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Research Report
Portfolio Optimization
with BNB

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This collaborative report between 21Shares and Binance Research analyzed the performance of traditional US equity, and fixed-income portfolios, without crypto, with BNB, and with BNB & BTC. In addition, different rebalancing techniques were also used in this study. We show how, like Bitcoin, BNB has displayed a low correlation with all traditional financial assets over the long-term. Moreover, this research shows the importance of considering skewness in regards to large negative tail risk involved across asset classes.

DATA AS OF MARCH 15 2020

Portfolio Optimization with BNB
Key Takewaways

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→ Like Bitcoin, BNB has displayed over the long-term a null correlation with all traditional financial assets like equities and commodities. However, BNB has also exhibited a lower than average correlation with other large-cap cryptocurrencies such as Bitcoin (BTC) and Ethereum (ETH).

→ This report analyzes the performance of traditional US equity and fixed-income portfolios, (1) without crypto, (2) with BNB, and (3) with BNB & BTC. In addition, different rebalancing techniques were also used in this study.

→ Thanks to their low correlations with other financial assets, the inclusion of cryptoassets to traditionally diversified portfolios drastically improved their risk-return characteristics, as measured by their higher Sharpe ratios. While both the BNB and BNB + BTC portfolios outperformed the crypto-free portfolio, the BNB portfolio outperformed the BNB + BTC on similar metrics, despite an increased level of volatility.

→ Tolerance-based rebalancing allows investors to limit their exposure to cryptoassets, while a monthly rebalancing sometimes leads to significant deviations from a portfolio's target exposure to the cryptocurrencies sector (e.g., during the January 2018's bull run).

→ With most assets displaying non-normally distributed returns, Skewness must also be considered in regard to large negative tail risks. Unlike other cryptocurrencies, BNB displayed positively skewed returns, which may be useful for investors to manage downside tail risk better, especially in a portfolio composed of negatively skewed assets.

Portfolio Optimization with BNB
Overview of BNB

## BNB: the Fuel of the Binance ecosystem

BNB powers the Binance ecosystem and is the native coin of Binance Chain. BNB is a cryptocurrency created in June 2017, launched during an ICO in July, and initially issued as an ERC-20 token. Designed to be used for fee reductions on the Binance exchange, its scope was extended over the years.

BNB currently powers the **Binance Chain as its native chain token**. For instance, it is used to pay fees on the Binance DEX, issue new tokens, send/cancel orders, and transfer assets.

At the core of the economics of BNB, there is a **burn system** leading to **periodic reductions of its total supply** (~ every three months). From the initial maximum supply of 200 million, burns will keep occurring until the supply reaches 100 million. In addition to its on-chain functions, **BNB has multiple additional use-cases**, as it offers fee discounts on Binance.com, can be used as a payment asset on third-party services and entails participation rights for Binance Launchpad.

The full breakdown of organizations and projects in the BNB ecosystem is displayed below.

Figure 1 — Organization and projects in the BNB ecosystem
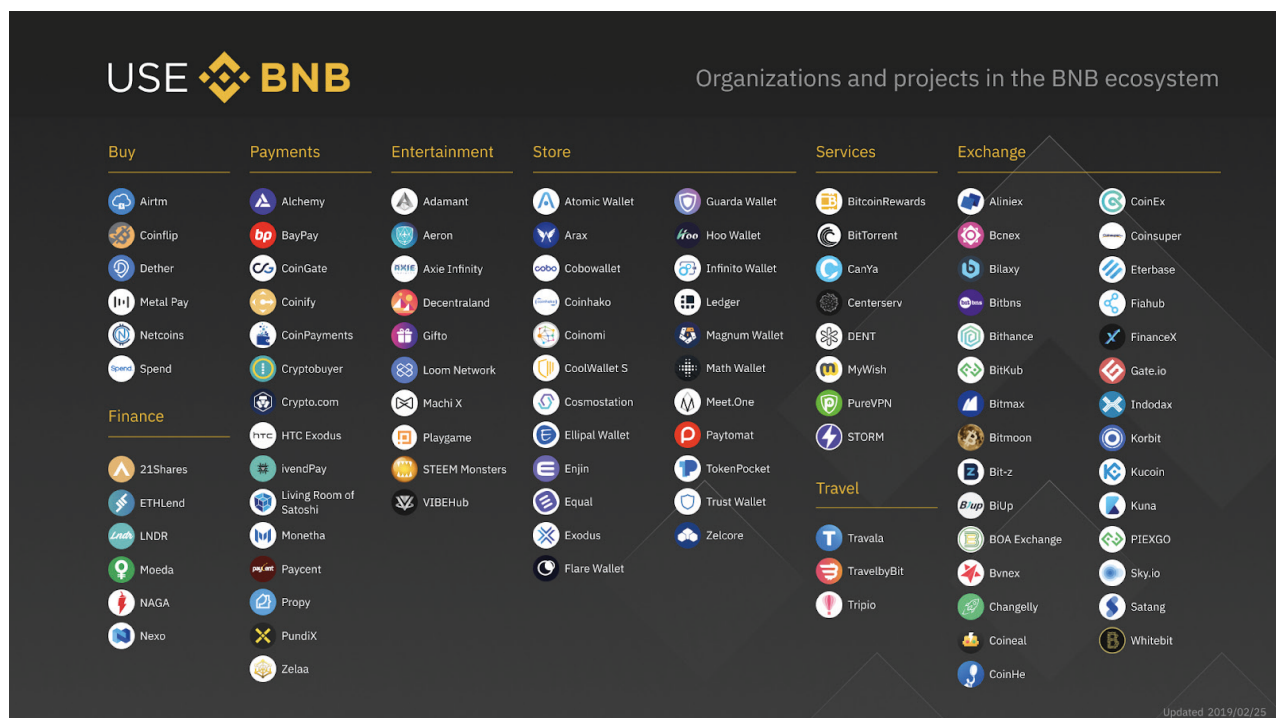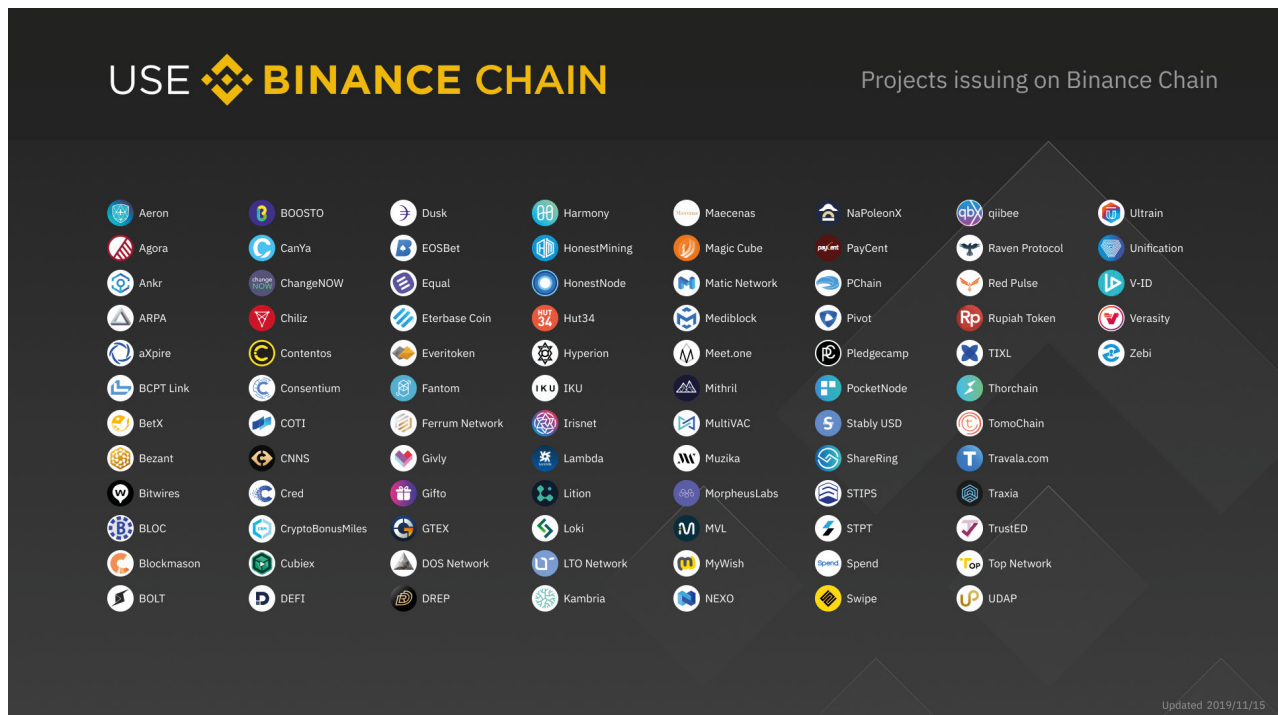
Portfolio Optimization with BNB
Overview of BNB

As discussed before, BNB is the native asset of the Binance Chain and is used to perform operations on the network, such as sending orders on the Binance DEX, transferring assets from one wallet to another, and issuing new assets. However, the **full scope of the Binance Chain is much larger** and is displayed in Figure 2.

After implementing the BEP-3 standard in late 2019, Hash Time-Locked Contract functions and further mechanisms have been made available to handle inter-blockchain token pegging. This is likely to further increase the interoperability with other programmable blockchains, like Ethereum.

Finally, the anticipated support of smart-contracts on the Binance Chain will likely foster additional use-cases for BNB, unlocking a new range of opportunities.

Figure 2 — Projects issuing on Binance Chain

Portfolio Optimization with BNB
Overview of BNB

Characteristics and Past Performance

While BNB is still **an entirely new financial asset**, it has displayed both extremely large positive returns in its first years, followed by significant drawdowns, and then further price rallies in subsequent years.

Chart 1 — Evolution of the Price of BNB in USD. Source: Binance.com

— BNB

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Table 1 — BNB Calendar Returns. Source: CoinMarketCap, Binance

Indicator	2017 (since ICO*)	2018	2019
Returns	8,540%	-29%	196%
Annualized Standard Deviation	290%	143%	81%

Table 2 — BNB Quarterly Returns. Source: CoinMarketCap, Binance

Period	Returns
Q4 2017	575%
Q1 2018	28%
Q2 2018	33%
Q3 2018	-32%
Q4 2018	-39%
Q1 2019	182%
Q2 2019	86%
Q3 2019	-51%
Q4 2019	-13%

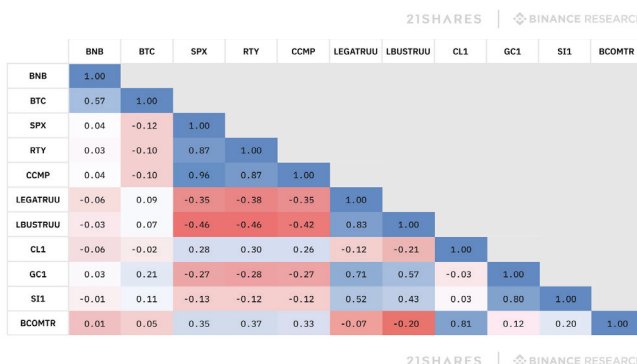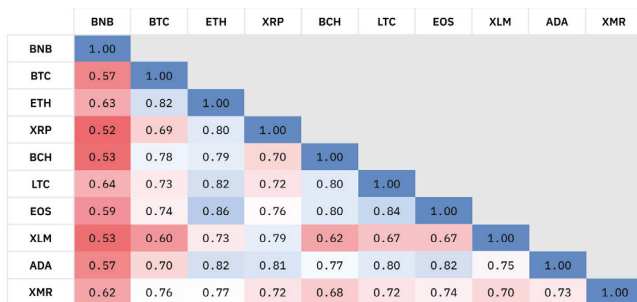Portfolio Optimization with BNB
Overview of BNB

Is BNB Correlated to Other Assets?

As illustrated in our previous reports about crypto-correlations, the intensity of the correlation relationships amongst cryptocurrencies and other crypo assets is often significantly positive. In 2019, the average correlation ratio amongst cryptocurrencies **stood at 0.72, a noticeably high value indicating a strong relationship between the returns of cryptoassets**.

Amongst ten of the largest marketcap cryptoassets, BNB was the least correlated asset — displaying an **average correlation of only 0.58**. BNB displayed a medium positive correlation with other large cryptoassets: only 0.57 with BTC, 0.52 with XRP, 0.64 with LTC, and 0.63 with ETH. In comparison, BTC and ETH, the two largest cryptoassets, **displayed a strong positive correlation** (0.82).

BNB appears to be a unique asset: not only is it uncorrelated with traditional financial assets, but it is also one of the lowest correlated assets with other cryptocurrencies. Hence, the next subsection focuses on the construction of model portfolios, including Bitcoin (BTC) and BNB, along with the backtesting of the performance of these portfolios.

Chart 2, 3 — Correlations between large cryptoassets by marketcap in 2019 and Correlations between BNB, BTC, and traditional financial assets in 2019

	BNB	BTC	ETH	XRP	BCH	LTC	EOS	XLM	ADA	XMR
BNB	1.00									
BTC	0.57	1.00								
ETH	0.63	0.82	1.00							
XRP	0.52	0.69	0.80	1.00						
BCH	0.53	0.78	0.79	0.70	1.00					
LTC	0.64	0.73	0.82	0.72	0.80	1.00				
EOS	0.59	0.74	0.86	0.76	0.80	0.84	1.00			
XLM	0.53	0.60	0.73	0.79	0.62	0.67	0.67	1.00		
ADA	0.57	0.70	0.82	0.81	0.77	0.80	0.82	0.75	1.00	
XMR	0.62	0.76	0.77	0.72	0.68	0.72	0.74	0.70	0.73	1.00

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	BNB	BTC	SPX	RTY	CCMP	LEGATRUU	LBUSTRUU	CL1	GC1	SI1	BCOMTR
BNB	1.00										
BTC	0.57	1.00									
SPX	0.04	-0.12	1.00								
RTY	0.03	-0.10	0.87	1.00							
CCMP	0.04	-0.10	0.96	0.87	1.00						
LEGATRUU	-0.06	0.09	-0.35	-0.38	-0.35	1.00					
LBUSTRUU	-0.03	0.07	-0.46	-0.46	-0.42	0.83	1.00				
CL1	-0.06	-0.02	0.28	0.30	0.26	-0.12	-0.21	1.00			
GC1	0.03	0.21	-0.27	-0.28	-0.27	0.71	0.57	-0.03	1.00		
SI1	-0.01	0.11	-0.13	-0.12	-0.12	0.52	0.43	0.03	0.80	1.00	
BCOMTR	0.01	0.05	0.35	0.37	0.33	-0.07	-0.20	0.81	0.12	0.20	1.00

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Asset	Ticker
S&P 500 Index	SPX
Russel 2000 Index	RTY
NASDAQ Composite	CCMP
Bloomberg Barclays Global Aggregate Index (USD)	LEGATRUU
Bloomnberg Barclays US Aggregate Index (USD)	LBUSTRUU
Oil	CL1
Gold	GC1
Silver	SL1
Bloomberg Commodity Index Total Return (USD)	BCOMTR

Portfolio Optimization with BNB
Methodology and Model Construction

In this report, two general approaches to the construction of a portfolio will be adopted:

→ Time-based rebalancing is the rebalancing of a portfolio at fixed, pre-defined intervals. For instance, BNB's weight is reallocated at the end of each month with different levels of exposure, such as 5%.

→ Tolerance-based rebalancing (also termed "Dynamic Boundary Rebalancing") is the rebalancing of a portfolio, whenever the effective portfolio weight of an asset in the portfolio exceeds target thresholds.

For all assets, transaction fees are included based on empirical data from exchanges and trading venues. For practical reasons, slippage is not considered for this analysis, even though it can be a key variable for large investors. Transaction fees are set at 0.10% for all assets. The portfolio construction is in line with 21 Shares' previous research paper (Ige, 2019) and shall be composed of traditional assets up to 95%. We adopt a traditional allocation of 60% equities / 40% bonds and focus solely on the US market. For the cryptocurrency allocation, we target a 5% allocation in this report with two different scenarios: (1) BNB alone, (2) BNB with BTC. Henceforth, four portfolios are backtested in the next subsection and benchmarked against two base portfolios with no exposure to cryptoassets. For all the portfolios, data is backtested from September 30th, 2017, to March 15th, 2020:

Portfolio 1: Monthly Rebalancing with BNB only

→ Portfolios are rebalanced, with a target of 5% for BNB, on the last business day of the month.

Portfolio 2: Monthly Rebalancing with BNB & BTC only

→ Portfolios are rebalanced, with a target of 2.5% for BNB and 2.5% for BTC, on the last business day of the month.

Portfolio 3: Tolerance-based Relancing with BNB only

→ Portfolios are rebalanced, with a target of 5% for BNB, whenever a boundary is crossed. Boundaries are set at 2.5% & 7.5% for rebalancing.

Portfolio 4: Tolerance-based Relancing with BNB and BTC

→ Portfolios are rebalanced, with a target of 2.5% for BNB and 2.5% for BTC, whenever a boundary is crossed. Boundaries are set 1.25% & 3.75% for both BNB and BTC.

Portfolio Optimization with BNB
Results and Interpretation

In the following section, we present the performance results for both our time-based and tolerance-based rebalancing strategies — by presenting calendar returns, annualized returns, volatiles, Sharpe ratios, and maximum drawdowns for the portfolios. We will then analyze the data in order to better understand to what extent BNB provides further diversification to an investor's portfolio.

Time-based Rebalancing

Chart 4 — Portfolio Performances (Base = 1000)
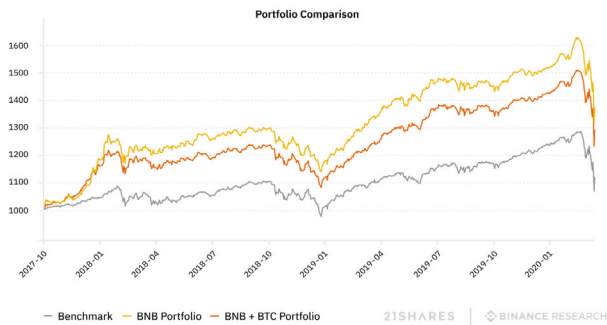
The portfolio with additional BNB outperforms both the benchmark and the enhanced portfolio combination of BTC and BNB in the time-rebalancing case. While the BNB portfolio has a much higher level of volatility than the BTC portfolio, this additional volatility is more than compensated for given the excess returns — indicated by the superior Sharpe ratio of **1.081** compared to **0.368** for the benchmark and **0.903** for the BNB + BTC mix portfolio.

Near the tail-end of the 2017-18 bull market, BNB's allocation within the portfolio briefly **reached a high of 14%** due to its sudden rise to the low-20s digits (USD) in early January. It is important to note, however, that the large deviation from the ideal BNB allocation of 5% could have unnecessarily given an investor a more-than-ideal exposure to the crypto market during the early months of the 2018 downturn — this would not happen if tolerance-based rebalancing had been used.

Table 4 — Key metrics for portfolios with time-based rebalancing

	Benchmark	BNB	BNB + BTC
Annualized Return	5.23%	17.87%	12.87%
Annualized Volatility	10.76%	15.35%	12.85%
Annualized Sharpe Ratio	0.368	1.081%	0.903
Maximum Drawdown	16.29%	19.22%	18.66%

Table 3 — Calendar returns

	Q4 2017	2018	2019	Q1 2020
Benchmark	3.92%	-2.77%	2.19%	-9.67%
BNB Portfolio	2.16%	-2.99%	29.09%	-0.31%
BNB + BTC Portfolio	16.77%	-5.36%	27.71%	-9.52%

Portfolio Optimization with BNB
Results and Interpretation

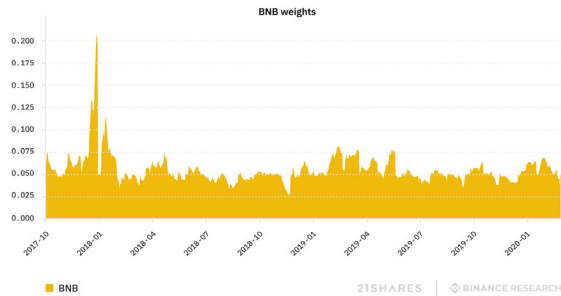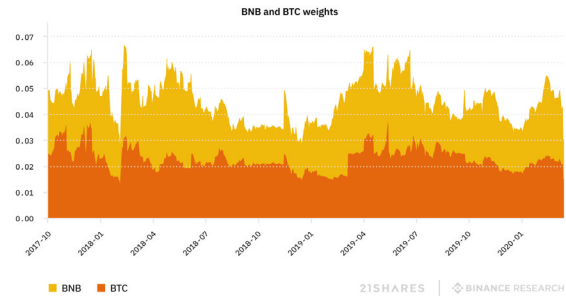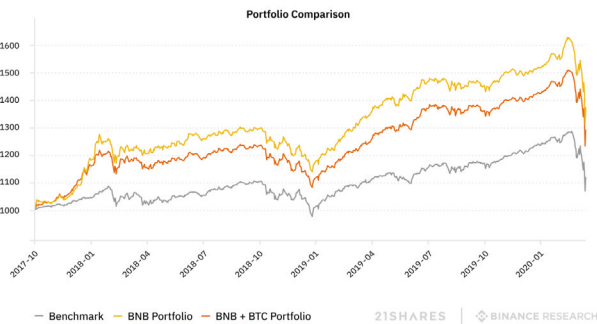*Chart 5 — Portfolio weights (5% BNB Portfolio) |*

BNB weights

BNB

Chart 6 `– Portfolio weights (2.5% BNB + 2.5% BTC Portfolio)

BNB and BTC weights

BNB   BTC

Tolerance-based Reabalancing

Chart 7 — Portfolio performances (Base = 1000)

Portfolio Comparison

— Benchmark — BNB Portfolio — BNB + BTC Portfolio

We see a similar trend to the time-rebalancing portfolio when we look at the tolerance rebalancing approach. The BNB portfolio performs better than both the benchmark and the BNB + BTC in terms of both annualized returns and Sharpe ratio, though — once again — the BNB portfolio is subject to a noticeably higher level of volatility than the others. As expected, the use of a tolerance-rebalancing strategy prevents the BNB allocation within the portfolio from reaching levels seen with the time-rebalancing analogous portfolio.

While this does reduce BNB exposure in the run-up to the 2017-18 price appreciation, it also allows the downwards exposure to be reduced during the 2018-19 bear market — this fact is reflected in the **greatly reduced volatility in both the tolerance-rebalancing BNB and BNB + BTC portfolios**. Finally, it seems that a tolerance-rebalancing strategy provides a more reliable way for an investor to ensure their portfolios are never unnecessarily overexposed to the crypto asset industry.

Portfolio Optimization with BNB
Results and Interpretation

BNB weights

BNB

BNB and BTC weights

BNB   BTC

Skewness

The severe market drawdown on the 12th of March — dubbed as the "**Black Thursday**" by some within the cryptoasset industry — has highlighted the importance of accounting for tail risk and Skewness of returns when building optimal portfolios, especially those with allocations of cryptoassets, such as BNB or BTC. Generally, modern portfolio theory assumes that the distribution of returns can be adequately understood through the use of the distribution's mean and standard deviation; within this context, these two metrics allow investors to calculate average returns

and volatility. However, the distribution of returns for financial assets rarely, if ever, follows a normal distribution, and this holds true for cryptoassets as well. The charts below show the distributions of returns of the three sample portfolios we calculated earlier using tolerance rebalancing whilst comparing them to samples following normal distributions with the same mean, standard deviation, and number of samples.

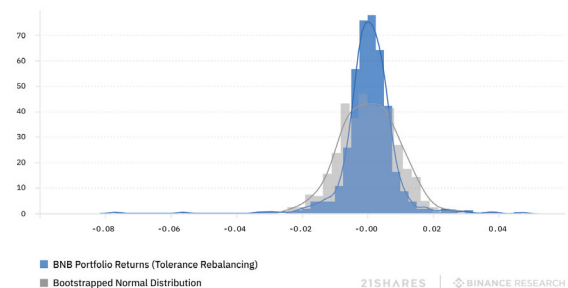Chart 10 — Portfolio distributions (Benchmark portfolio — rebalancing)

Benchmark Portfolio Returns (Tolerance Rebalancing)
Bootstrapped Normal Distribution
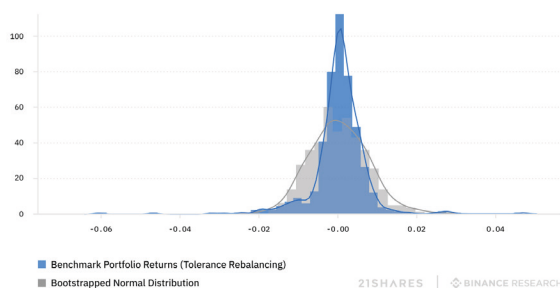
Chart 11 — Portfolio distributions (BNB portfolio — rebalancing)

BNB Portfolio Returns (Tolerance Rebalancing)
Bootstrapped Normal Distribution

Results and Interpretation

Chart 12 — Portfolio distributions (BTC|BNB portfolio — rebalancing)
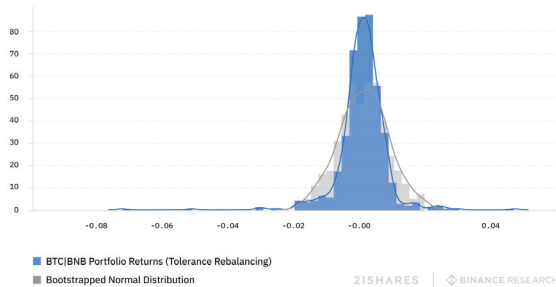
As we can see, **none of the portfolio's distributions match closely to the normal distribution**. Noticeably, their distributions are negatively skewed and have fatter tails than the normally distributed data set. These two facts can be represented by the metrics Skewness and Kurtosis, where for a normally distributed dataset, its Skewness will be 0 and its Kurtosis 3.

However, as the table below demonstrates, the Skewness and Kurtosis of the portfolio's returns deviate noticeably from metrics that could reasonably suggest their normality. In addition, we use three popular tests for the normality of any distribution — the Shapiro-Wilk, D'Agostino's K^2, and the Anderson Darling tests — at a 5% significance level to further confirm our doubts of the normality of the portfolio's returns.

Table 7 — Portfolio Skewness, Kurtosis, and normality tests

	Normal Distrbuton	Benchmark	BNB	BTC + BNB
Skewness	0	-1.42	-1.33	-1.76
Kurtosis	3	16.9	18.6	20.7
Shapiro-Wilk Test	Pass	Fail	Fail	Fail
D'Agostino's K^2 Test	Pass	Fail	Fail	Fail
Anderson Darling Test	Pass	Fail	Fail	Fail

The presence of fat-tailed distributions in the returns of the three portfolios and for cryptoasset returns presents an important warning for investors, as modern portfolio theory taken alone — without the consideration of the skewness of returns and tail risk — can lead to a systematic underestimation of downside risk, as was the case on "Black Thursday". Most equities, Bitcoin, and other "risk-on" assets, exhibit negative skewness. Interestingly, BNB has a positive skewness of **1.65**, which places it into a category of other positively skewed assets (generally) such as VIX and safe-haven assets — in the following example we use the iShares Barclays 1-3 Year Treasury Bond Fund (SHY) as an example of one.

Table 8 — Skewness of different assets

	BTC	BNB	VIX	SHY
Skewness	-0.373	1.65	3.38	0.905

Portfolio Optimization with BNB

Results and Interpretation

Negatively skewed returns mean that one would generally expect to see the asset produce frequent small gains and infrequent large losses — as is the case with equities in recessionary periods and Bitcoin. Conversely, positively skewed returns mean that one would generally expect to see the asset produce frequent small losses and infrequent large gains. VIX is an easily understood example of this, as it tracks the implied volatility of the S&P500, which generally goes through extended periods of low volatility (e.g., during the post-2008 bull run) before a noticeable, but rare drawdown and heightened volatility phase. BNB also exhibiting the property of being positively skewed might explain why it could be an especially useful addition to a portfolio that generally consists of negatively skewed assets — helping to bring the overall portfolio skewness closer to 0 and making it more resilient to downside long-tail events.

Portfolio Optimization with BNB
Conclusion

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This analysis has added to the research that suggests that **adding small amounts of a cryptoasset to a "traditional" portfolio can drastically improve its risk-adjusted return**s. In the context of BNB, we showed how its addition to a balanced portfolio can provide substantial diversification benefits, and that both tolerance and monthly rebalanced portfolios with a 5% target allocation of BNB outperform a portfolio without any cryptoasset allocation. Interestingly, over the study period, the BNB portfolio also outperformed the portfolio with target weights of 2.5% respectively, for both BNB and BTC, despite BNB having a relatively lower than average correlation with Bitcoin.

One under-examined aspect of applying modern portfolio theory to the crypto market has been the effect of Skewness and Kurtosis of returns on an investor's risk and expected returns. We showed how — owing to large amounts of Skewness and Kurtosis — traditional portfolios and portfolios with cryptoassets have returns that do not follow a normal distribution and are generally negatively skewed. This fact can lead to investors underestimating downside risk if they don't properly account for this fact. BNB, interestingly, has had positively skewed returns over the last two years, which allows it to function as a means for investors to further hedge against the present downside tail risk, which is particularly pronounced in portfolios composed of negatively skewed assets.

Portfolio Optimization with BNB
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4) Ige, L (2019). Portfolio Optimization With Crypto Assets. https://www.amun.com/img/uploads/amun-portfolio-optimization-with-crypto.pdf

Footnotes

1) There are plenty of other papers (e.g. Hougan 2018, Binance Research 2019) which investigate the diversification benefits of Bitcoin in traditional portfolios.