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Cryptocurrencies and the Sharpe Ratio of Traditional Investment Models

How did portfolios perform during the pandemic?

PREPARED BY

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Commissioned by DDA & Cryptology Asset Group

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Introduction

Just over a year ago, DDA published a report analyzing the impact of cryptocurrencies on the performance of traditional portfolios. Our report concluded that a small, rebalancing allocation to cryptocurrencies has a significant impact on the Sharpe ratio of all the portfolios investigated. We have updated our analysis to determine whether an allocation to cryptocurrencies would have benefitted these same portfolios over the past 12 months.

The past year was special for most investors because most portfolios took a considerable hit, due to the spread of the corona pandemic, lock downs and the resulting economic downturn. This report analyses whether cryptocurrencies could have helped investors weather the crisis a bit better.

The hypothesis underlying this report is that the Sharpe Ratio (Return vs. Volatility) increases for all models by including cryptocurrencies in the asset allocation. To examine the impact cryptocurrencies 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 individual's portfolio and a pension fund portfolio.

Figure 1: Comparison Sharpe Ratios

Investment model	Time span	Reference Index	1% Rebalancing	3% Rebalancing	5% Rebalancing
Traditional stock bond portfolio (50/50)	Up to 2021-06	6.7929	7.6619	8.9972	9.8459
	Up to 2019-12	6.8109	8.7668	9.7907	9.7122
Traditional stock bond portfolio (80/20)	Up to 2021-06	6.3342	6.9339	7.9761	8.7968
	Up to 2019-12	6.6564	8.1671	9.5328	9.7860
Balanced portfolio	Up to 2021-06	4.8814	5.7146	7.1076	8.1286
	Up to 2019-12	3.9965	6.2045	8.1212	8.5975
Endowment model	Up to 2021-06	4.7319	5.3381	6.4234	7.3207
	Up to 2019-12	4.6509	6.4220	8.2163	8.7601
Pension Fund model	Up to 2021-06	4.7008	5.4196	6.6677	7.6455
	Up to 2019-12	4.1144	6.1022	8.0165	8.5699
Family Office model	Up to 2021-06	3.4459	4.0152	5.0684	5.9859
	Up to 2019-12	2.7565	4.5318	6.7274	7.6785

Executive Summary

Cryptocurrencies are quickly establishing themselves as a new asset class. Retail investors have long profited from significant returns, but the markets are gradually opening to institutional investors as well. An example is the passing of a law allowing specialized alternative investment funds based in Germany to invest up to 20% of their assets under management into crypto currencies. This poses the question of how portfolios may benefit from an allocation to crypto currencies. This report analyses how the Sharpe ratio is impacted by adding, 1%, 3% and 5% of Cryptocurrencies to your portfolio, rebalancing monthly.

The crypto index is constructed based on the 10 largest Cryptocurrencies in the market and reweighted on an annual basis. The underlying portfolios were constructed to reflect typical exposure profiles for the differing types of investors, as shown in. Figure 1.

The analysis was first conducted in early 2020 and has now been repeated with data up through June 2021, which includes a significant contraction in the crypto markets. Despite the contraction, the results are overwhelmingly positive for a crypto allocation. As shown in Figure 1, the Sharpe ratio increased considerably for all portfolios under investigation. The reference index reflects the Sharpe ratio without any allocation to crypto currencies. The rebalanced indices indicate the indices with an allocation to crypto currencies. The annualized returns outperform the reference indices as well, as shown in the report.

This analysis showed that an allocation to Cryptocurrencies has a significant, positive impact on any of the portfolios investigated despite their volatility the recent, temporary market crash in the cryptomarkets. Consequently, Cryptocurrencies have proven to be an essential component of professional portfolios, even during times of economic crisis.



Investment Models

The aim of this research report is to determine how the risk-return profile changes if cryptocurrencies 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 the traditional portfolio allocation model, consisting of equities and bonds. The benefits of this investment approach are 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

Table 1: Norway Model 50/50 Portfolio Allocation

Index	Weight
Equities	50.0%
Bonds	50.0%

index. For a comprehensive list of tickers used in this report the reader is referred to the Data section.



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	80.0%
Bonds	20.0%

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 its risk-reward performance. This rationale led to the asset allocation depicted in Table 3.



Table 3: Balanced Portfolio Allocation

Index	Weight
Equities	40.0%
Bonds	30.0%
Commodities	12.5%
Real Estate	12.5%
Cash	5.0%



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. The main reason is that US endowment funds usually have a minimum annual 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 2.

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 take more risk. Hohenadl and Platt's research (2020) found evidence of the same behavior 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 allocations. Hedge fund allocations have 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, such as

Figure 2: Average Asset Allocation for US University Endowments as of June 2017

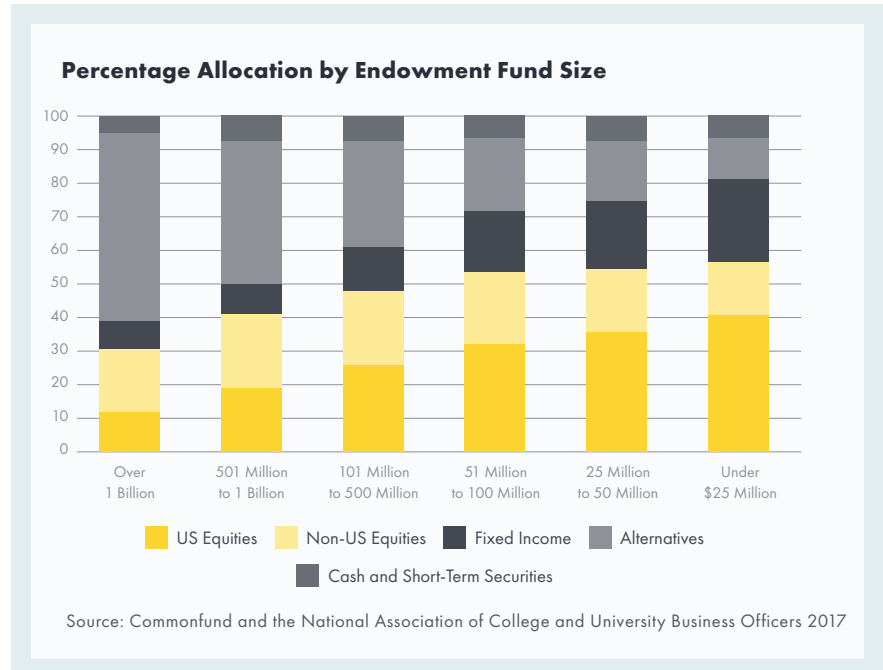


Table 4: Endowment Fund allocation

Index	Weight
Equities	31.3%
Bonds	10.1%
Commodities	5.5%
Real Estate	8.5%
Private Equity	22.7%
Hedge Funds	15.0%
Infrastructure	2.5%
Timber & Forestry	2.5%
Cash	1.9%

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.



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) plans and is influenced by the age of the workforce invested.

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 3 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%.

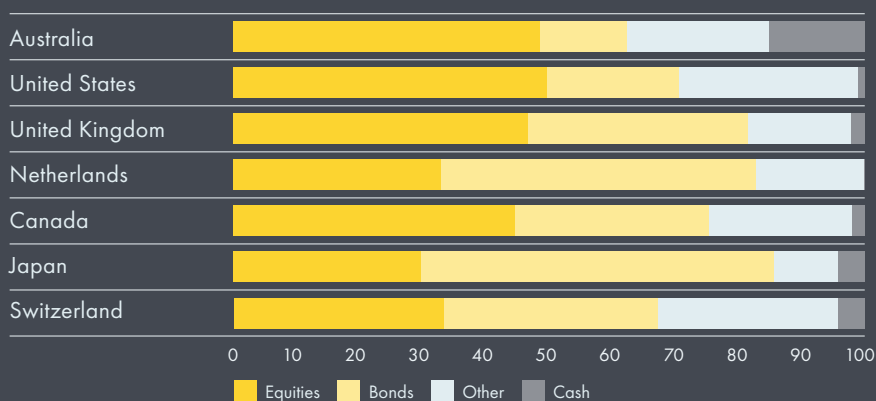
For the purposes of this report, an asset allocation had to be chosen. The authors decided to use average values of the regional allocations and to take into account the trend of increasing allocations to alternatives. The following asset allocation is used to conduct the analysis:

Table 5: Pension Fund allocation

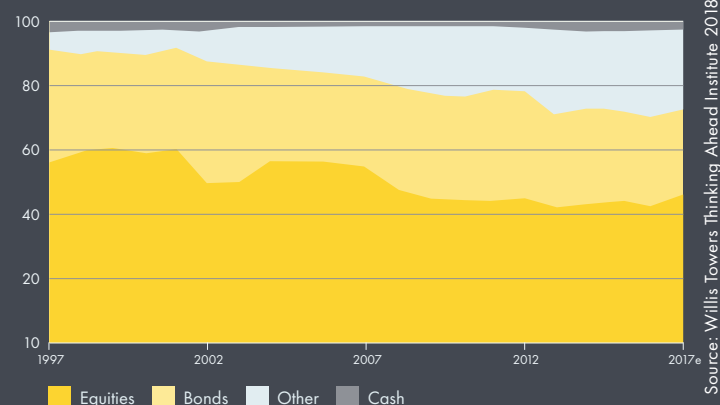
Index	Weight
Equities	40.0%
Bonds	25.0%
Commodities	10.0%
Real Estate	12.0%
Private Equity	10.0%
Cash	3.0%

Figure 3: Regional Asset Allocation of Pension Funds and Evolution of Allocation

Regional Asset Allocation



Asset Allocation over Time



Source: Willis Towers Thinking Ahead Institute 2018



Family offices / High Net Worth Individuals

Family offices or high net worth individuals (HNWI) are generally characterized 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 instances.

Financial products exist, however, that permits investors to borrow against their illiquid position and invest it into more liquid assets, allowing the investor a more favorable 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 cryptocurrencies on the portfolio's Sharpe ratio.

Table 6: Family Office allocation

Index	Weight
Equities	55.0%
Bonds	20.0%
Commodities	3.0%*
Real Estate	4.0%
Private Equity	3.0%*
Cash	15.0%

* Approximated values



Methodology

As mentioned in the introduction, the purpose of this analysis is to assess how the Sharpe ratio is impacted by including cryptocurrencies 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 cryptocurrencies 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 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 increases¹.

Note that the risk-free rate of return was assumed to be zero. Given the historically low base interest 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 $\sqrt{12}$ to convert them into an annual Sharpe ratio.

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 favorable investment, whereas a Sharpe ratio less than 1 is an unfavorable 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 show the 10-year Sharpe ratio of the same index as 7.7 (Comdirect Bank, 2020).

Equation 1: Sharpe Evaluation Criteria

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



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 and then add them up. 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 familiar with. Please refer to the Appendix for an 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

This section provides an overview of the data used in this analysis as well as the manipulations applied.

Data sources

The data sourcing was separated into two categories, namely cryptocurrency 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 30.06.2021. All indices were sourced in US Dollars. Table 7 below provides an overview of the different tickers used². 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 underlying 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 been in existence 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 Crypto10 index, offered by BITA (AvaTrade, 2020)³.

In order to construct the index the 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 cryptocurrencies over time and is weighted by market capitalization.

It is worth noting that up until 2019 the names in the list of the 10 largest currencies remained relatively constant, despite significant change in the crypto currency space. The market capitalization, number of cryptocurrencies and returns saw significant increases over the past decade, but the main players remained relatively stable up to 2019. As a result, the crypto

currencies that form the index are Bitcoin, Ethereum, XRP, Litecoin, Tether, Bitcoin Cash, EOS, Binance Coin, Bitcoin SV and Tezos. From 2019 onwards the coins listed as the largest 10 by market cap changed considerably, which was taken into account in the index. The weights of the index at each point in time are shown in Table 8.

Initially the index was supposed to cover the time period 2009-2021, 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 2013-2021 where new players had entered the market and liquidity was no longer an issue.

Of course not all of the cryptocurrencies listed above existed between 2013 and today. 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.

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	MXWOORE	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.

⁴ The underlying assumption is that a portfolio manager can only look at historical data during the rebalancing process.

Additionally, the weight of each of the cryptocurrencies was calculated based on the market capitalization of the previous year⁴. 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 capitalization 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 expensive in the real world.

Table 8: Crypto Index Weights

Year End	Coin	Weight	Year End	Coin	Weight
2013	Bitcoin	92.0%	2018	Bitcoin SV	1.0%
2013	Litecoin	6.0%	2018	EOS	2.0%
2013	XRP	2.0%	2018	Ethereum	13.0%
2014	Bitcoin	84.0%	2018	Litecoin	2.0%
2014	Litecoin	2.0%	2018	Tether	2.0%
2014	XRP	15.0%	2018	Tezos	0.0%
2015	Bitcoin	94.0%	2018	XRP	14.0%
2015	Ethereum	1.0%	2019	Binance Coin	1.0%
2015	Litecoin	2.0%	2019	Bitcoin	76.0%
2015	Tether	0.0%	2019	Bitcoin Cash	2.0%
2015	XRP	3.0%	2019	Bitcoin SV	1.0%
2016	Bitcoin	93.0%	2019	EOS	1.0%
2016	Ethereum	4.0%	2019	Ethereum	8.0%
2016	Litecoin	1.0%	2019	Litecoin	2.0%
2016	Tether	0.0%	2019	Tether	2.0%
2016	XRP	1.0%	2019	Tezos	1.0%
2017	Binance Coin	0.0%	2019	XRP	5.0%
2017	Bitcoin	51.0%	2020	Bitcoin	79.0%
2017	Bitcoin Cash	10.0%	2020	Ethereum	13.0%
2017	EOS	1.0%	2020	XRP	2.0%
2017	Ethereum	16.0%	2020	Litecoin	1.0%
2017	Litecoin	3.0%	2020	Bitcoin Cash	1.0%
2017	Tether	0.0%	2020	Binance Coin	1.0%
2017	Tezos	0.0%	2020	Chainlink	1.0%
2017	XRP	19.0%	2020	Cardano	1.0%
2018	Binance Coin	1.0%	2020	Polkadot	1.0%
2018	Bitcoin	62.0%	2020	Stellar	1.0%
2018	Bitcoin Cash	3.0%			

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 incurred during the 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.

Table 9: Sharpe Ratio results

	Reference Index	1% Rebalancing	3% Rebalancing	5% Rebalancing
Traditional stock bond portfolio (50/50)	6.7929	7.6619	8.9972	9.8459
Traditional stock bond portfolio (80/20)	6.3342	6.9339	7.9761	8.7968
Balanced portfolio	4.8814	5.7146	7.1076	8.1286
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Pension Fund model	4.7008	5.4196	6.6677	7.6455
Family Office model	3.4459	4.0152	5.0684	5.9859



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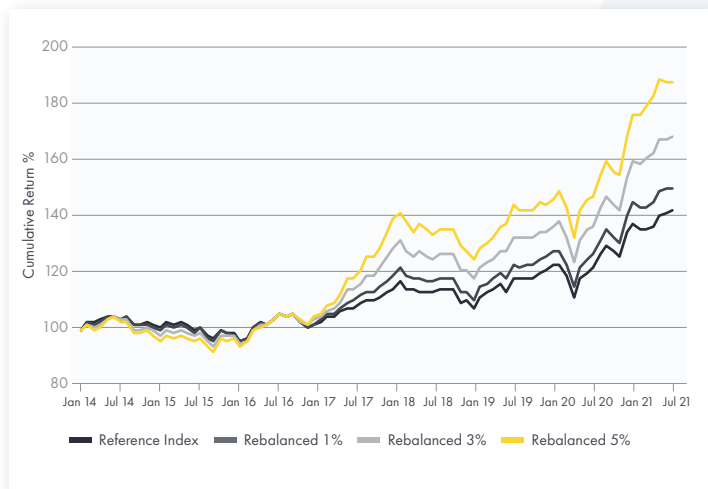
Patrick Lowry, CPA
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CEO, CRYPTOLOGY ASSET GROUP



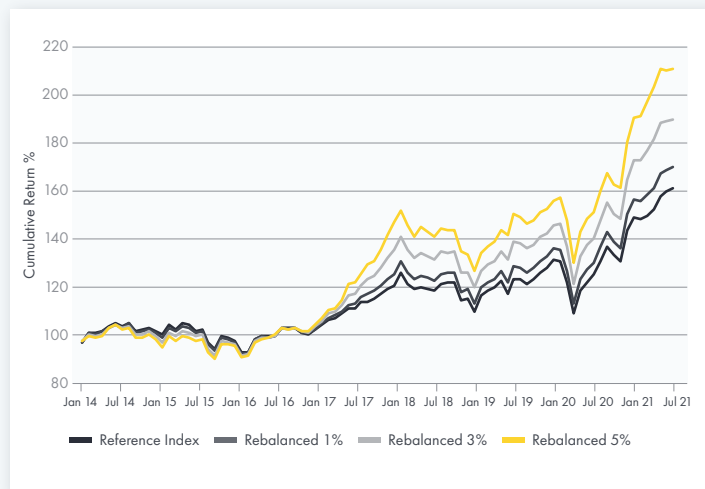


Figure 4: Cumulative returns of indices including crypto currencies

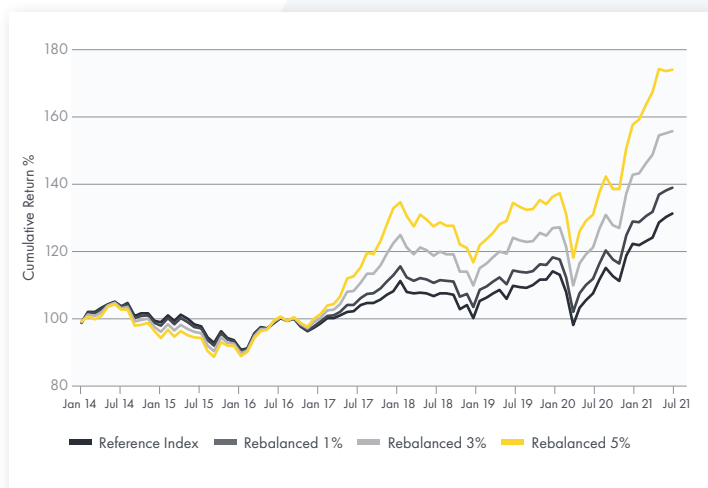
Norway 50/50 Portfolio



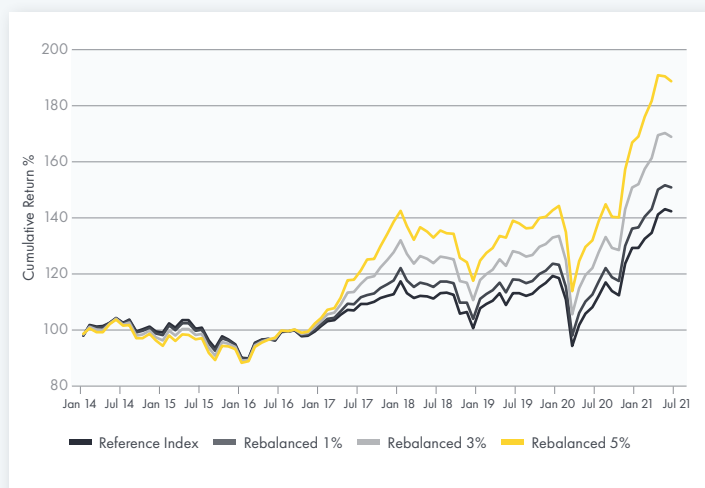
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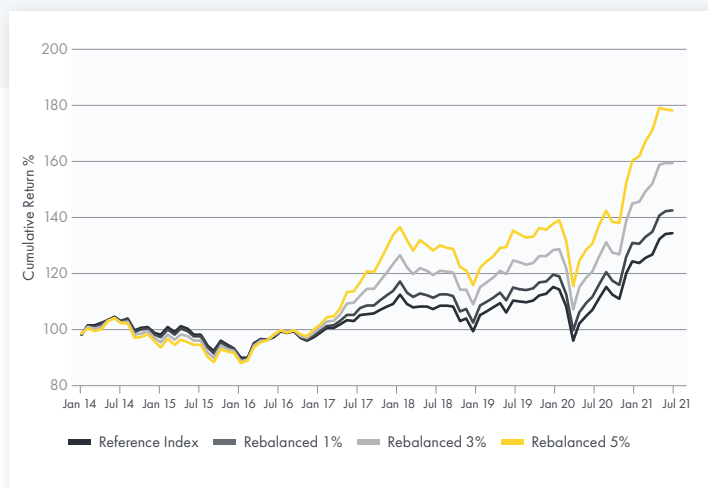
Balanced Portfolio



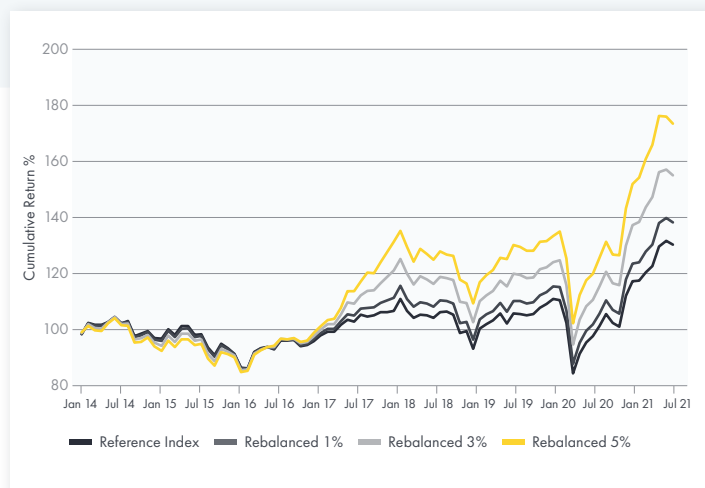
Endowment Portfolio



Pension Fund



Family Office



Results

Following the data analysis and evaluation, the findings of the report are unambiguous. First, the results of the Sharpe ratio are discussed. Table 9 below shows the Sharpe ratio of the reference index which excludes any cryptocurrencies. The results range from 3.44 for the family office model to 6.79 for the traditional stock bond portfolio. The table also provides the Sharpe ratio of the reference index after adding 1%, 3% and 5% of cryptocurrencies to the reference index.

The analysis shows that adding cryptocurrencies increased the Sharpe ratio for every single portfolio. Furthermore, there is a positive correlation between the addition of cryptocurrencies 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 6.33 with no cryptocurrencies included to approx. 6.93 with 1% crypto; 9.00 with 3% crypto and to 9.85 with 5% crypto included.

These results are not only in line with the findings from the previous report, they also underline that the Sharpe ratio increased significantly with the inclusion of cryptocurrencies in the portfolio during the corona pandemic and could have – therefore – provided much needed diversification opportunities.

In conclusion the addition of cryptocurrencies generally increased the Sharpe ratio of a given portfolio, considering that in all cases a continual increase in the Sharpe ratio was observed. In relative terms the Sharpe ratio increased the most for all portfolios when moving from a 1% crypto allocation to a 3% crypto allocation. This evidences that a comparatively small holding of cryptocurrencies can significantly improve a portfolio's performance.

Note, however, that this research was focused on rather small asset allocations of cryptocurrencies. 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 cryptocurrencies would have impacted the performance of their portfolio with a view to the return only. Figure 4 outlines the evolution of the various portfolios over time. The starting point of the analysis is January 2014 where all portfolios have a value of 1. The grey line represents the reference index, whereas the blue lines represent the portfolios including cryptocurrencies. As shown the cumulative return of the portfolios including cryptos significantly beats 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 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 cryptocurrencies. It is visible, that with the addition of 1%, 3% and 5% of cryptocurrencies, the Alpha factor raises for each portfolio.

Table 10 supplements this point by showing the annualized returns of the indices. The reference indices all have returns in single digits, ranging between 3.6% and 6.6%. The annualized returns of an index including 5% of cryptocurrencies all reached triple digits, ranging from 7.6% for the family office to 10.5% of the 80/20 Norway model.

This report finds that the addition of cryptocurrencies to any portfolio covered had a positive impact on the returns as well as the risk-reward performance of the portfolio. This finding holds despite a significant correction in the crypto markets during the beginning of 2021. Furthermore, the addition of more cryptocurrencies led to even higher returns.

Table 10: Annualised Returns

	Reference Index	1% Rebalancing	3% Rebalancing	5% Rebalancing
Traditional stock bond portfolio (50/50)	4.7%	5.5%	7.1%	8.7%
Traditional stock bond portfolio (80/20)	6.6%	7.4%	8.9%	10.5%
Balanced portfolio	3.7%	4.5%	6.1%	7.7%
Endowment model	4.9%	5.7%	7.2%	8.8%
Pension Fund model	4.1%	4.9%	6.5%	8.1%
Family Office model	3.6%	4.4%	6.0%	7.6%



Comparison against previous results

As outlined in the introduction this type of analysis was first published in May 2020 and now updated with new data, which includes the period of the corona pandemic as well as the crypto market crash in March to May 2021. Figure 4 and Figure 5 show how the Sharpe ratios of each investment model, as well as their annualized returns, were affected by the crises.

The Sharpe ratio of the traditional stock and bond portfolio decreased compared to the initial results of the first report. Notice that both the Sharpe ratio from the reference index, as well as the rebalanced indices, declined. The behavior for the remaining portfolios, however, is slightly different. For the Balanced Portfolio, Endowment, Pension Fund and Family Office models, the Sharpe ratio of the reference index increased. While the Sharpe ratio of the rebalanced indices has increased

significantly above the Sharpe ratio of the reference indices, the ratios are slightly lower compared to the initial findings.

Looking at the annualized returns of the investment models, a similar pattern is observed. Across the board, the inclusion of crypto currencies in the portfolio leads to a significant improvement of the overall return. Compared to the results from the initial report, the risk adjusted returns slightly decreased, however.

There are several reasons for this behavior, which are discussed in turn below. The reason for the decrease in the Sharpe ratio of the traditional stock and bond portfolio is that the bond index performed relatively poorly since the COVID pandemic. Hence, the risk-return profile altered. The reason that the Sharpe ratios of the reference indices of other investment models have increased is that the commodity, Hedge Fund and Private Equity indices performed reasonably well with little volatility since March 2020.

Figure 4: Comparison Sharpe Ratios

Investment model	Time span	Reference Index	1% Rebalancing	3% Rebalancing	5% Rebalancing
Traditional stock bond portfolio (50/50)	Up to 2021-06	6.7929	7.6619	8.9972	9.8459
	Up to 2019-12	6.8109	8.7668	9.7907	9.7122
Traditional stock bond portfolio (80/20)	Up to 2021-06	6.3342	6.9339	7.9761	8.7968
	Up to 2019-12	6.6564	8.1671	9.5328	9.7860
Balanced portfolio	Up to 2021-06	4.8814	5.7146	7.1076	8.1286
	Up to 2019-12	3.9965	6.2045	8.1212	8.5975
Endowment model	Up to 2021-06	4.7319	5.3381	6.4234	7.3207
	Up to 2019-12	4.6509	6.4220	8.2163	8.7601
Pension Fund model	Up to 2021-06	4.7008	5.4196	6.6677	7.6455
	Up to 2019-12	4.1144	6.1022	8.0165	8.5699
Family Office model	Up to 2021-06	3.4459	4.0152	5.0684	5.9859
	Up to 2019-12	2.7565	4.5318	6.7274	7.6785

The reason the Sharpe ratios and returns of the rebalanced indices have decreased compared to the previous report is the significant market downturn that occurred between May to July 2021. During the time the price of one Bitcoin decreased by over 50%.

This result must be interpreted with caution, however. Firstly the crypto markets have recovered from the downturn since late July 2021 and have recuperated a large part of

the losses. It is worth noting that the price of one Bitcoin crossed the \$50,000 barrier once again in early Sept. 2021. Secondly, a skilled investor should bear in mind that even with such a market contraction in the crypto industry, the rebalanced portfolios still significantly outperformed the reference indices across the board.

Not only have the results of the first report been confirmed, but we further can conclude that adding

cryptocurrencies to a portfolio will have a beneficial impact. This report has also shown that these results still hold true during an isolated downturn in the crypto markets, showing that the inclusion of cryptocurrencies will benefit the portfolio even if there is a temporary downturn.

Figure 5: Comparison Annualized Returns

Investment model	Time span	Reference Index	1% Rebalancing	3% Rebalancing	5% Rebalancing
Traditional stock bond portfolio (50/50)	Up to 2021-06	4.7%	5.5%	7.1%	8.7%
	Up to 2019-12	3.9%	5.8%	9.5%	13.2%
Traditional stock bond portfolio (80/20)	Up to 2021-06	6.6%	7.4%	8.9%	10.5%
	Up to 2019-12	5.6%	7.5%	11.2%	14.9%
Balanced portfolio	Up to 2021-06	3.7%	4.5%	6.1%	7.7%
	Up to 2019-12	2.4%	4.3%	8.0%	11.7%
Endowment model	Up to 2021-06	4.9%	5.7%	7.2%	8.8%
	Up to 2019-12	3.5%	5.4%	9.1%	12.8%
Pension Fund model	Up to 2021-06	4.1%	4.9%	6.5%	8.1%
	Up to 2019-12	2.8%	4.7%	8.4%	12.0%
Family Office model	Up to 2021-06	3.6%	4.4%	6.0%	7.6%
	Up to 2019-12	2.1%	4.0%	7.7%	11.3%

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 $\frac{E(R)}{\sigma} = \frac{0.34\%}{1.73\%} = 0.197$
- The monthly Sharpe ratio is converted into an annual Sharpe ratio by scaling it by a factor of $\sqrt{12}$: $0.1966 * \sqrt{12} = 0.681$.
- 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 9. Note that the other Sharpe ratios presented in the table were calculated using the same methodology.

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