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RESEARCH REPORT

The Impact of Crypto Currencies on the Sharpe Ratio of Traditional Investment Models

An Empirical Study

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Introduction

Whilst the methodologies for portfolio management and asset allocation have been examined extensively in countless empirical studies, digital assets and crypto currencies have not received proper coverage yet. Since this asset has a strong growth history in recent years, this report is designed to cover this research gap.

The main goal of this research report is to examine the impact an allocation of crypto currencies has on traditional and alternative investment portfolios. The report not only investigates returns, but also considers the impact on correlation, standard deviation and volatility. In the interest of providing a tangible outcome, this report analyzes two time frames, the past decade from 01.01.2009 to 31.12.2019 and the past year 01.01.2019 to 31.12.2019.

The hypothesis underlying this report is that the Sharpe Ratio, a common measurement for risk-adjusted returns as a function of price volatility, increases for all portfolio allocation models by including crypto currencies in the asset allocation strategy. Furthermore, it is expected that crypto currencies not only increase Alpha of the given portfolios but decrease any systematic risk (Beta) through almost zero correlation with traditional or alternative asset classes.

To examine the impact crypto currencies have on investment portfolios, this report investigates different portfolio structures, with particular focus on the following investment models: a traditional stock/bond portfolio (with weights of 50/50 and 80/20), a balanced portfolio (stocks/ bonds/real estate/gold/ commodities), an endowment model portfolio; a family office/high net worth individuals portfolio and a pension fund portfolio.

Investment Models

The aim of this research report is to determine how the risk-return profile changes if crypto currencies are included in the portfolio allocation. In order to analyse the impact, several different portfolio allocation methods were chosen. These allocation models are outlined in turn in the following section.

Norway Model (50/50)

The Norway model is considered a traditional portfolio allocation model, consisting of equities and bonds. The benefits of this investment approach are typically low costs and fees, high transparency as well as a reduced risk of selecting a poorly performing manager. However the approach also has its drawback, the main one being limited potential for value add via stock selection (CFA Institute, 2019).

For the purposes of this analysis, an asset allocation of 50% equities and 50% bonds was chosen. Equities are proxied by the MSCI World Equity Index excluding emerging markets. The reason for choosing this index is that a 50/50 split between equities and bonds indicates risk aversion of the investor. Consequently, a more conservative equity index is deemed more appropriate. Bonds are represented by the iShares Global Government Bond index. For a comprehensive list of indices used in this report, the reader is referred to the Data section.

Table 1: Norway Model 50/50 Portfolio Allocation

Index	Weight
Equities	50.00%
Bonds	50.00%

Norway model (80/20)

In addition to the 50/50 Norway model, the analysis was repeated with an 80/20 Norway model where 80% of assets is allocated to equities and 20% is allocated to bonds. In contrast to the 50/50 split however the relatively large exposure to equities indicates more risk-taking ability of the investor, which should be reflected in the geographic asset allocation. Consequently, the MSCI World including emerging markets was chosen as a proxy for equity allocation.

Table 2: Norway Model 80/20 Portfolio Allocation

Index	Weight
Equities	80.00%
Bonds	20.00%

Balanced Portfolio

The balanced portfolio aims to cover the major asset classes. For the purposes of this report, the asset classes chosen were equities, bonds, commodities and real estate. The underlying rationale is that the traditional portfolio is supplemented by two additional asset classes to improve the risk-reward performance. This rationale led to the asset allocation depicted in Table 3.

Table 3: Balanced Portfolio Allocation

Index	Weight
Equities	40.00%
Bonds	30.00%
Commodities	12.50%
Real Estate	12.50%
Cash	5.00%

Endowment funds

Endowment funds have vastly different investment approaches depending on the country and the size of the endowment funds. In their article, Hohenadl and Platt (2020) analysed that US endowment funds structurally differ from German endowment funds, for example. The main reason is that US endowment funds usually have a minimum payout ratio of 5%, whereas German endowment funds face no such constraint. As a result, US endowment funds historically took more risk in order to earn returns sufficient to meet the payout requirements.

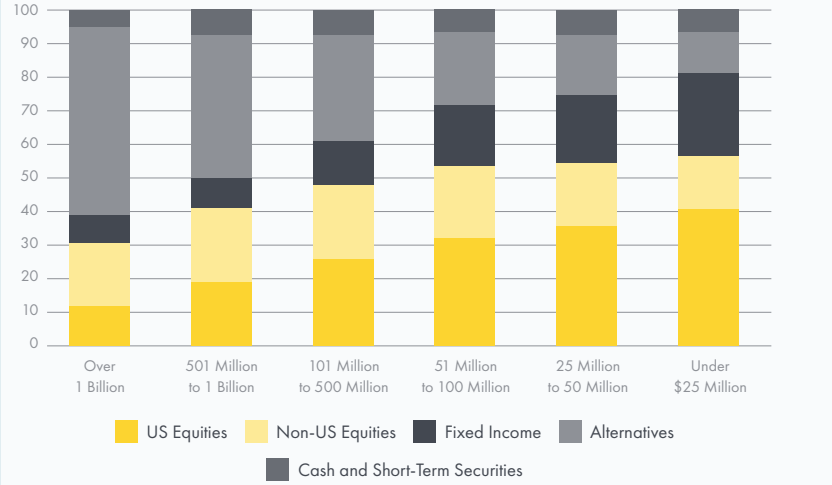
Furthermore, research conducted by the Commonfund and the National Association of University and Business Officers (NACUBO) found that the asset allocation differs by size as shown in Figure 1.

As shown, the larger funds have a considerably higher allocation to alternative investments compared to smaller funds (NACUBO, 2017). This is in line with expectations since larger funds have a higher liquidity buffer and can therefore seek more risk. Hohenadl and Platt's research (2020) found evidence of the same behaviour in German endowment funds.

It is worth noting that, over time, exposure to alternatives increased significantly from 32% to 57%. This allocation change was predominantly driven by increases in private equity, venture capital and private real estate. Hedge fund allocation has remained stable. Conversely this led to a decrease in equity and fixed income allocation.

Due to the heterogeneity in asset allocations of endowments the decision was made to reconstruct the allocation profile of the largest funds. The largest and most well-known endowment funds belong to the top US universities, namely the likes of Stanford, Harvard and Yale, whose asset allocation is used as a proxy for large endowment funds for the purposes of this analysis. As a result, the following asset allocation, as presented in Table 4, was used.

Figure 1: Average Asset Allocation for US University Endowments as of June 2017



Source: Commonfund and the National Association of College and University Business Officers 2017

Table 4: Endowment Fund allocation

Index	Weight
Equities	31.30%
Bonds	10.10%
Commodities	5.50%
Real Estate	8.50%
Private Equity	22.70%
Hedge Funds	15.00%
Infrastructure	2.50%
Timber & Forestry	2.50%
Cash	1.90%

Pension Funds

Similar to endowment funds, the composition of pension funds differs significantly across the globe. Generally, pension funds' investment objectives are dependent on whether they are a defined benefit (DB) or defined contribution (DC) plan and is influenced by the age of the invested workforce.

The left panel of Figure 2 shows geographical differences in asset allocation for pension funds. For example, Japan and the Netherlands have a relatively large portion allocated to bonds. In contrast, the United States and Switzerland have a small allocation to bonds but larger exposures to alternative investments.

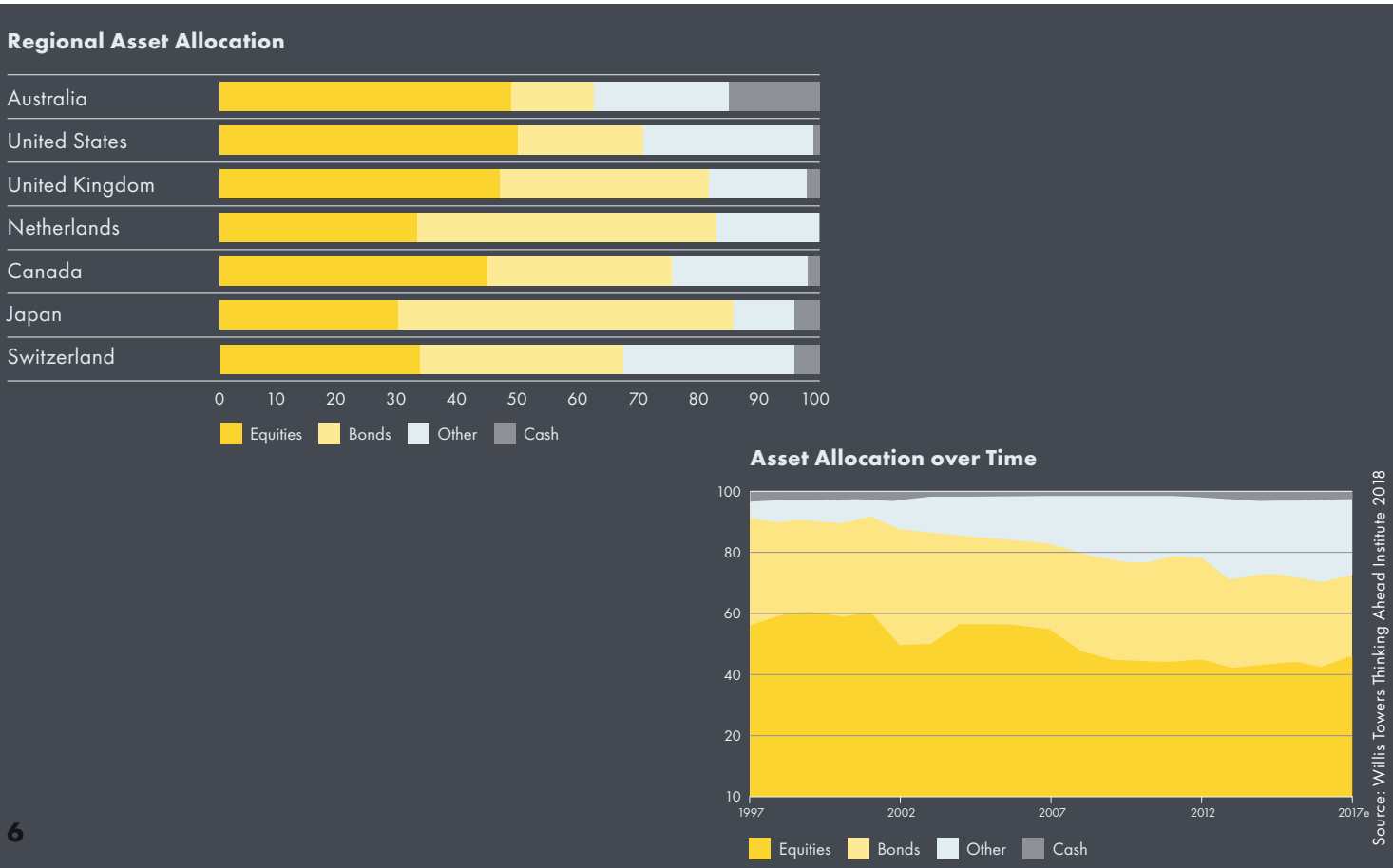
The right panel of Figure 2 shows that allocations have also changed over time. In the late 90s the allocation was akin to the classical Norway model with a small portion of alternative investments mixed into the allocation. Over the past decade, however, the allocation of alternatives steadily increased to approx. 20%.

Table 5: Pension Fund allocation

Index	Weight
Equities	40.00%
Bonds	25.00%
Commodities	10.00%
Real Estate	12.00%
Private Equity	10.00%
Cash	3.00%

For the purposes of this report, an asset allocation had to be chosen. The authors decided to use average values of the regional allocations and to take into account the trend of increasing allocations to alternatives. As such, the following asset allocation is used to conduct the analysis:

Figure 2: Regional Asset Allocation of Pension Funds and Evolution of Allocation



Family offices / High Net Worth Individuals

Family offices or high net worth individuals (HNWI) are generally characterised as investors with a large position in their own company leading to a high exposure towards traditional equity investments. In other words, their exposure is not only skewed towards private equity, but is illiquid in most cases.

Financial products exist, however, that allow investors to borrow against their illiquid position and invest it into more liquid assets, allowing the investor a more favourable portfolio allocation. Prior to the financial crisis in 2008, HNWI attempted to mirror investment strategies from large endowments funds, such as the Harvard fund. However, post the 2008 crisis, allocations have changed for HNWI. Research conducted by the US Trust in 2018 showed that the average HNWI portfolio allocation is made up of what is reflected in Table 6.

For the purposes of this analysis, the same allocation is used to assess the impact of crypto currencies on the portfolio's Sharpe ratio.

Table 6: Family Office allocation

Index	Weight
Equities	55.00%
Bonds	20.00%
Commodities	3.00%*
Real Estate	4.00%
Private Equity	3.00%*
Cash	15.00%

*Approximated values

Methodology

As mentioned in the introduction, the purpose of this analysis is to assess how the Sharpe ratio is impacted by including crypto currencies in the portfolio allocation. The aim is to determine whether the various investment strategies would benefit from the additional diversification.

The hypothesis is based on the premise that the returns of crypto currencies are unrelated to most other asset classes, which should improve the risk-reward performance of the portfolio.

Whether the risk-reward performance is improved will be assessed by the Sharpe ratio. Classic portfolio theory suggests that an asset should be added to the portfolio if the following condition is met.

Equation 1 states that an asset should be included in the portfolio if its Sharpe ratio is larger than the product of the market Sharpe ratio and the correlation coefficient. The key point of this analysis is to investigate the impact of including a crypto index with weights of 1%, 3% or 5% in the reference index. Therefore, the crypto index was added to the reference index with the respective weight and a new index was created. For each of the investment models, a total of four indices was created:

100% reference index

99% reference index
+ 1% crypto index

97% reference index
+ 3% crypto index

95% reference index
+ 5% crypto index

The Sharpe ratio of the reference index is then compared to the Sharpe ratio of the newly created index. The hypothesis is that the Sharpe ratio increases as the weight of the crypto index increases[1].

Note that the risk-free rate of return was assumed to be zero. Given the historically low base rates over the past decade, this was deemed a realistic assumption. Furthermore, the data used in this analysis is monthly. However, investors are generally used to seeing an annual Sharpe ratio. In line with Lo (2003) the results are scaled by a factor of 12 to convert them into an annual Sharpe ratio.

The authors note, depending on the source, Sharpe ratios can look considerably different. In investment management, the Sharpe ratio is often used to evaluate the riskiness of an investment. The rule of thumb is that a Sharpe ratio exceeding 1 is a favourable investment, whereas a Sharpe ratio less than 1 is an unfavourable investment. This statement strongly depends on the way the Sharpe ratio was calculated, however. For example, the 10-year Sharpe ratio for the MSCI World index is 0.75 according to MSCI (2020). However, investor portals will show the 10 year Sharpe ratio of the same index as 7.7 (Comdirect Bank, 2020).

Equation 1: Sharpe Evaluation Criteria

$$\frac{E(R_{new}) - R_F}{\sigma_{new}} > \left| \frac{E(R_p) - R_F}{\sigma_p} \right| Correlation(R_{new}, R_p)$$

The reason for this difference is that companies have different approaches to calculating the Sharpe ratio. The MSCI, for example, calculates one Sharpe ratio over 10 years, which is why the number is 0.75. Investor portals usually calculate 10 individual Sharpe ratios for each year, and then add them up for a final Sharpe ratio. This is how these portals are able to show 10-year Sharpe ratios in excess of 5. Consequently, the authors had to choose whether to present the results in line with the MSCI or investor portals. The authors chose to use the best of both worlds. In this report, one Sharpe ratio is calculated over the entire time period, however, the results are presented such that they are compatible with investor portals. In order for our findings to be compatible with investors, the resulting Sharpe ratio was multiplied by a factor of 10, which converts the Sharpe ratio into an order of magnitude that investors are more familiar with. Please refer to the Appendix for a worked example on how the Sharpe ratios were calculated for this report.

[1] Note that the other indices were reweighted accordingly. For example in the Norway 50/50 model the addition of a 5% crypto index reduces the weights of equities and bonds to 47.5% each.

Data

As mentioned in the introduction, the purpose of this section provides an overview of the data used in this analysis as well as manipulations applied.

Data sources

The data sourcing was separated into two categories, namely crypto currency data and non-crypto market data. The non-crypto market data encompasses all economic data used to create reference indices. This data was sourced daily from Bloomberg and covered a time period from 1.1.2009 to 31.12.2019. All indices were sourced in US Dollars. Table 7 provides an overview of the different tickers used[2]. Furthermore Table 7 provides further details of the assets contained within each index and the rationale as to why they were included in this analysis.

Data Preparation

In order to filter out daily volatility, the decision was made to focus on monthly data. The reason is that monthly data is aggregated enough to smooth out daily volatility but not too aggregated to miss key trends in the data. Monthly return series were created for each of the indices mentioned above. Note that the return was measured from one month-end to the next.

The index returns were combined according to the weights outlined in the section Investment Models. For example, the Norway 50/50 portfolio was constructed by equally weighting the returns of the equity index and the return of the bond portfolio. This is considered the reference index.

Crypto Index

Nowadays, crypto currency indices exist, but they have only meaningfully existed since 2017-2018 and therefore do not provide a large amount of historical data. Consequently, a bespoke index was designed specifically for this report, in order to have richer historical data. The index methodology is akin to the Crypto 10 index, offered by BITA (AvaTrade, 2020).[3] In order to construct the index returns, trade volumes and market caps were sourced from the website www.coinmarketcap.com as a starting point. The index consists of the 10 largest crypto currencies over time and is weighted by market capitalisation.

Whilst there was significant change in the crypto currency space, the 10 largest currencies remained relatively stable. The market capitalisation, number of crypto currencies and returns saw significant increases over the past decade, but the main players remained relatively stable. The crypto currencies that form the index are Bitcoin, Ethereum, XRP, Litecoin, Tether, Bitcoin Cash, EOS, Binance Coin, Bitcoin SV and Tezos.

Initially the index was supposed to cover the time period 2009 – 2019, i.e. an entire decade. However the earlier years posed two significant challenges. Firstly, only Bitcoin was available in the first few years and secondly, market liquidity was low. As a result, the decision was made to focus the analysis on the years 2013 – 2019 where new players had entered the market and liquidity was no longer an issue.

Of course, not all of the crypto currencies listed above existed between 2013 and 2019. For example in 2013 only Bitcoin, Litecoin and XRP were around, whereas in 2016 it was Bitcoin, Ethereum, XRP, Litecoin and Tether. If a crypto currency did not exist in a given year, it was not factored into the calculation of the index return, nor the weighting.

In line with the other market variables, the monthly return of every crypto currency was calculated. Additionally, the weight of each of the crypto currencies was calculated based on the market capitalization in that particular year. The individual returns were weighted by the corresponding weight to derive the crypto currency index. Note that the returns have been calculated on a monthly basis, while the market capitalisation has been calculated on a yearly basis. In other words, the reweighting of the index occurred annually. The rationale of limiting the rebalancing of the index is to firstly avoid volatility and secondly to provide a more realistic index, since rebalancing is relatively expensive in the real world.

Table 7: Bloomberg tickers

Index	Ticker	Overview
MSCI World incl. Emerging Markets	MXWD	This index was chosen to represent the performance of the full opportunity set of large- and mid-cap stocks across 23 developed and 26 emerging markets. It aims to reflect the overall economic condition of the existing equity markets. As of December 2019, it covers more than 3,000 constituents across 11 sectors and approximately 85% of the free float-adjusted market capitalization in each market.
MSCI World excl. Emerging Market	MXWO	The MSCI World index represents the equity markets of 23 developed countries. It was included into this report to provide a relevant overview of the economic conditions in the developed and therefore more stable equity markets worldwide.The index is a market cap weighted stock market index of 1,644 stocks from companies throughout the world.
iShares Global Govt Bond Index	IGLO LN	This index was chosen to provide a relevant allocation of governmental bonds and therefore a fixed income asset class. The funds consists of over 99% governmental bonds and the remaining percentages as cash. The largest position are US-Bonds, with 39.81% allocated assets, next are Japan with 18.45%, France with 7.94%, Italy with 7.18%, UK with 5.18% and Germany with 5.05%. Other bonds include Belgium, Spain, Canada and Australia.
Commodities	BCOM	This index was chosen in order to provide relevant information about the commodity market. The index is calculated on an excess return basis and reflects commodity futures price movements. The index rebalances annually, weighted 2/3 by trading volume and 1/3 by world production and weightcaps are applied at the commodity, sector and group level for diversification.
Real Estate	MXWO0RE	The MSCI World Real Estate index was chosen to reflect the real estate market. It is a free floatadjusted market capitalizationindex that consists of large and mid-cap equity across several developed countries. The companies in the index are mainly Real Estate Investment Trust (REIT) companies, supplemented by RE operating companies. Geographically thefunds invests in: US with 64% assets allocated, Japan with 10.27% , Hong Kong with 8.02%, Australia with 5.12%, Germany with 3.86% and other countries with 8.73%.
Private Equity	PSPIV	The index includes securities, ADRs and GDRs of 40 to 75 private equity companies, including business development companies (BDCs), master limited partnerships (MLPs) and other vehicles whose principal business is to invest in, lend capital to or provide services to privately held companies (collectively, listed private equity companies). The fund and the index are rebalanced and reconstituted quarterly. Country-wise the funds allocates to: US 43.01%, UK with 13.81%, Switzerland with 7.68%, France 5.37%, Sweden 5.30%, Germany with 3.82% and others with 12.44%.
Hedge Funds	HFRI5FWC	The HFRI 500 Fund Weighted Composite Index is a global, equal-weighted index of the largest hedge funds that report to the HFR Database which are open to new investments and offer at least quarterly liquidity. The index constituents are classified into Equity Hedge, Event Driven, Macro or Relative Value strategies. The index is rebalanced on a quarterly basis.
Infrastructure	IGF US Equity	This index was chosen to provide relevant information and allocation towards theinfrastructure sector. The fund has major exposure towards companies providing utilities (52.21%), transportation (32.85%) and energy (14.53%) companies. Geographically the fund is invested in: US with 44.68%, Canada with 9.40% , Spain and Australia with 8.40% each, Italy with 6.85%, China with 5.31%, France with 5.24% and others with 9.31%.
Timber & Forestry	WOOD US Equity	The fund was chosen to primarily to mirror the endowment fund's allocation to the alternative asset class timber and forestry. The fund is mainly engaged in companies from following sectors: Paper & Forest Production (56.89%), Equity Real Estate Investment Trusts (22.26%), Containers & Packaging (16.44%) and Household Durables (3.86%). Geographically the fund is exposed into: US with 33.70%, Japan with 15.63%, Sweden with 14.40%, Finland with 10.69%, Brazil with 8.44%,Canada with 6.47% and others with 10.10%.

[2] For each index the day's closing price was used (PX LAST)

[3] Note that allocations in this bespoke index are not capped at 25% as is the case in the Crypto10 index by BITA.

Each reference index was the supplemented with the crypto index. The allocation of the crypto index was chosen to be 1%, 3% and 5%, leading to one reference index and three newly created indices.

The Sharpe ratio was calculated for each of these indices. The section results not only outlines the resulting Sharpe ratios but also illustrates how these newly created indices would have performed against the reference index cumulatively over time. Before presenting the results, some assumptions and limitations of the analysis should be pointed out.

Assumptions

The analysis assumes a perfectly passive investment strategy. This implies that the losses and volatility incurred during "crypto winter" are fully taken into account.

Classical portfolio theory assumes that the portfolio is created from individual stocks, bonds and other asset classes. In this particular case proxy indices were used. Given the global nature of the indices the assumption is made that they are representative of the market portfolio.

Results

Following the data analysis and evaluation, the findings of the report are unambiguous. Firstly, the results of the Sharpe ratio are discussed. Table 8 below shows the Sharpe ratio of the reference index which excludes any crypto currencies. The results range from 2.76 for the family office model to 6.81 for the traditional stock bond portfolio. The table also provides the Sharpe ratio of the reference index after adding 1%, 3% and 5% of crypto currencies to the reference index.

The analysis shows that adding crypto currencies increased the Sharpe ratio substantially for every single portfolio. Furthermore, there is a positive correlation between the addition of crypto currencies and the increase in the Sharpe ratio. In the example of the traditional 80/20 stock bond portfolio, it can be observed that the Sharpe ratio increases from 6.66 with no crypto currencies included to approx. 8.17 with 1% crypto, 9.53 with 3% crypto and to 9.79 with 5% crypto allocated.

In conclusion, the addition of crypto currencies generally increased the Sharpe ratio of a given portfolio, considering that in 17 out of 18 cases a relevant increase in the Sharpe ratio was observed. In relative terms, the Sharpe ratio increased the most for all portfolios when moving from a 0% crypto allocation to a 1% crypto allocation. This evidences that a comparatively small holding of crypto currencies can significantly improve a portfolio's performance.

Note, however, that this research was focussed on rather small asset allocations of crypto currencies. These findings may not apply to allocation changes from 40% to 45%, which is outside the scope of this research report.

Having seen these results, investors might like to know how the addition of crypto currencies would

Table 8: Sharpe Ratio results

	Reference Index	1% Rebalancing	3% Rebalancing	5% Rebalancing
Traditional stock bond portfolio (50/50)	6,8109	8,7668	9,7907	9,7122
Traditional stock bond portfolio (80/20)	6,6564	8,1671	9,5328	9,7860
Balanced portfolio	3,9965	6,2045	8,1212	8,5975
Endowment model	4,6509	6,4220	8,2163	8,7601
Pension Fund model	4,1144	6,1022	8,0165	8,5699
Family Office model	2,7565	4,5318	6,7274	7,6785

have impacted the performance of their portfolio with a view to the return only. Figure 3 (on the following page) outlines the evolution of the various portfolios over time. The starting point of the analysis is March, 2013 where all portfolios have a value of 1. The darker line represents the reference index, with the lighter and yellow lines representing portfolios including crypto currencies. As shown, the cumulative return of the portfolios including cryptos significantly outperforms the reference index, in some cases by more than 100%. The finding is clearly positive.

The Alpha factor of a portfolio is defined as the actual rate of return of the portfolio minus the expected rate of return of the portfolio. For reasons of comparison, the expected rate of return on portfolio is defined as the return of the reference index without any addition of crypto currencies. It is visible, that with the addition of 1%, 3% and 5% of crypto currencies, the Alpha factor raises substantially for each portfolio.

Table 9 supplements this point by showing the annualised returns of the indices. The reference indices all have returns in single digits, ranging between 2.1% and 5.6%. The annualised returns of an index including 5% of crypto currencies all reached double digits ranging from 11.3% for the family office to 14.9% of the 80/20 Norway model.

Based on the time period investigated and the fact that crypto currencies have been on the rise over recent years, this report finds that the addition of crypto currencies to any portfolio covered had a positive impact on the returns as well as the risk-reward performance of the portfolio. Furthermore, a greater allocation of more crypto currencies, unsurprisingly, led to even higher returns. This most likely is due to the value of crypto currencies skyrocketing over the past decade.

Additionally, the report examined the impact of allocation of crypto currencies towards the Beta of a given portfolio. The Beta, in portfolio theory, is defined as the sensitivity to systematic risk of a given portfolio. Having a Beta of 1 would imply that the portfolio behaves exactly like the "market" portfolio, whereas a Beta of less than 1 implies that the asset is not as sensitive to market movements.

Initially, it was assumed that the correlation between the crypto index and the market portfolio was close to zero. However, correlations were found to be in the range of 20% for all portfolios investigated. Due to the high volatility of crypto currencies, the Beta was found to be in excess of 1.

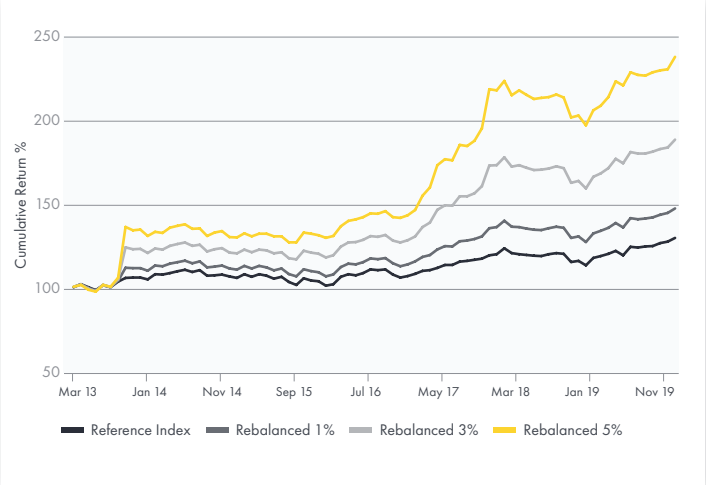
Since the correlation between returns of crypto currencies and investment portfolios is not perfect, the addition of crypto currencies to the portfolios still had a significantly positive impact on returns and the Sharpe ratio. The correlation factor will be investigated in our next empirical research study.

Table 9: Annualised Returns

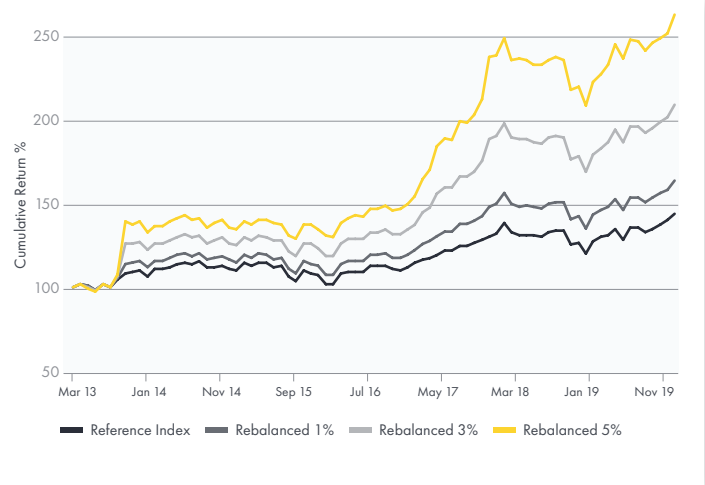
	Reference Index	1% Rebalancing	3% Rebalancing	5% Rebalancing
Traditional stock bond portfolio (50/50)	3,9%	5,8%	9,5%	13,2%
Traditional stock bond portfolio (80/20)	5,6%	7,5%	11,2%	14,9%
Balanced portfolio	2,4%	4,3%	8,0%	11,7%
Endowment model	3,5%	5,4%	9,1%	12,8%
Pension Fund model	2,8%	4,7%	8,4%	12,0%
Family Office model	2,1%	4,0%	7,7%	11,3%

Figure 3: Cumulative returns of indices including crypto currencies

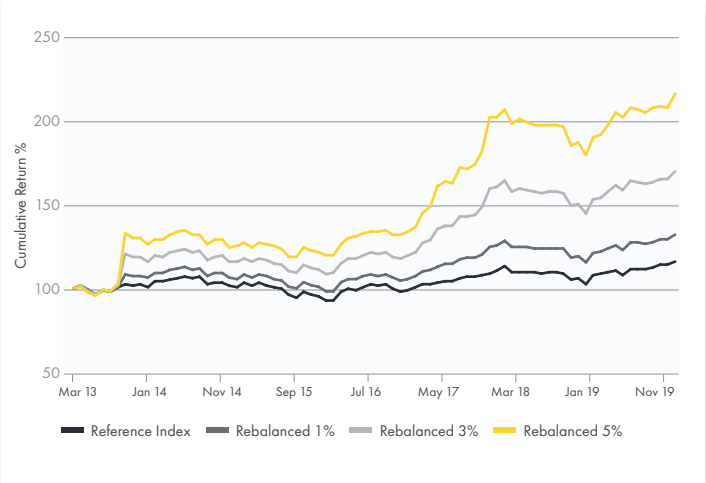
Norway 50/50 Portfolio



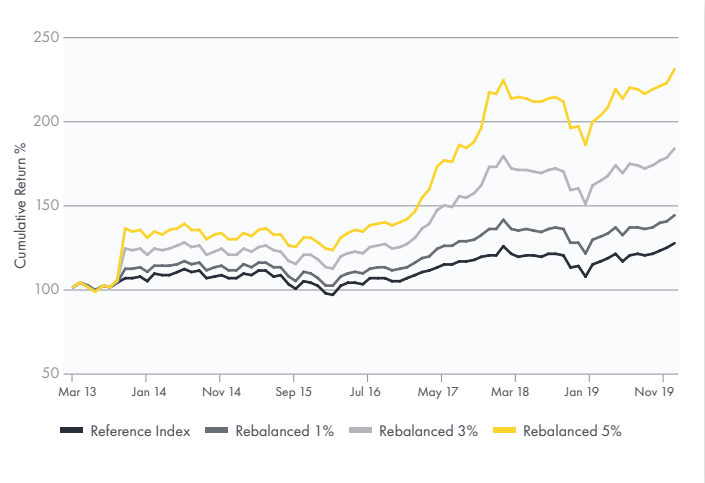
Norway 80/20 Portfolio



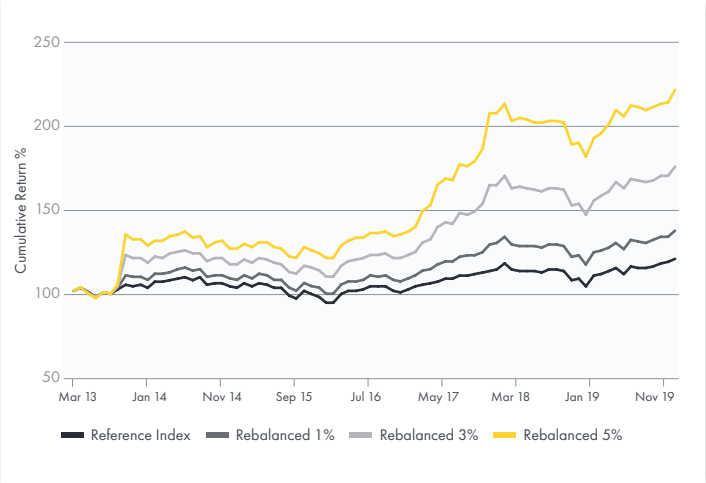
Balanced Portfolio



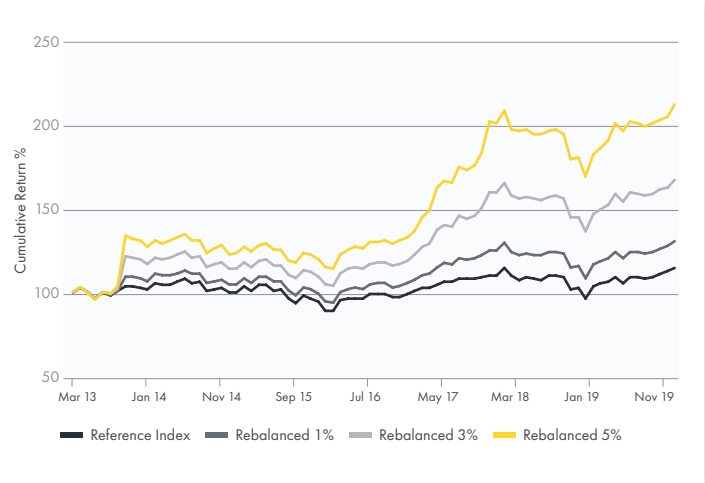
Endowment Portfolio



Pension Fund



Family Office



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Maximilian Lautenschläger
MANAGING PARTNER, DDA

Appendix

This section provides an overview of how the Sharpe ratios were calculated for this report. The example is based on the returns of the reference index in the Norway 50/50 model.

- The average monthly return of the reference index is **0.34%**.
- The monthly standard deviation of the monthly returns σ is **1.73%**.
- The monthly Sharpe ratio is calculated as $\frac{E(R)}{\sigma} = \frac{0.34\%}{0.73\%} = 0.197$
- The monthly Sharpe ratio is converted into an annual Sharpe ratio by scaling it by a factor of **12: 0.1966 * 12 = 0.681**.
- Note that this Sharpe ratio is in line with the reported 10-year Sharpe ratio of the MSCI World (MSCI, 2020).
- In order to make the annual Sharpe ratio compatible with other investor portals, it was scaled by a factor of 10. This is because investor portals calculate 10 individual Sharpe ratios and then add them up.
- Consequently the final Sharpe ratio for the reference index in the Norway model 50/50 is given by **0.681 * 10 = 6.81**.
- This value is presented in Table 8. Note that the other Sharpe ratios presented in the table were calculated using the same methodology.

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