard deviation of prices over the trading

days in a year. The Standard & Poor's shows a volatility higher by 7.4% than Bloomberg's as it is more heavily based on the products impacted. Figure 3 reveals that the two indices are nonetheless highly correlated with only a 4% difference, justifying our reliance on both for the analysis.

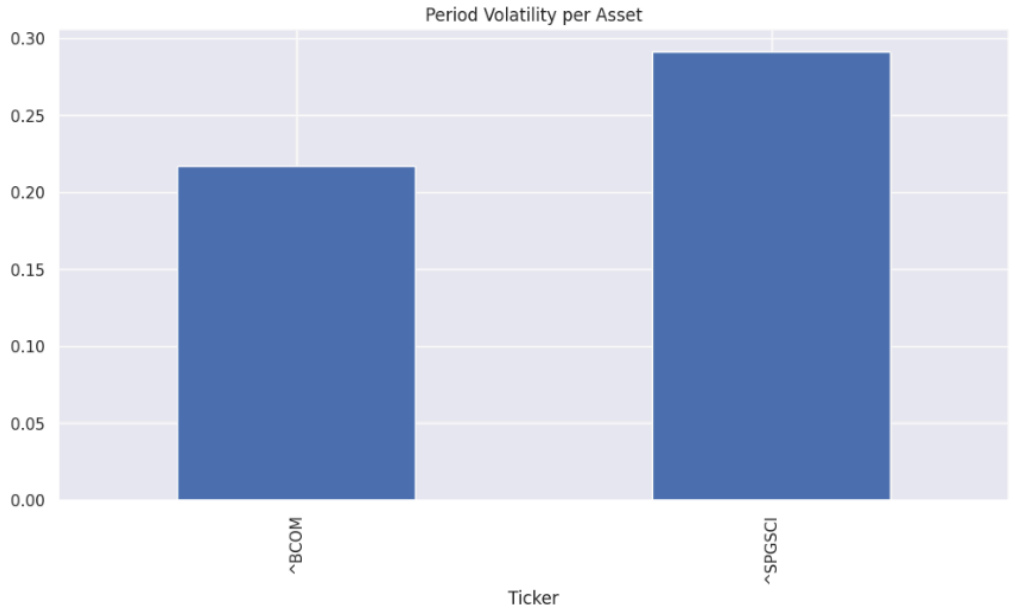

Fig. 2 The Volatility of the Bloomberg and S&P Commodity Indices over the period specified.

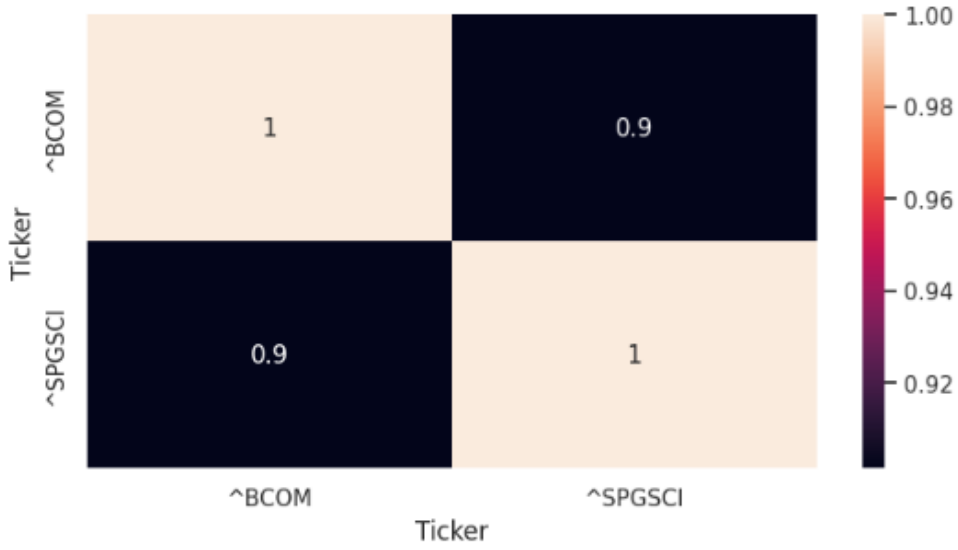

Fig. 3 The correlation matrix of the commodities-only portfolio.

Now that we have qualified the behavior of the data through its parameters, we can introduce our portfolio building model. To do so, we make a distinction in evaluating performance between a commodities-only portfolio and a diversified portfolio, containing also treasuries and equities. As seen below in figure 4, the former only presents a difference of around 1.5% in returns between the safest and riskiest option over the 9 month-span for n=1000 random combinations

of weights to each index. This marginal difference might indicate that a risk averse approach is enough to take advantage of the volatile window, especially given that the standard deviation exceeds the 15% average without reaching the 30% mark synonymous with investor fear.

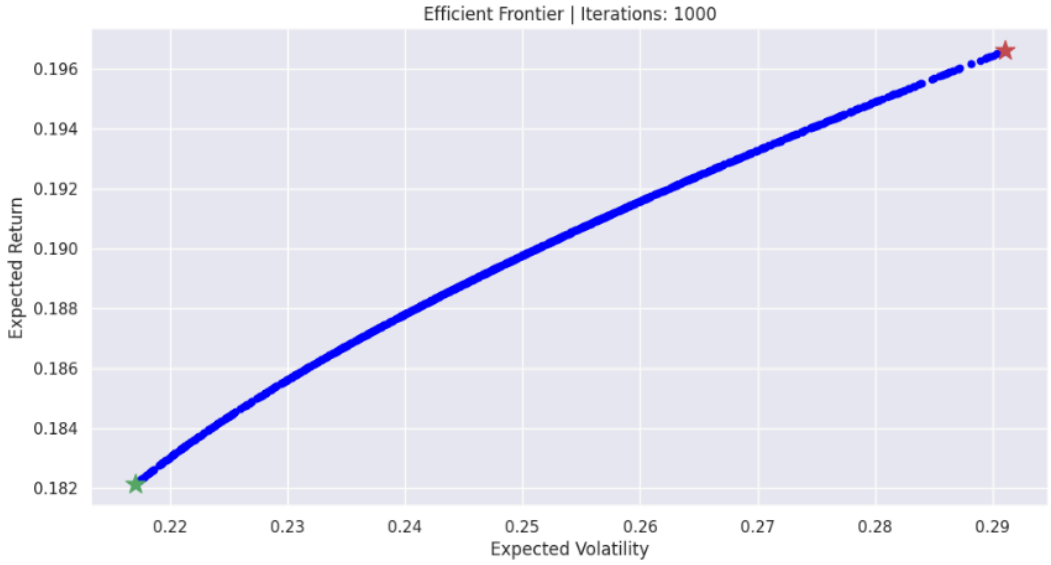

Fig. 4 The safest (in green) and riskiest (in red) commodities-only portfolios according to MPT

We will broaden our outlook to a diversified portfolio containing the S&P500 and the interest rate on a 10-year treasury note. In parallel to the commodities market, the period also marked high volatility for the equities and US treasuries market due to the hike in interest rates by the Federal reserve as an initial response to the inflation buildup from the pandemic (as seen in figure 5). The correlation matrix in figure 6 reveals that even though the 10-Year US Note is the highest performing asset, commodities remain the desired complementary investment.

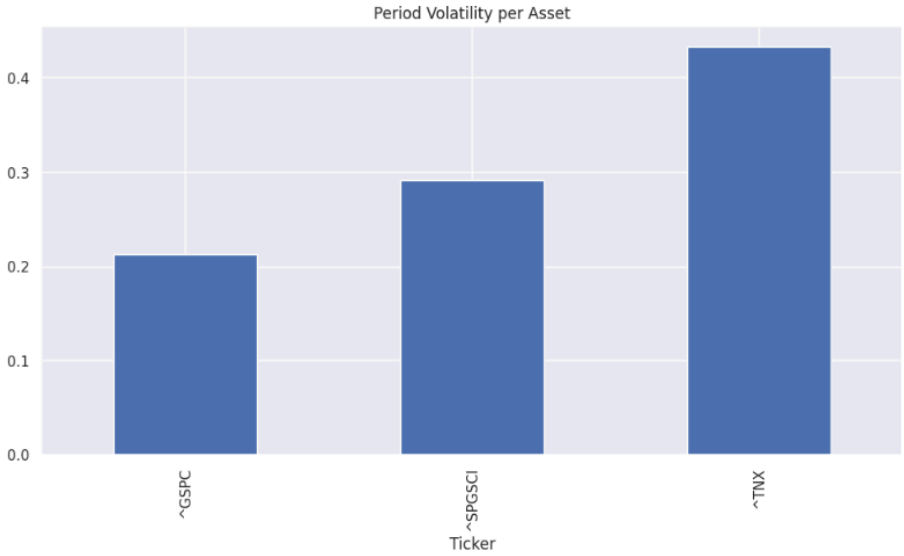

Fig. 5 The volatility of each asset in the diversified portfolio from December 2021 to September 2022.

Fig. 6 The correlation matrix of the diversified portfolio.

The portfolio combinations yielded by our model reveal that risk aversion is not the path to leverage diversification and its profits. As shown on figure 7, a market participant willing to have an asset allocation configuration resulting in a volatility just below 30% would have been able to achieve returns between 60% and 80%. It must be noted that the time interval chosen for the analysis is unique given that all 3 major asset classes were affected at once by sustained external shocks caused by unforeseen events and international market intervention.

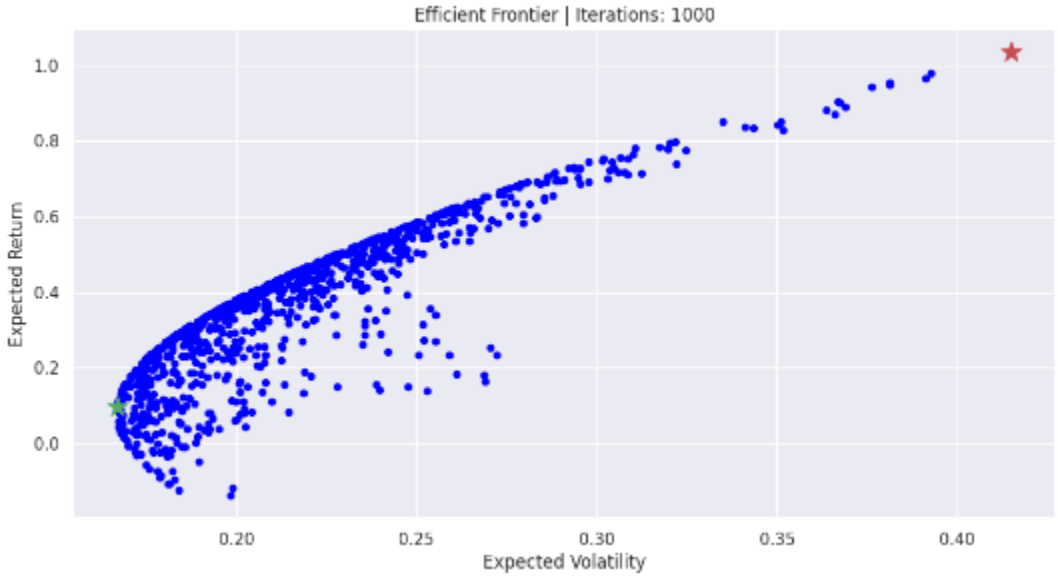

Fig. 7 The safest (in green) and riskiest (in red) diversified portfolios according to MPT

For a century, the federal reserve has played a central role in managing the economy's expansion and contraction via purchasing of treasury assets and adjustment of the federal funds rate. These actions aim to stimulate the economy in times of high unemployment and reduce purchasing power in times of high inflation. However, it was not until the financial crisis of 2008 that the federal funds rate was reduced to almost null (0.25%), which coupled with a large-scale

acquisition of treasuries was the only path to national economic recovery. In theory, these actions dampen the risk associated with long-term interest rates by signaling to prospective investors that the Fed will continue to act as a guarantor of market stability. The reduction in the supply of treasuries also leads to an increase in the bidding prices of the available government-issued securities, thus lowering their yield. These actions which are intended to produce a rebalancing effect by taking advantage of the spread between long term and short term rates have been termed quantitative easing and introduced by the Bank of Japan during the country's deflationary period in the early 2000s. The 2020 pandemic-induced lockdowns have resumed these practices at a scope larger than before, with the Federal reserve buying 80 Billion dollars worth of U.S. treasuries and 40 Billion dollars worth of mortgage backed securities each month between June 2020 and October 2021 when its spending rate was tapered and halted in March 2022. The public markets provide multiple indices that track the interest rate offered on each treasury issued, which we will use in our study as a substitute for tracking auction data. We thus examine 13 week bills, 10 year notes and 30 year bonds as representation of short term, medium term and long term rates respectively.

To introduce the impact of interest rates on the equity market, we compare the time series data of the medium and long term to short term rates from the beginning of quantitative easing until the peak of the following rates hike. This period is chosen because it allows for a reasonable market entry (government-announced lockdowns) and exit (rates stagnant for multiple months after stepwise increase over a brief interval) points. We observe from figures 8 and 9 that the general trend is consistent for all 3 issues but that there is a gap at the trough, allowing more purchasing space for medium and long term securities, which confirms our theoretical understanding of the practice.

Fig. 8 Medium term rates (in red) as compared to short term rates (in blue) before, during and after quantitative easing

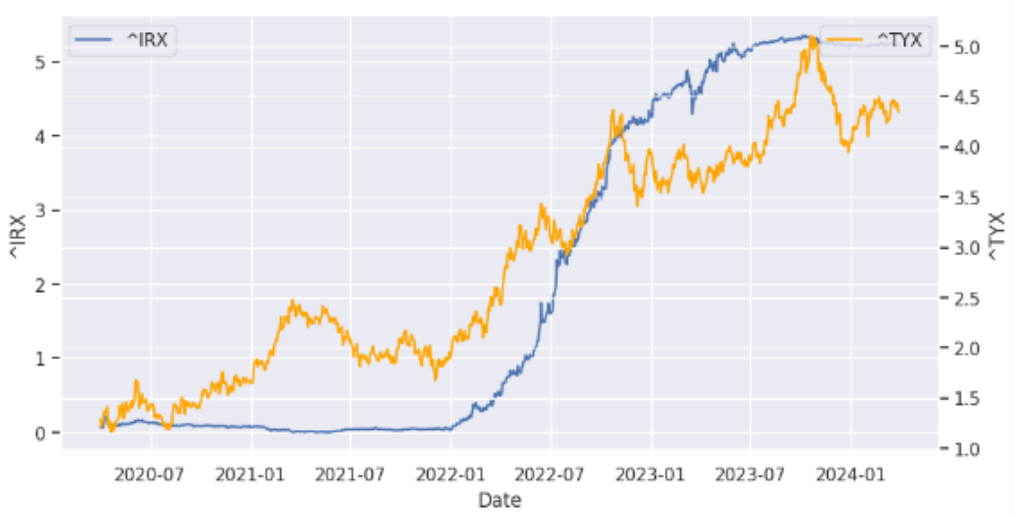

Fig. 9 Long Term rates (in orange) as compared to short term rates (in blue) before, during and after quantitative easing

We then focus our attention on the performance measures of each by evaluating the prospective returns and volatility over the following scenario. It is obvious from the results in figures 10 and 11 that this asset class might be ideal in reducing the overall risk of a portfolio but will not be a considerable driver of returns. Nonetheless, the optimal treasury in our case is the 13-week bill as it provides the highest expected return and lowest volatility.

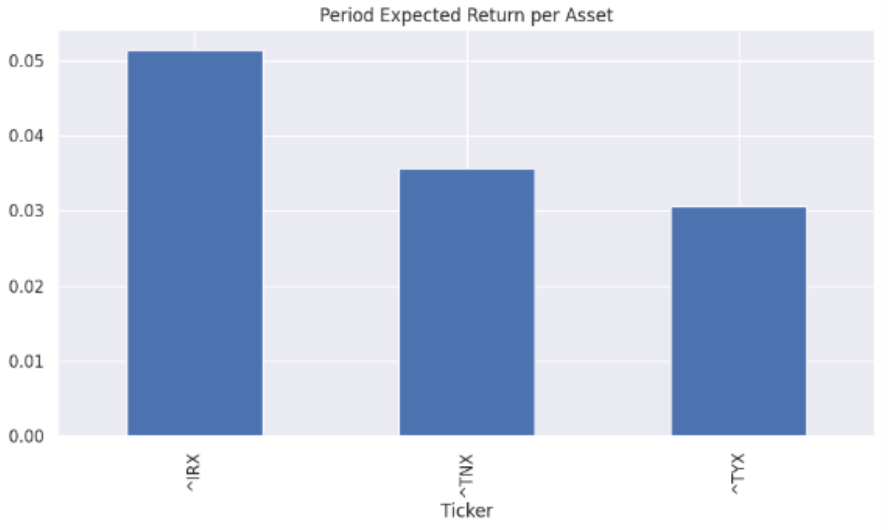

Fig. 10 The expected returns on 13-week bills, 10-year notes and 30-year bonds over the period specified

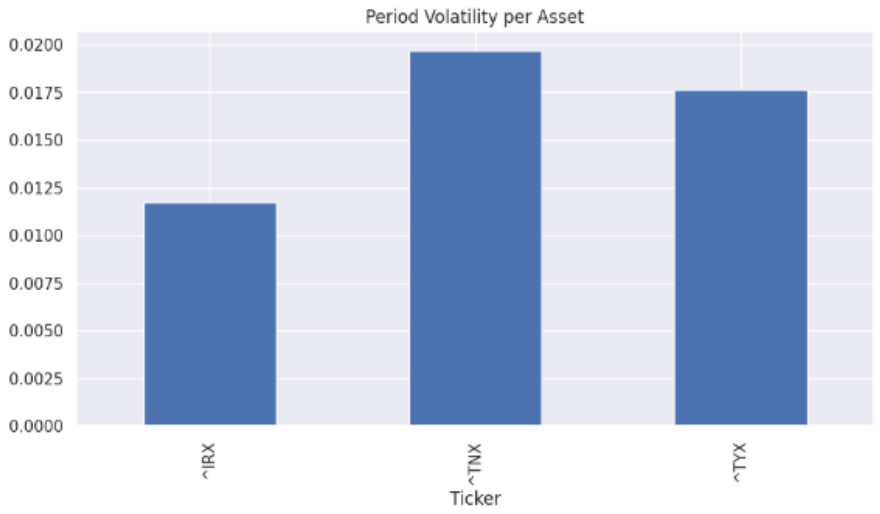

Fig. 11 The volatility of 13-week bills, 10-year notes and 30-year bonds over the period specified

The correlation matrix in figure 12 reveals that medium and long term treasury issues are highly interconnected. Finally, we replace the risk-free investment in our diversified portfolio from the previous section with the optimal 13-week bill and use the current time window of analysis for performance evaluation. The efficient frontier obtained in figure 13 shows that we are able to achieve 56% returns at just below 20% volatility, a 1% increase from the initial portfolio iteration at the same risk level.

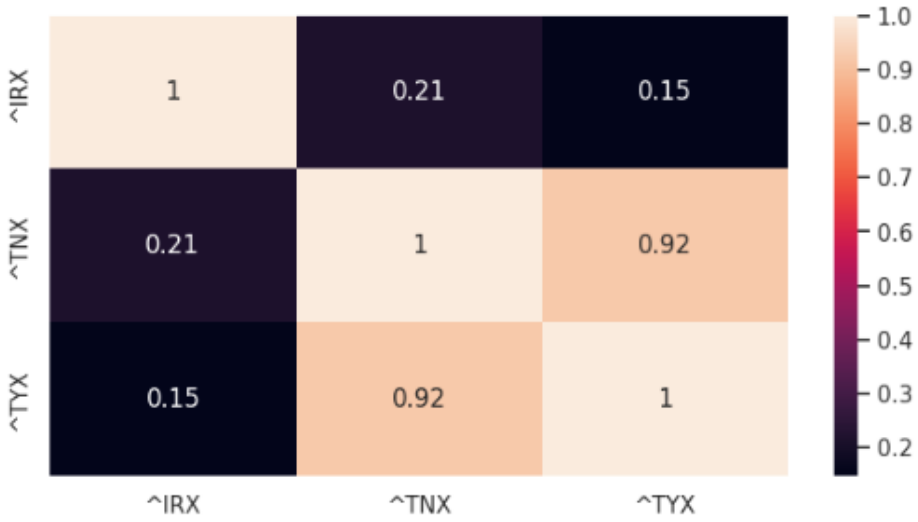

Fig. 12 The correlation matrix of the treasuries-only portfolio

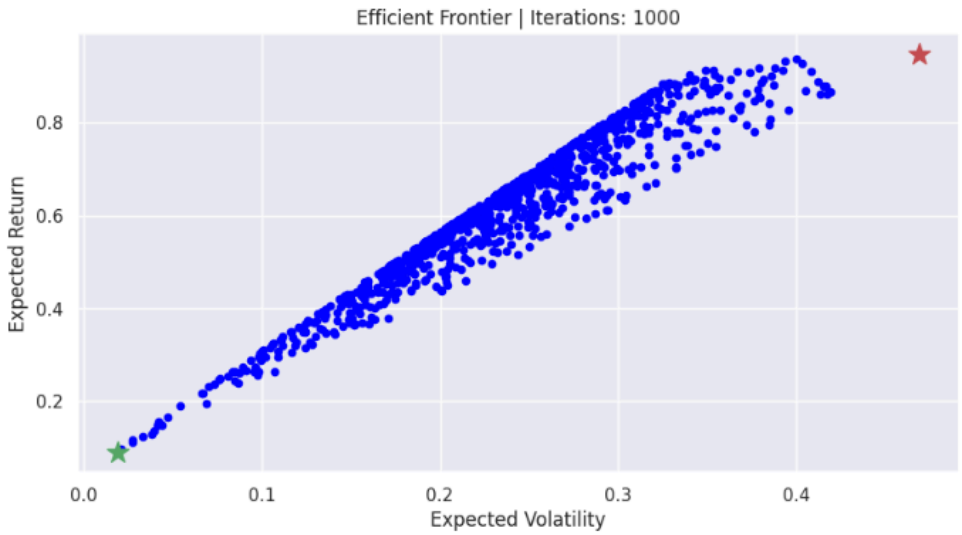

Fig. 13 The safest (in green) and riskiest (in red) updated diversified portfolios

We now examine how the intended stimulation of the economy affected the equities market. Our focus is on Artificial Intelligence as a technological innovation that has the potential to enhance productivity gains across multiple industries in the near future and which has started to be priced in the value of companies leading its development. This exponential growth is analogous to a disruptor agent expected to stand the test of time due to the focus on infrastructure build-up by companies at its forefront on the public markets. This stage, however, comes as a natural follow-up to the chapters preceding it: the semiconductor boom in the 1960s, the personal computer revolution in the 1970s, software in the 1980s, internet in the 1990s and early 2000s, and social media in the 2010s. This era is marked by one company towering over all others in the space currently, Nvidia, which has made the transition from designing its GPUs for video games applications to scientific computing which coincided with the development of neural networks and the need for parallel computing frameworks to train machine learning models over an increasingly high number of parameters. Its focus on hardware design and outsourcing manufacturing has enabled it to pivot faster and scale its revenues in the desired direction. Instead of having to allocate capital to reinvent a production base, the company relies on trusted partners with the technical and operational legacy in fabrication (such as TSMC and Micron). Nvidia's range of products also extends to data center architecture which aligns with the investment strategy of Big Tech towards building up this massive computing real estate. As a result, positioning themselves as a complement and not a substitute for the massively capitalized technology-based companies on the public markets allows Nvidia to chart its own path towards profitability. Other than Apple which has a hardware development legacy (geared towards consumers nonetheless), the other Big Tech companies have all risen in value through software or internet based applications. As a result, it is hard to envision a competitor disrupting the advantage currently held by Nvidia in terms of Intellectual Property for any type of processing unit to be used at scale in the context of artificial intelligence.

By plotting the time series data of its price alongside Microsoft, which has publicly entered a strategic partnership with OpenAI last year positively impacting its valuation among speculators, we observe from figure 14 that Nvidia's increase was 5 times greater than an already impressive tripling of Microsoft's share value.

Fig. 14 Nvidia and Microsoft's stock prices over the specified timeframe

If these 2 companies are any indication and given the current state of the S&P 500 where technology dwarfs other industries in market capitalization, we can expect that technology will continue to attract the most capital accumulation and the entities with the greatest market share in their respective field will continue to reap the rewards. Also, the appearance of freely accessible and user-friendly generative artificial intelligence tools, broadening the scope and dimensions of search, has given a look into the transformative power that this innovation can have on all sectors of the economy. As a result, it is fair to deduce that any company with vast resources that has decided to pivot its business model partially or fully towards this "arms race" has a high likelihood of accelerating its profitability now and in the future.

In constructing the finalized version of our portfolio, we seek an equity component that is heavily skewed towards companies that fit the criteria described above. We thus resort to technology ETFs and inspect their holdings, narrowing our search down to iShares U.S. Technology ETF. Our final asset selection achieves marginal coefficients (figure 15) that do not reflect a strong correlation between each. The resulting efficient frontier (figure 16) shows that we are able to achieve 59% returns at just below 20% volatility, a 3% increase from the intermediate portfolio iteration at the same risk level.

Fig. 15 The correlation matrix of the final diversified portfolio

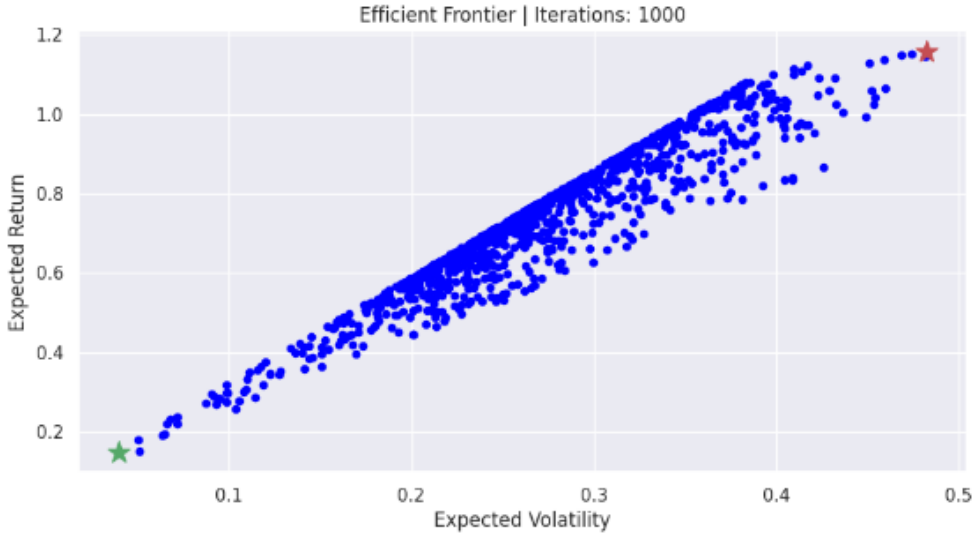

Fig. 16 The safest (in green) and riskiest (in red) final diversified portfolios

In conclusion, we used the Modern Portfolio Theory as a tool to examine the optimal asset allocation in terms of returns and volatility based on the selection criteria and a fundamental understanding of the market dynamics. The aim of this study was to provide a clearer picture of the unique profit opportunities that have occurred thus far in the decade. The continuation of this work will entail developing a portfolio model that accounts for downside risk and for present value, in addition to a more thorough fundamental analysis of the economic factors at play in each market.