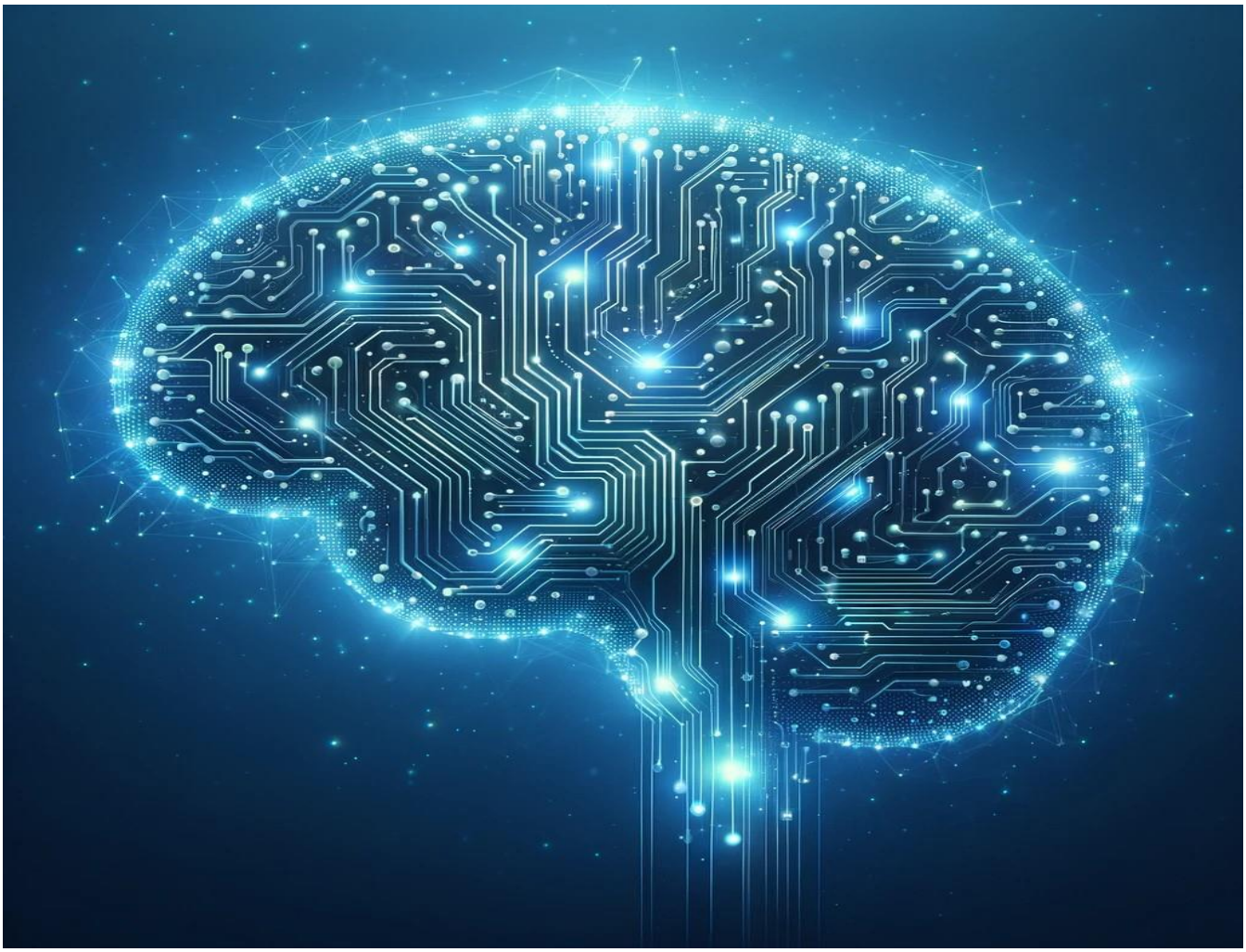

Advancing Portfolio Construction and Optimization: AI's Role in Boosting Returns, Lowering Risks, and Streamlining Efficiency

> "While our analyst team still spends the vast majority of its workday analysing fundamentals, getting overall portfolio positioning right is equally essential to generating returns"
>
> **Dan Loeb** (US billionaire investor and hedge fund manager)

Abstract: This paper is a practical guide on how Artificial Intelligence (AI) and Machine Learning (ML) can support professional investors in portfolio construction and optimisation and identifies three methods for seamlessly integrating ML-based portfolio construction into an existing investment process. It provides a compelling comparative analysis of traditional techniques and modern ML-based approaches to portfolio construction and optimisation. The paper illustrates how, unlike traditional tools such as mean-variance optimisation and the capital asset pricing model, ML methods adapt dynamically to market changes, acting like a navigation system or GPS in the ever-evolving financial terrain. This adaptability enables ML based portfolios to outperform traditional methods through better predictive analytics, automated rebalancing and risk management, leading to more efficient, scalable and customised portfolio solutions. The paper argues that integrating ML into portfolio construction is not just an upgrade, but a significant innovation in asset management. This offers precision and efficiency beyond the capabilities of traditional methods, thereby increasing portfolio returns, reducing risk, and improving efficiency.

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Introduction

Change is the only constant in the universe and nowhere is this more evident than in investing. As Benjamin Franklin once said, “An investment in knowledge pays the best interest.” These words are particularly relevant in today's era of Artificial Intelligence (AI) and the subset of Machine Learning (ML). In this age, knowledge is not just acquired, it is smartly created by AI, reshaped and utilized in innovative ways, revolutionizing the asset management industry. The effectiveness of traditional portfolio management techniques that worked well in the past decades may not be as effective in the coming years due to the increasing use of AI and ML by many investors and asset management companies. These new technologies offer increased portfolio return or alpha, efficiency gains by reducing management expenses and management time, and lower portfolio risk.

Achieving long-term outperformance with controlled risk is not merely determined by stock selection, but also by the weighting of those stocks in the portfolio. The famous investor Michael Burry provided an insightful explanation of this aspect: "A portfolio manager must understand that safeguarding against loss does not end with finding the perfect security at the perfect price. If it did, then the perfect portfolio would likely consist of one security. Rather, to the extent possible, I have the responsibility to structure the portfolio such that if any of a number of unforeseen events occur, that I do not lose the whole, or even a significant portion, of the client's money"[1].

AI technologies have transformed portfolio construction and optimization into streamlined and effective processes. This paper compares traditional methods with cutting-edge ML techniques, also addressing critical questions every portfolio manager faces. These include determining the optimal number of stocks and their ideal weight, as well as the benefits of industry or style diversification. Importantly, we also explore ways to minimize portfolio risk.

This paper is essential for professional active investors and portfolio managers who want to understand the significant potential of ML in portfolio construction and optimization and how to integrate it into their investment strategies seamlessly. Although the focus is on equity investing, these principles apply almost equally to other asset classes.

Let us shortly look back, how portfolio construction developed over time. The story begins in the 1950s with Harry Markowitz's 'Modern Portfolio Theory', which emphasises diversification and risk-return trade-offs. In the 1960s, the Capital Asset Pricing Model was introduced to enhance risk evaluation. The Efficient Market Hypothesis in the 1970s paved the way for passive investing and index funds. The 21st century has seen the emergence of global diversification and sophisticated strategies, thanks to advances in technology and quantitative analysis. Recently, ESG investing and sustainable finance have redefined portfolio construction approaches. This history demonstrates the pursuit of balancing risk and reward in a complex financial landscape.

In a constantly changing world, particularly in investing, AI and ML are reshaping the asset management industry. These technologies enhance portfolio return, increase efficiency and reduce risks.

We emphasize the importance of the portfolio structure beyond pure stock selection to mitigate unforeseen losses.

In this paper we compare traditional methods of portfolio construction and optimization with cutting-edge ML techniques.

We show in a real-world case study how an asset manager successfully implemented ML in portfolio construction and optimization.

We conclude with a practical guide on how to implement ML solutions in an existing investment process.

The paper starts with a brief overview of the investment process, positioning portfolio construction and optimization within the broader Investment Circle. We then explore the goals of portfolio construction and optimization and comparing traditional and ML-based methods. Finally, we present a practical case study of an asset manager who implemented ML solution for portfolio construction and achieved strong results. We also explain the different methods to implement ML solutions in the existing investment process.

The author of this paper, with over 15 years of experience as a fund manager, has established himself as a distinguished expert in the application of AI in investing, combining a deep understanding of traditional asset management with cutting-edge technological insights to guide investors through the evolving landscape of asset management.

Essential Steps in the Investment Process of Equity Investors

This paper explores the role of portfolio construction and optimisation in the equity investment process by looking at the Investment Circle. Subsequent papers will cover the remaining steps of the process in the coming weeks.

This paper explores the impact of ML on portfolio construction and optimization. It highlights the role of ML in enhancing results throughout the Investment Circle.

The main focus of the paper is to construct and optimize a portfolio using ML.

At each stage of the investment process, the investor has the opportunity to use cutting-edge technology such as ML as a supporting tool to improve results.

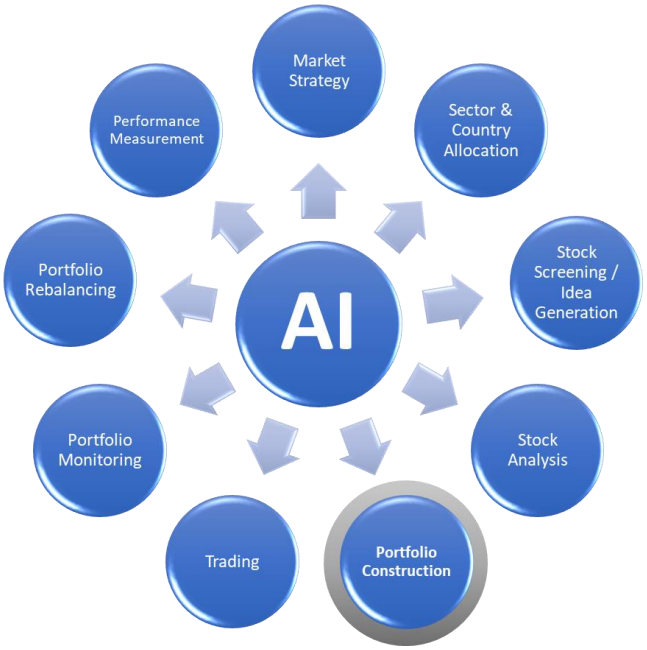


Chart 1: Investment Circle

Traditional investment approaches usually start with developing an overall market strategy. Crafting a market strategy requires a deep understanding of current market dynamics. This initial strategy serves as the foundation and matures over time through frequent investment committee meetings. These gatherings refine the strategy, making it even more robust.

As we explore the investment process further, the complex interplay between sector & country allocation becomes apparent, closely linked to the initial market strategy. It is like conducting a symphony, where each instrument represents a sector or a country, and the conductor is the overarching strategy.

The first climax of this financial symphony occurs during stock selection. This phase connects the third and fourth steps in the investment journey: stock screening and stock analysis. For more information on new technologies in stock screening, please refer to our previous paper, which compares traditional and ML-based stock screening methods and also presents a real-world case study[2].

However, the focus of this paper is on the equally important second climax - portfolio construction.

To fully understand the impact of ML on portfolio construction and optimization, we must first break down the fundamental principles and objectives that form the basis of this complex process.

Approaches to Portfolio Construction and Optimization

Portfolio construction and optimization may seem like two sides of the same coin, but they play distinct roles in investing.

Portfolio construction is the art of forming the portfolio from scratch. It involves selecting which stocks to include and determining the appropriate allocation for each. The process involves customising the investments to align with portfolio goals, risk tolerance, investment horizon and constraints. It can be compared to creating a recipe where the right ingredients and their proportions are chosen to create a dish that suits the guest's taste. For instance, consider the investment approach of the renowned investor Peter Lynch who is known for his 'invest in what you know' philosophy. To construct his portfolio, he would select a mix of companies from different industries he understood well, such as a combination of retail giants and emerging tech firms, based on his investment goals and risk appetite.

Portfolio optimization, on the other hand, involves fine-tuning an already well-built machine. It entails adjusting the weights of the stocks in an existing portfolio to achieve an ideal balance between risk and return. Think of adjusting the seasoning in the dish to achieve the perfect flavour profile. The aim is to maximise potential return for the level of risk the investor is willing to accept.

Understanding these concepts is crucial. In essence, portfolio construction is the first step in building the investment base. It involves selecting the appropriate mix of stocks and their initial allocation or weight. Portfolio optimization, on the other hand, is a continuous process that is part of the ongoing journey of portfolio rebalancing.

In this section, we will focus on discussing portfolio construction. There are several ways to construct a portfolio, but we will concentrate on a few.

Portfolio construction and optimization are important but separate parts in the investment process. Portfolio construction involves selecting and allocating stocks to create a balanced financial composition that aligns with investment goals, risk tolerance and constraints.

In contrast, portfolio optimization involves adjusting the weights of stocks in an existing portfolio to balance risk and return within a given framework.

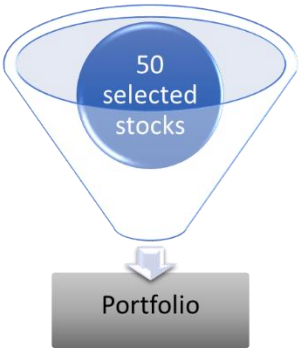
There is the constant debate between diversified and concentrated portfolios. Diversification reduces portfolio risk, but also lowers potential return.

Portfolio risk can be divided into idiosyncratic and systematic risks. Idiosyncratic or single asset risk can be diversified away, while systematic or market risk cannot.

The debate over the ideal number of stocks to hold has been ongoing since the inception of the markets. The constant debate is whether to have diversified or concentrated portfolios. Diversification means not putting all your eggs in one basket. It involves spreading risk across different companies, sectors and perhaps regions. For instance, a diversified portfolio may include tech giants, healthcare firms and real estate companies, reducing the impact if one sector underperforms. Diversification is the traditional shield against market volatility. Diversification is a balancing act that involves distributing investments across a spectrum of stocks to mitigate the impact of any single one's downfall. However, it can also limit the potential for extraordinary gains, making it a double-edged sword.

Warren Buffett for example is not a fan of diversification, he rather prefers concentrated portfolios "You know, we think diversification is - as practiced generally - makes very little sense for anyone that knows what they're doing...it is a protection against ignorance"[3]. Curiously, Buffett's portfolio currently lists 45 stocks. Nevertheless, most of his investments, approximately 80%, are concentrated in just five companies with the largest being – by far – Apple Inc[4]. In addition to the potential for higher returns, a concentrated portfolio allows investors to focus more closely on a select few companies, making it easier to stay informed about each investment and make quick decisions when necessary. However, we leave the decision on portfolio diversification to the portfolio manager and their preference.

Benchmarks are crucial for guiding portfolio managers and serve as a North Star in the investment world. Common benchmarks are indices, such as the Euro Stoxx 50 or S&P 500 and provide a measure of success. While some managers claim independence from benchmarks or indices, their performance and hence paycheck are inevitably evaluated against them. Therefore, every portfolio manager compares themselves to a benchmark - at least internally.



Let us look at an example: When faced with a choice of 50 well-researched stocks, how does one create a winning portfolio? The answer lies in a blend of art and science, where each move is as crucial as the opening gambit in a game of chess. What are the available strategies?

The most common ones we would like to mention:

1. **Equal Weighting**: The simplest method, the portfolio will be weighted equally among all stocks (2% each in the example)
2. **Market Capitalization Weighting**: The portfolio is allocated a percentage to each stock based on its market capitalization, with larger companies receiving a higher weight. This method is commonly used in index funds.

3. **Discretionary weighting:** Each stock will be weighted based on the portfolio manager's conviction. Factors to consider include:
    a. Potentially high price upside to downside, like the Kelly Criterion
    b. Diversification (geographically, industries)
    c. Maximum risk tolerance
    d. Market cap target (mix of small caps and large caps)
    e. Value vs growth style exposure
4. **Risk-Adjusted Weighting**: Allocation is based on the risk profile of each stock, like mean-variance models. Lower risk stocks (fundamental risk or price volatility) may receive a higher allocation. However, assessing the risk of each stock adds complexity to the process.

There are several more ways to determine the weight of a stock in a portfolio. Although we will not delve deeply into these, the techniques range from price weighting, where stock weight is based on its price, to more nuanced approaches such as growth versus value weighting, customised themes that cater to specific investment narratives, or even liquidity weighting which is important for maintaining agile trading.

The key to portfolio construction is aligning stock selection with the investor's goals and risk appetite. Constraints, such as avoiding certain sectors, geographies or stocks, are also important, especially for those who prioritize ESG and sustainability factors. Additionally, it is crucial to set boundaries for how much each single stock can weigh in the portfolio to maintain balance (e.g. minimum weight for a single stock is 1.0%, maximum weight is 5.0%).

Portfolio managers have the crucial responsibility of balancing cost and value, which includes the expenses of creating and maintaining the portfolio, especially considering transaction costs.

A portfolio can be compared to a ship navigating the turbulent waters of the market, with two types of risk: overall market risk and risk associated with individual holdings. Risk management is a key aspect of portfolio management. The already mentioned diversification is a strategy that can help mitigate risk and stabilize the portfolio.

For instance, idiosyncratic risk or unsystematic risk, which is the unique risk associated with individual securities, can be managed through intelligent portfolio construction. While market-wide systematic risk, influenced by broader economic forces, cannot be controlled. Recent financial literature suggests that a portfolio needs 30-50 stocks to neutralize idiosyncratic risk (compared to 8-10 stocks in the 1960s)[5].

Portfolio managers frequently employ scenario analysis to manage risks. This involves simulating different market conditions using Monte Carlo simulations to assess the portfolio's performance. It ensures that decisions are made with a comprehensive understanding of potential risks and sector impacts. While classic Monte Carlo simulations offer a straightforward, rule-based approach to scenario

analysis, ML models are also increasingly being used for this purpose. ML can be utilised to analyse historical data and predict future market behaviours and risk scenarios. It is especially useful in detecting non-linear patterns and interactions among a large number of variables. ML can effectively handle large and complex datasets and can adapt to new data. This makes it powerful in environments such as investing where the underlying data patterns are complex and evolving.

Finally, when optimizing portfolios, there are two main approaches: absolute and relative. Absolute optimization focuses solely on maximizing returns for a given level of risk, operating independently of benchmarks. On the other hand, relative optimization compares the portfolio to a chosen benchmark with the primary objective of outperforming it. In this case, the information ratio is used to measure the additional return the strategy yields over the benchmark for the risk undertaken. Relative optimization is crucial in active portfolio management. The objective is not only to achieve good returns but also to do so in relation to a predetermined benchmark. This approach promotes a more nuanced view of risk and return, taking into account how the portfolio performs in relation to the broader market or a specific benchmark[6].

In the following chapter, we compare traditional techniques for constructing and optimizing a portfolio to ML-based techniques.

Comparative Analysis: ML-Based vs. Traditional Techniques

Investing has always been a combination of art and science, and portfolio construction is no exception. Some traditionalists rely on their instincts and experience without mathematical optimization, determining portfolio weights primarily by intuition. Others use mathematical tools such as those provided by Bloomberg, BlackRock's Aladdin, or Morningstar Direct. A few practitioners are already embracing the benefits of ML in portfolio construction. Let's explore this exciting new world.

Imagine a world where portfolio management is not just a routine job, but an ever-evolving puzzle. ML-based techniques excel in this area. They can be compared to having a chess grandmaster at your disposal, always thinking several moves ahead. Unlike classical approaches such as Mean-Variance Optimization and the Capital Asset Pricing Model, which are similar to using a roadmap in an ever-changing terrain, ML techniques act as a GPS, constantly recalibrating and navigating through the financial landscape's twists and turns.

For instance, consider the shift from a growth-style market to a value-style market. Conventional approaches, such as Markowitz's Modern Portfolio Theory, act as a reliable compass, providing a general direction but failing to consider obstacles or shortcuts. In contrast, ML functions as a cutting-edge navigation system, rapidly adjusting and proposing a new combination of stocks to ensure the portfolio remains on track.

ML takes portfolio construction further, acting as a sophisticated guide, providing dynamic, real-time navigation through market changes.

It differs from classical methods such as Mean-Variance Optimization by providing predictive analytics and automated rebalancing for a proactive and adaptable strategy.

ML enhances risk management by analysing a wider range of factors and improves efficiency in handling large amounts of data.

Ultimately, ML in portfolio construction represents a significant innovation, offering tailored and efficient solutions that surpass traditional methods.

The beauty of ML in the investment process lies not only in its technological skill but also in its philosophical shift. It is similar to upgrading from a simple colour television to a 4K Ultra HD one, with a stark difference. ML-powered portfolio construction is not only adaptable but also proactive. It is like having a portfolio manager who never sleeps, constantly analysing the market and adjusting the portfolio to align with constraints and goals, even as the market ebbs and flows.

One impressive example of ML's capabilities is in **predictive analytics**. Traditional methods are comparable to driving by looking in the rearview mirror, while ML is like looking ahead through the front window. For instance, in a volatile market, a traditional portfolio might remain unchanged, but a ML model might shift towards more defensive assets, predicting storms before they occur. ML models are inherently dynamic. They can continuously learn from new data, adjusting their predictions and strategies based on the latest information. This enables a more real-time response to market changes.

Automated rebalancing is another advantage of ML in portfolio construction. Traditional portfolio management typically adheres to a set schedule. However, what if the market landscape changes unexpectedly? ML can be compared to a self-driving car that navigates and adjusts in real-time, ensuring the most efficient route is always taken. The ability to analyse data and adjust portfolios in real-time can offer greater efficiency and timeliness.

Risk management in portfolio construction involves more than just controlling numbers, it requires a holistic view of the situation. While traditional methods may focus on volatility and correlation, this is similar to judging a book by its cover. However, ML reads between the lines, containing a broader spectrum of risk factors and predicting potential pitfalls with greater accuracy.

One significant benefit of using ML in portfolio construction is its ability to **align the investment committee's market outlook** and strategy within each portfolio. This translation is done through the conversion of high-level strategies into specific model portfolios. Often, the final portfolios only partially reflect the committee's guidance, with portfolio managers exercising considerable independent judgment. In addition, the committee's process of asset allocation regularly follows a rigid approach based on the projected returns for each asset class and sub-asset class. However, the committee does often not adequately consider risk management. For example, if the committee is optimistic about technology stocks, a ML approach can ensure that the portfolio is still diversified and risk parameters are maintained in line with the committee's overall risk appetite.

Furthermore, ML improves the **efficiency and scalability** of portfolio construction. It is comparable to having a supercomputer at your disposal, capable of processing vast amounts of financial data with ease, surpassing the capabilities of traditional methods.

Finally, ML provides **customized solutions** tailored to specific investment goals, risk profiles, and constraints. It is similar to a master chef preparing a gourmet meal, customized to the guest's unique taste, rather than a one-size-fits-all buffet.

In summary, the integration of ML in portfolio construction is not just an upgrade; it is a strong innovation in asset management, offering precision, adaptability, and efficiency that traditional methods can scarcely match.

Case Study

Challenge

This case study focuses on a Dutch Asset Management firm (AM) that manages approximately 60 billion Euros. The firm specializes in creating customized investment strategies for institutional clients. Their services range from managing equity and bond portfolios to alternative investments and private equity.

Historically, this asset manager has relied on traditional portfolio construction methods, such as the mean-variance optimization. However, this approach has shown its limitations: it is a slow process with a lot of assumptions and struggles to be tailored to each unique investment strategy. This one-size-fits-all method resulted in long portfolio construction times and suboptimal portfolio performance, especially when incorporating specific client requirements and constraints.

The AM recognised artificial intelligence as a crucial factor in the Asset Management industry and hence for their strategies. However, developing this capability internally posed significant challenges, including high costs, the need for specialised IT experts and the expected slow process often found in in-house developments. In essence, they identified the crucial role of AI, but their circumstances required them to adopt an external solution.

Solution

The AM partnered with a well-known AI software provider based in the UK to improve their portfolio construction capabilities, rather than developing them in-house.

This collaboration provided the AM with state-of-the-art, ML-powered tools. The AM was able to modernise their approach to portfolio construction by seamlessly integrating this AI solution. The solution offers portfolio managers a user-friendly platform, empowering them to swiftly construct and interact with portfolios.

The software's flexibility enables to use algorithmic prediction of markets and stocks, but also the integration of the AM own investment outlook. The platform optimises portfolios rapidly, blending AI-generated suggestions with the asset manager's specific needs. The combination of AI technology and customised input enhances the personalisation of the portfolio construction.

Result

The implementation of an AI-driven system represented a change in the AM approach. The AM witnessed a significant reduction in the time required for portfolio construction and optimization due to the system's ability to balance portfolios quickly and accurately. This efficiency gain enabled the portfolio management teams to allocate more resources to other strategic, value-adding activities.

Moreover, the system's flexibility in accommodating the AM strategies and constraints transformed the portfolio construction process into a highly adaptable one. This adaptability was complemented by a scenario analysis tool, which offered the AM comprehensive and unbiased market insights, surpassing the limitations of traditional and labour-intensive techniques.

This improvement in portfolio construction led to a better decision-making process, resulting in significant cost reductions and a more effective investment strategy overall.

The key requirement of the AM was to maintain full control of the final investment decision by the in-house portfolio manager, which has been met.

Takeaways

Machine Learning or Artificial Intelligence is transforming portfolio construction and optimization, representing a significant shift in investment decision-making. This paper not only highlights the benefits and advantages of ML-based methods but also encourages investment professionals to adopt this technological breakthrough for more precise decision-making and improved portfolio outcomes.

It is crucial to remember that AI cannot replace the strategic insight and experience of an investor. Instead, it should be viewed as a powerful tool for portfolio creation. The key to success depends on the collaboration between human portfolio managers and AI systems. Humans are skilled at working with limited data such as at IPOs, while AI excels with large datasets.

One common question is how to integrate AI into existing portfolio processes? There are three main methods for incorporating AI into the daily operations of investors and portfolio managers:

Firstly, large asset management firms often develop their own AI tools, requiring IT experts and people who can translate between IT and portfolio management. This approach allows for customized solutions to meet specific requirements, although it can be expensive and complex. It is critical to keep up with AI's rapid changes, as this method may not always be aligned with the latest technology.

Secondly, investors who do not have in-house IT expertise can use existing third-party software. These tools are cost-efficient and incorporate the latest AI innovations. They are both budget-friendly and state-of-the-art.

An increasing number of asset managers are adopting a hybrid strategy that combines in-house development with external solutions. This approach reaches a perfect balance, offering bespoke technology solutions that align with unique investment tactics and organizational needs with state-of-the-art technology.

As discussed in our previous paper, we believe that quantum computing, combined with AI, represents the next technological milestone. Quantum computing offers extraordinary processing power, enabling the analysis of massive datasets at incredible speeds. At the World Economic Forum in January 2024, Jack Hidary, CEO of Sandbox, and Colin Bell, CEO of HSBC, stated that quantum-inspired algorithms will further revolutionize diversification and asset allocation, leading to improved portfolio performance and stability, and ultimately better returns and risk management[7].

If you need help identifying potential applications, selecting the appropriate AI strategy, or choosing the right AI software for your investment process, our team is ready to support you.

AI and ML are revolutionising portfolio management, and investment professionals are rushing to adopt it to improve decision making and portfolio outcomes.

However, AI isn't a replacement for a human investor's strategic insight, but a complementary tool.

The integration of AI into investment strategies can be approached in three ways:

1) building in-house AI tools, which are customisable but complex

2) using third-party software, which is cost-effective and up-to-date

3) a hybrid method that combines both for tailored solutions.

Looking ahead, the potential of quantum computing in AI is noteworthy, promising even faster analysis of large data sets for improved portfolio performance and risk management.

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About SMC

SMC is an innovative consulting boutique specialized in Artificial Intelligence, Digital Transformation and Change Management processes. Initiated by a trio of industry-leading experts, SMC directs its expertise towards serving clients in Asset Management and the broader Industrial sector.

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