A New Frontier

How Digital Assets Are Reshaping Asset Allocation

GRAYSCALE®

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It's not every day, or even every decade, that an entirely new asset class is born. Yet, through a combination of computer science, cryptography, economics, and network theory, digital assets have arrived and are proving that they are an asset class unlike any other. As they transform our global financial infrastructure and challenge modern monetary theory[1], we believe digital assets are one of the most exciting investment opportunities of the 21st century.

In this paper, we will demonstrate why we view digital assets as a brand new asset class that can enhance strategic asset allocation and help investors build portfolios with higher risk-adjusted returns. We will provide a few different lenses through which the reader can gain a deeper understanding of the role that digital assets may play in building more efficient portfolios.

As first outlined by Chris Burniske and Adam White in their January 2017 whitepaper titled Bitcoin: Ringing the Bell for a New Asset Class, we believe that digital assets provide exposure to unique market opportunities and risks, thus creating a diversifying return stream for investors. As such, they should be considered a component of the optimal beta portfolio[2] alongside traditional assets such as equities, bonds, and real estate.

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1. Source: Economic Research: Federal Reserve Bank of St. Louis. The Case for Central Bank Electronic Money and the Non-case for Central Bank Cryptocurrencies. Vol. 100, No.2, April 16, 2018. Aleksander Berentsen and Fabian Schar. https://research.stlouisfed.org/publications/review/2018/02/13/the-case-for-central-bank-electronic-money-and-the-non-case-for-central-bank-cryptocurrencies.
2. A "beta portfolio" is a theoretical portfolio of investments that includes every type of asset available in the global financial market, with each asset weighted in proportion to its total presence in the market. The "optimal beta portfolio" is the portfolio that includes every type of asset available in the global financial market, with each asset weighted in order to maximize the return of the portfolio per unit of risk. Source: Investopedia.

Since the focus of this paper is on portfolio construction, we will not go deep into detail on the investment merits of individual digital assets. However, we encourage you to review the pioneering work of Burniske and White, as well as our previous investment theses for select digital assets here:

- Bitcoin & the Rise of Digital Gold (June 2016)
- Hedging Global Liquidity Risk with Bitcoin (December 2016)
- Into the Ether with Ethereum Classic (August 2017)
- The Zcash Investment Thesis (January 2018)

It should be noted that numerous investment opportunities exist outside of the digital assets that we have explored, but our analyses are intended to paint a picture of our general framework for assessing real-world use cases that drive the investability of the asset class.

A Brief Intro to Modern Portfolio Theory

> "*Diversification is the one free lunch of investing, and when you see a free lunch, the only rational thing to do is eat.*"[3]
>
> Cliff Asness, Managing Principal and CIO at AQR Capital Management

New asset classes are rare and very powerful because they offer a unique return stream that can provide a diversification benefit. This might seem like a simple concept, but few investors truly appreciate the impact this can have on the return/risk profile of a portfolio, and subsequent wealth creation.

According to Modern Portfolio Theory ("MPT"), by estimating the future returns, volatilities, and correlations of various assets, and pairing different combinations of each, an efficient frontier of portfolios can be constructed, in which the level of return is optimized per unit of risk.[4] While it has proven difficult to estimate these parameters for assets over short periods of time, in the long-run, equilibrium risk, return, and correlation values can be estimated more reliably, making this framework incredibly valuable for disciplined investors who stick to a strategic asset allocation.[5]

We generally subscribe to the notion that the optimal return/risk ratio for a portfolio can be found on the efficient frontier. But contrary to conventional wisdom, we think many of today's asset allocators are missing out on a "free lunch." That's because (i) digital assets represent a brand new investment opportunity that is uncorrelated to other asset classes and (ii) investors are gen-

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erally under-allocated to this sector. It is our view that the optimal beta portfolio lies somewhere higher than what was previously believed to be the efficient frontier, and digital assets are the proverbial "missing piece of the puzzle."

FIGURE 1: **THE NEW EFFICIENT FRONTIER**
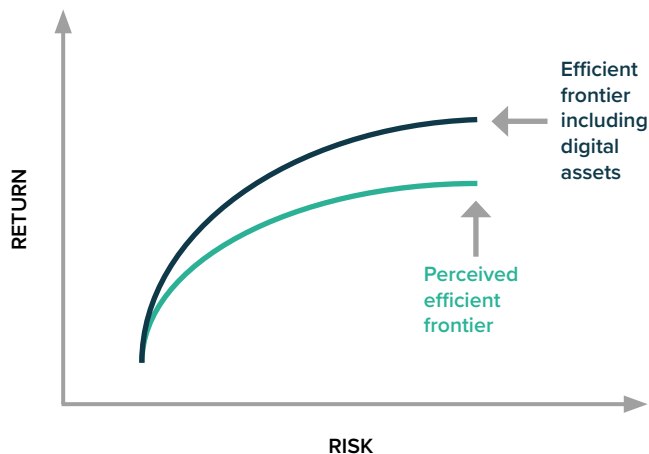
By viewing digital assets in this context, we're simply taking well-established portfolio management principles and applying them to a new class of assets. Throughout the remainder of this paper, we will provide evidence of how diversification can be extended to digital assets and why we believe they are a valuable tool to investors seeking to build sustainable portfolios with higher risk-adjusted returns.

A Brand New Asset Class

Over the past several years, Bitcoin (BTC) has embodied the power of decentralized systems, exhibiting no single point of failure in both a permissionless and censorship-resistant manner. This important proof-of-concept has now led to an explosion in the development of second-generation blockchain protocols, designed to expand upon the capabilities of Bitcoin by modifying its social, economic and/or technological constructs to satisfy entirely different needs. These differences have necessitated a new way to describe the assets that operate these protocols. There are no longer just digital currencies, but also digital commodities and digital tokens, which fall into the broader category of digital assets.

Digital currencies, like Bitcoin, seek to fulfill the role of a decentralized global currency and store-of-value, a necessary alternative to government-monopolized fiat monetary regimes in the post-financial crisis world. Others, like Zcash (ZEC) and Monero (XMR), build upon Bitcoin's role by offering privacy-enhancing features that further protect the identities of users and their transaction details. Digital commodities, like Ethereum (ETH), fuel decentralized applications (DApps) that can execute complex, condition-based transactions through the use of smart contracts, while assets like Ethereum Classic (ETC) are a hybrid

currency and commodity, combining the monetary characteristics that have made Bitcoin successful as a digital store-of-value with the smart contract capabilities of Ethereum. There are also new networks like Filecoin (FIL), billed as "Airbnb for file storage," that seek to demonstrate the value that distributed networks can provide as a more efficient data storage architecture, with built-in incentives for users who contribute unused file storage capacity. These are just a few examples of how digital assets are functioning today.

Moreover, digital assets are squarely at the intersection of some of the most significant trends reshaping the global economy[6], including:

- A new market paradigm, characterized by slower economic growth, high debt burdens, and divergent central bank policies.
- Rapid advancements in financial technologies and payment infrastructure, which now make it possible to move, settle, and clear value/assets at the same speed as information in a digital format.
- Regulatory shifts, altering financial industry economics and significantly increasing the cost of compliance and financial operations.
- Demographic shifts, driven by (i) the next generation of investors entering their prime earning years (i.e., millennials) and (ii) baby boomers entering retirement and tapping underfunded pension plans.

The combination of these micro and macro factors has led many to believe that digital assets are among the greatest technological and financial innovations since the advent of the internet itself.

While digital assets have already begun addressing various use cases, this technology will likely evolve in many ways that we cannot possibly imagine. Still, it is becoming clearer that it will be very difficult for a single asset to be optimized for all use cases simultaneously. For that reason, we think it is likely that multiple digital assets will survive, thrive, and complement one another within this new financial and technological architecture, solidifying a bona fide asset class.

Combining the growth opportunities that digital assets offer as a revolutionary technology and the store-of-value characteristics that many of them possess as alternative currencies, digital assets may have the potential to provide both inflation protection and growth exposure concurrently.

The Power of Diversification

Now that we've established why we believe digital assets have and will continue to be a unique investment opportunity, we'll quantitatively reinforce the power of uncorrelated assets and why they are a foundational element of building more balanced portfolios.

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6. Source: BlackRock: Built for Change. Geraldine Buckingham, Global Head of Corporate Strategy. June 2016. http://ir.blackrock.com/Cache/1500088361.PDF?O=PDF&T=&Y=&D=&FID=1500088361&iid=4048287.

Below we show the formula for calculating portfolio risk:

FIGURE 2: **CALCULATING PORTFOLIO RISK**

$$\sigma_p = \sqrt{w_A^2\sigma_A^2 + W_B^2\sigma_B^2 + 2W_A W_B \sigma_A \sigma_B \rho_{AB}}$$

Where:

w_A = Proportion of the portfolio invested in Asset 1
w_B = Proportion of the portfolio invested in Asset 2
σ_A = Asset 1 standard deviation of returns[7]
σ_B = Asset 2 standard deviation of returns
$\rho_{A,B}$ = Correlation coefficient[8] between the returns of Asset 1 and Asset 2

We can use this formula to gain a deeper understanding of the profound impact that uncorrelated assets can have on a portfolio by holding all other factors constant (e.g., volatility, portfolio weight, expected return, etc.) and running a sensitivity analysis to assess how assets with different correlation coefficients affect portfolio risk.

The table in Figure 3 shows the cumulative portfolio risk reduction (i.e., diversification benefit) that an investor can realize when constructing balanced portfolios that include anywhere from two to fifteen assets with different correlation coefficients. For the purpose of this analytical exercise, we define a balanced portfolio as one in which each asset has equal weight and volatility.

FIGURE 3: **THE IMPACT OF ASSET CORRELATIONS ON PORTFOLIO RISK**

ASSET NUMBER	Correlation Coefficient						
	-0.4	-0.2	0	0.2	0.4	0.6	0.8
	Cumulative Portfolio Risk Reduction						
2	-45%	-37%	-29%	-23%	-16%	-11%	-5%
3	-74%	-55%	-42%	-32%	-23%	-14%	-7%
4		-68%	-50%	-37%	-26%	-16%	-8%
5		-80%	-55%	-40%	-28%	-18%	-8%
6			-59%	-42%	-29%	-18%	-9%
7			-62%	-44%	-30%	-19%	-9%
8			-65%	-45%	-31%	-19%	-9%
9			-67%	-46%	-32%	-20%	-9%
10			-68%	-47%	-32%	-20%	-9%
11			-70%	-48%	-33%	-20%	-10%
12			-71%	-48%	-33%	-20%	-10%
13			-72%	-49%	-33%	-21%	-10%
14			-73%	-49%	-33%	-21%	-10%
15			-74%	-50%	-34%	-21%	-10%

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7. In finance, standard deviation is applied to the annual rate of return of an investment to measure the investment's volatility or risk. The more spread apart the data, the higher the deviation. Standard deviation is calculated as the square root of variance. We use the terms standard deviation, volatility, and risk interchangeably throughout this paper. Source: Investopedia.
8. The correlation coefficient is a measure that determines the degree to which two variables' movements are associated. In the case of calculating portfolio risk, the variables being evaluated are asset returns. Source: Investopedia.

For example, if an investor were to construct a balanced portfolio consisting of four assets, where each asset has a correlation of zero with one another (ρ = 0), the risk of that portfolio would be 50% lower than if those same four assets were perfectly correlated (ρ = 1). We're able to derive this from the formula shown in Figure 2.

We can also create a real world example that reinforces this point in a more intuitive way, by assuming that the excess return and volatility of each asset within the portfolio is 4% and 10%, respectively.

If the assets in the portfolio are perfectly correlated (ρ = 1), the Sharpe ratio of the portfolio would be 0.4 (4% excess return / 10% portfolio risk). In this scenario, there is no diversification benefit, as the risk of the portfolio is no lower than that of the individual assets that comprise it.

However, if those same four assets were uncorrelated (ρ = 0), an investor would be able to structure a portfolio with a Sharpe ratio of 0.8 (4% excess return / 5% portfolio risk). Due to the uncorrelated nature of the assets in this scenario, the risk of the portfolio can be reduced from 10% to 5% (a 50% reduction), resulting in a Sharpe ratio that is twice as high.

This analysis highlights how important uncorrelated assets are in portfolio construction and how investors can build portfolios with higher risk-adjusted returns, not necessarily by finding better performing assets, but by properly combining uncorrelated returns streams.

Based on their unique use cases and applications, it is clear there is a qualitative basis for digital assets to be lowly-correlated with traditional assets. In the next step of our analysis, we will assess whether this concept is quantitatively reinforced in reality, by observed market returns.

In Figure 4 we examine the relationship that some of the larger, more established digital assets have to traditional assets and each other through a correlation matrix constructed from the rolling one-month returns over the last 1.5 years. We selected this timeframe for our analysis because we believe it broadly constitutes the most complete historical dataset for the digital assets that we have chosen to analyze. For the sake of consistency and for comparison purposes, we will use this timeframe throughout the remainder of this paper.

FIGURE 4: **MULTI-ASSET CORRELATION MATRIX**[9]
December 31, 2016 through May 31, 2018. Based on Rolling One-Month Returns

ASSET	Bitcoin BTC	Ethereum ETH	XRP XRP	Bitcoin Cash BCH	Litecoin LTC	Ethereum Classic ETC	Zcash ZEC
S&P 500 Index	0.24	0.19	0.02	0.02	0.09	0.13	0.11
Nasdaq Composite	0.11	0.15	0.04	0.09	0.03	0.18	0.07
MSCI World Price Index	0.18	0.27	0.11	0.03	0.08	0.18	0.14
MSCI EAFE Price Index	0.09	0.38	0.25	0.01	0.06	0.24	0.18
MSCI Emerging Markets Price Index	(0.10)	0.20	0.19	0.07	(0.11)	0.07	0.01
Bloomberg Commodity Index	(0.24)	(0.31)	0.14	0.13	(0.24)	(0.30)	(0.26)
Barclays Capital Bond Index	0.01	0.18	0.10	(0.00)	0.00	0.21	0.08
COMEX Gold Index	(0.14)	0.07	0.06	0.06	(0.18)	(0.01)	0.02
DJCME Spot FX Index	(0.17)	0.14	0.07	(0.10)	(0.08)	0.15	0.01
Swiss Franc (CHF)	(0.20)	0.21	0.08	(0.14)	(0.06)	0.23	0.13
Canadian Dollar (CAD)	(0.25)	(0.07)	0.05	0.02	(0.11)	(0.11)	(0.06)
British Pound (GBP)	(0.27)	(0.13)	0.05	(0.25)	(0.00)	(0.01)	(0.24)
Euro (EUR)	(0.06)	0.23	0.12	(0.02)	(0.03)	0.24	0.09
Japanese Yen (JPY)	(0.11)	0.07	(0.08)	(0.06)	(0.16)	0.05	0.00
Chinese Renminbi (RMB)	(0.20)	(0.00)	0.02	(0.14)	(0.14)	(0.09)	(0.07)
Russian Ruble (RUB)	(0.03)	0.15	0.15	(0.14)	0.01	0.04	0.03
Argentine Peso (ARS)	0.27	0.09	(0.05)	0.14	0.16	0.14	(0.01)
Thai Baht (THB)	(0.10)	0.11	(0.06)	(0.14)	(0.15)	0.08	(0.03)
Singapore Dollar (SGD)	(0.13)	0.13	0.04	(0.03)	(0.13)	0.09	(0.00)
Brazilian Real (BRL)	(0.12)	(0.08)	(0.04)	(0.06)	(0.11)	(0.12)	(0.29)

Maximum: 0.38
Minimum: -0.31
Average: 0.01

	BTC	ETH	XRP	BCH	LTC	ETC	ZEC
Bitcoin (BTC)	1.00	0.36	0.20	0.39	0.57	0.50	0.42
Ethereum (ETH)	0.36	1.00	0.31	0.51	0.29	0.72	0.84
XRP (XRP)	0.20	0.31	1.00	0.28	0.52	0.29	0.34
Bitcoin Cash (BCH)	0.39	0.51	0.28	1.00	0.34	0.63	0.62
Litecoin (LTC)	0.57	0.29	0.52	0.34	1.00	0.45	0.35
Ethereum Classic (ETC)	0.50	0.72	0.29	0.63	0.45	1.00	0.76
Zcash (ZEC)	0.42	0.84	0.34	0.62	0.35	0.76	1.00

Maximum: 0.84
Minimum: 0.20
Average: 0.46

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From the previous charts, we can see that the rolling one-month return correlations range from slightly negative to slightly positive, with an average of zero. This provides evidence that digital assets can be considered a diversifying component in multi-asset portfolios. Moreover, many digital assets are imperfectly correlated to one another, which means there may even be diversification benefits within the asset class itself.

In the next section, we will provide examples of how digital assets can be used by portfolio managers as a tool to build portfolios with better risk-adjusted returns.

Building Better Portfolios with Digital Assets

As digital assets promote economic growth in innovative ways, they offer investors an opportunity to build more efficient portfolios.

Slower global growth, secular-high debt burdens, deteriorating effectiveness of monetary policies, and low yielding assets are all contributing to a savings crisis that threatens the economic welfare of future generations. We have entered a low return environment for traditional assets, with significant downside risk, rendering it difficult for many investors to achieve their target returns.

In order to resolve these challenges, there are two options available to investors. They can:

1. Increase exposure to risky assets already held in their portfolios, in an attempt to generate higher returns, which will mean holding more concentrated, less diversified portfolios, with higher risk of ruin; or
2. Identify uncorrelated assets with positive expected returns, and use them to build more efficient portfolios.

As an investment that is uncorrelated to other components of investors' portfolios, digital assets can further enhance a strategic asset allocation.

To gain a deeper understanding of the diversification benefits that digital assets can offer, we conducted a series of portfolio simulations to see how an allocation to Bitcoin and an equal-weighted mix of select digital assets might have impacted the return and risk profile of a portfolio comprised of global equities and bonds (the "Global 60/40").[10]

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10. "Global 60/40" consists of a 60% allocation to the iShares MSCI ACWI and a 40% allocation to the Vanguard Total International Bond ETF.

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FIGURE 5: **HYPOTHETICAL SIMULATED PORTFOLIO PERFORMANCE**[11]
December 31, 2016 through May 31, 2018

PORTFOLIO	Global 60/40	Global 60/40 +1% Bitcoin	Global 60/40 +3% Bitcoin	Global 60/40 +5% Bitcoin
Total Return (Cumulative)	15.7%	18.7%	24.7%	31.0%
Total Return (Annualized)	10.9%	12.9%	17.0%	21.1%
Risk (Annualized Std Dev)	6.2%	6.3%	6.9%	7.8%
Sharpe Ratio	1.61	1.90	2.33	3.24
Ratio Improvement	--	18%	45%	101%
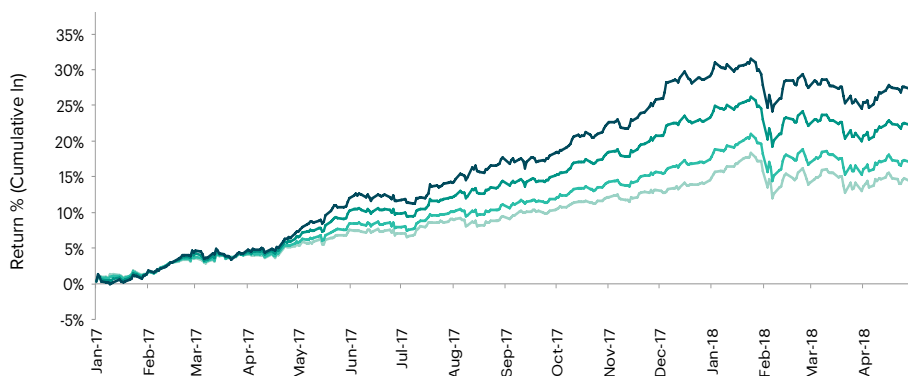
From the chart above, we can see that even small allocations to Bitcoin can significantly enhance the returns of traditional portfolios, like the Global 60/40, without materially increasing volatility. For example:

- Adding a 1% Bitcoin allocation to the Global 60/40 increased the hypothetical simulated cumulative return by 293 bps, without materially increasing volatility to improve risk-adjusted returns by 18%.
- Adding a 3% Bitcoin allocation to the Global 60/40 increased the hypothetical simulated cumulative return by 896 bps, without materially increasing volatility to improve risk-adjusted returns by 45%.
- Adding a 5% Bitcoin allocation to the Global 60/40 increased the hypothetical simulated cumulative return by 1,524 bps, without materially increasing volatility to improve risk-adjusted returns by 101%.
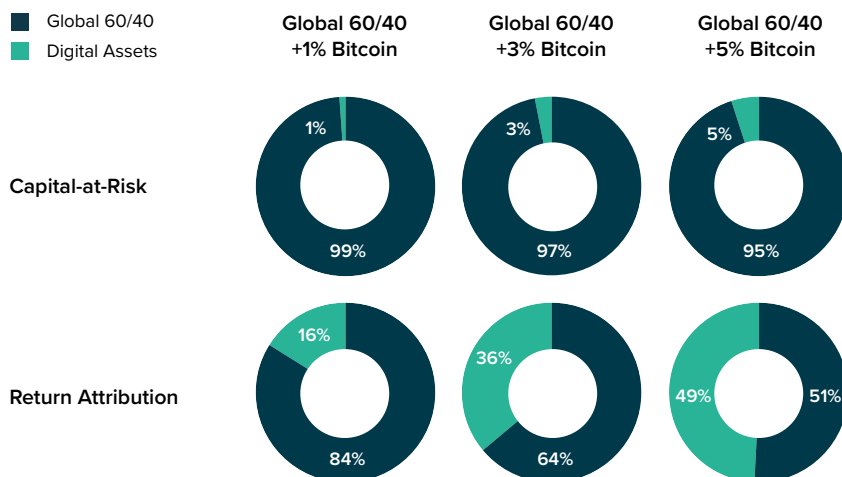
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11. HYPOTHETICAL SIMULATED PERFORMANCE RESULTS HAVE CERTAIN INHERENT LIMITATIONS. There is no guarantee that the market conditions during the past period will be present in the future. Rather, it is most likely that the future market conditions will differ significantly from those of this past period, which could have a materially adverse impact on future returns. Unlike an actual performance record, simulated results do not represent actual trading or the costs of managing the portfolio. Also, since the trades have not actually been executed, the results may have under or over compensated for the impact, if any, of certain market factors, such as lack of liquidity. Simulated trading programs in general are also subject to the fact that they are designed with the benefit of hindsight. NO REPRESENTATION IS BEING MADE THAT ANY ACCOUNT WILL OR IS LIKELY TO ACHIEVE PROFITS OR LOSSES SIMILAR TO THOSE SHOWN. PAST PERFORMANCE IS NOT INDICATIVE OF FUTURE RESULTS.
Source: Bloomberg, CoinMarketCap.com. Performance is shown from December 31, 2016 through May 31, 2018. We selected the timeframe for our analysis because we believe it broadly constitutes the most complete historical dataset for the digital assets that we have chosen to analyze. For the sake of consistency and for comparison purposes, we will use this timeframe throughout the paper. Annualized figures are based on 252 trading days. "Global 60/40" consists of a 60% allocation to the iShares MSCI ACWI and a 40% allocation to the Vanguard Total International Bond ETF. Return attribution is based on the excess returns of the hypothetical simulated portfolios including digital assets as compared to the "Global 60/40". Performance of BTC is based on the daily values from CoinMarketCap.com. THE GLOBAL 60/40 + 1%/3%/5% BITCOIN RESULTS ARE HYPOTHETICAL AND ARE NOT BASED ON ACTUAL RETURNS OR HISTORICAL PERFORMANCE. BITCOIN HAS HISTORICALLY EXPERIENCED SIGNFICANT INTRADAY AND LONG-TERM PRICE SWINGS AND PAST PERFORMANCE IS NOT NECESSARILY INDICATIVE OF FUTURE RESULTS. Component asset weights are held constant over the period. The Sharpe Ratio is calculated as the annualized excess return of the portfolio over the 3-month US T-Bill divided by the standard deviation of excess returns. Ratio improvement is calculated by taking the Sharpe Ratio of the Global 60/40 + 1%/3%/5% Bitcoin Portfolios and dividing each by the Sharpe Ratio of the Global 60/40 Portfolio.

Furthermore, we can run attribution on the hypothetical simulated portfolios to identify what proportion of the cumulative period returns were driven by an allocation to Bitcoin versus the Global 60/40. This can help a portfolio manager assess whether the return received on an investment was commensurate with the level of risk taken.

FIGURE 6: **HYPOTHETICAL SIMULATED PORTFOLIO RISK & RETURN ATTRIBUTION[12]**
December 31, 2016 through May 31, 2018

As the previous charts show:

- Adding a 1% Bitcoin allocation to the Global 60/40 drove approximately 16% of the hypothetical simulated portfolio's return for the period under analysis.
- Adding a 3% Bitcoin allocation to the Global 60/40 drove approximately 36% of the hypothetical simulated portfolio's return for the period under analysis.
- Adding a 5% Bitcoin allocation to the Global 60/40 drove approximately 49% of the hypothetical simulated portfolio's return for the period under analysis.

12. HYPOTHETICAL SIMULATED PERFORMANCE RESULTS HAVE CERTAIN INHERENT LIMITATIONS. There is no guarantee that the market conditions during the past period will be present in the future. Rather, it is most likely that the future market conditions will differ significantly from those of this past period, which could have a materially adverse impact on future returns. Unlike an actual performance record, simulated results do not represent actual trading or the costs of managing the portfolio. Also, since the trades have not actually been executed, the results may have under or over compensated for the impact, if any, of certain market factors, such as lack of liquidity. Simulated trading programs in general are also subject to the fact that they are designed with the benefit of hindsight. NO REPRESENTATION IS BEING MADE THAT ANY ACCOUNT WILL OR IS LIKELY TO ACHIEVE PROFITS OR LOSSES SIMILAR TO THOSE SHOWN. PAST PERFORMANCE IS NOT INDICATIVE OF FUTURE RESULTS.
Source: Bloomberg, CoinMarketCap.com. Performance is shown from December 31, 2016 through May 31, 2018. We selected the timeframe for our analysis because we believe it broadly constitutes the most complete historical dataset for the digital assets that we have chosen to analyze. For the sake of consistency and for comparison purposes, we will use this timeframe throughout the paper. "Global 60/40" consists of a 60% allocation to the iShares MSCI ACWI and a 40% allocation to the Vanguard Total International Bond ETF. Return attribution is based on the excess returns of the hypothetical simulated portfolios including digital assets as compared to the "Global 60/40." Performance of BTC is based on the daily values from CoinMarketCap.com. THE GLOBAL 60/40 + 1%/3%/5% BITCOIN RESULTS ARE HYPOTHETICAL AND ARE NOT BASED ON ACTUAL RETURNS OR HISTORICAL PERFORMANCE. DIGITAL ASSETS HAVE HISTORICALLY EXPERIENCED SIGNFICANT INTRADAY AND LONG-TERM PRICE SWINGS AND PAST PERFORMANCE IS NOT NECESSARILY INDICATIVE OF FUTURE RESULTS. Component asset weights are held constant over the period.

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From the above, it becomes clear that placing even small amounts of capital at-risk through an allocation to Bitcoin may meaningfully drive portfolio return in certain investment environments.

In the second series of portfolio simulations, we took this one step further. Instead of allocating exclusively to Bitcoin within the digital asset bucket, we invested across an equal-weighted mix of Bitcoin (BTC), Bitcoin Cash (BCH), Ethereum (ETH), Ethereum Classic (ETC), Litecoin (LTC), XRP (XRP), and Zcash (ZEC). This simulation can provide insight as to whether allocating to a diversified mix of digital assets can improve the risk-adjusted returns of portfolios versus those solely containing Bitcoin.

FIGURE 7: **DIGITAL ASSET ALLOCATION IN HYPOTHETICAL SIMULATED PORTFOLIO**

■ Global 60/40
■ Digital Assets

■ Bitcoin (BTC)
■ Bitcoin Cash (BCH)
■ Ethereum (ETH)
■ Ethereum Classic (ETC)
■ Litecoin (LTC)
■ XRP (XRP)
■ Zcash (ZEC)
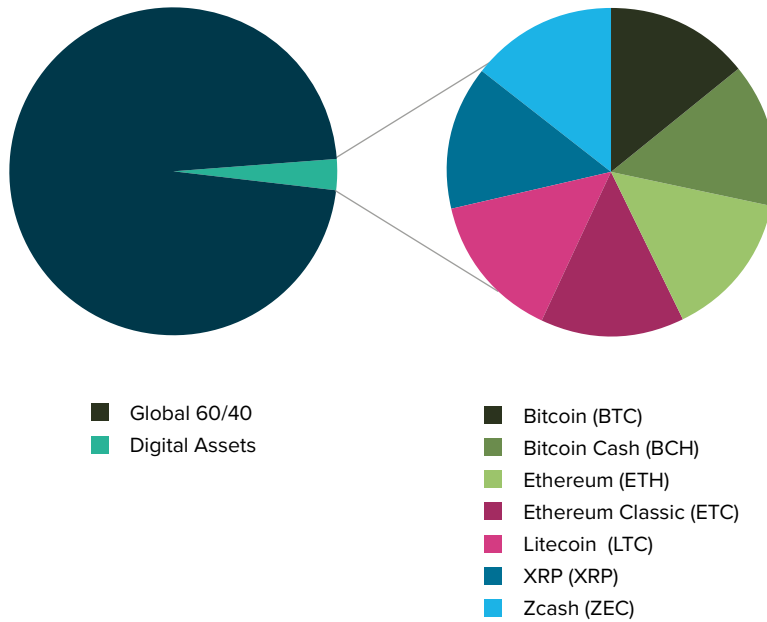
There are a number of different weighting mechanisms one can use when evaluating the impact of a digital asset mix. For the purpose of this analysis, we opted for simplicity, and a weighting scheme that does not bias (overweight or underweight) any digital asset relative to another.

FIGURE 8: **DIGITAL ASSET ALLOCATION IN HYPOTHETICAL SIMULATED PORTFOLIO**[13]
December 31, 2016 through May 31, 2018

PORTFOLIO	Global 60/40	Global 60/40 +1% Digital Assets	Global 60/40 +3% Digital Assets	Global 60/40 +5% Digital Assets
Total Return (Cumulative)	15.7%	20.6%	30.8%	41.8%
Total Return (Annualized)	10.9%	14.2%	21.0%	28.2%
Risk (Annualized Std Dev)	6.2%	6.4%	7.1%	8.2%
Sharpe Ratio	1.61	2.09	2.84	4.28
Ratio Improvement	--	**30%**	**76%**	**166%**

Looking at the chart above, it appears that portfolios containing allocations to a mix of digital assets performed even better than those only including Bitcoin. For example:

- Adding a 1% digital asset allocation to the Global 60/40 increased the hypothetical simulated cumulative return by 484 bps, without materially increasing volatility to improve risk-adjusted returns by 30%.
- Adding a 3% digital asset allocation to the Global 60/40 increased the hypothetical simulated cumulative return by 1,508 bps, without materially increasing volatility to improve risk-adjusted returns by 76%.
- Adding a 5% digital asset allocation to the Global 60/40 increased the hypothetical simulated cumulative return by 2,610 bps, without materially increasing volatility to improve risk-adjusted returns by 166%.

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13. HYPOTHETICAL SIMULATED PERFORMANCE RESULTS HAVE CERTAIN INHERENT LIMITATIONS. There is no guarantee that the market conditions during the past period will be present in the future. Rather, it is most likely that the future market conditions will differ significantly from those of this past period, which could have a materially adverse impact on future returns. Unlike an actual performance record, simulated results do not represent actual trading or the costs of managing the portfolio. Also, since the trades have not actually been executed, the results may have under or over compensated for the impact, if any, of certain market factors, such as lack of liquidity. Simulated trading programs in general are also subject to the fact that they are designed with the benefit of hindsight. NO REPRESENTATION IS BEING MADE THAT ANY ACCOUNT WILL OR IS LIKELY TO ACHIEVE PROFITS OR LOSSES SIMILAR TO THOSE SHOWN. PAST PERFORMANCE IS NOT INDICATIVE OF FUTURE RESULTS.
Source: Bloomberg, CoinMarketCap.com. Performance is shown from December 31, 2016 through May 31, 2018. We selected the timeframe for our analysis because we believe it broadly constitutes the most complete historical dataset for the digital assets that we have chosen to analyze. For the sake of consistency and for comparison purposes, we will use this timeframe throughout the paper. Annualized figures are based on 252 trading days. "Global 60/40" consists of a 60% allocation to the iShares MSCI ACWI and a 40% allocation to the Vanguard Total International Bond ETF. "Digital Assets" consists of an equal-weighted mix of Bitcoin (BTC), Ethereum (ETH), XRP (XRP), Bitcoin Cash (BCH), Litecoin (LTC), Zcash (ZEC), and Ethereum Classic (ETC). THE GLOBAL 60/40 + 1%/3%/5% DIGITAL ASSETS RESULTS ARE HYPOTHETICAL AND ARE NOT BASED ON ACTUAL RETURNS OR HISTORICAL PERFORMANCE. DIGITAL ASSETS HAVE HISTORICALLY EXPERIENCED SIGNFICANT INTRADAY AND LONG-TERM PRICE SWINGS AND PAST PERFORMANCE IS NOT NECESSARILY INDICATIVE OF FUTURE RESULTS. Component asset weights are held constant over the period. The Sharpe Ratio is calculated as the annualized excess return of the portfolio over the 3-month US T-Bill divided by the standard deviation of excess returns. Ratio improvement is calculated by taking the Sharpe Ratio of the Global 60/40 + 1%/3%/5% Digital Assets Portfolios and dividing each by the Sharpe Ratio of the Global 60/40 Portfolio.

Given what we know about MPT, this is not all that surprising. Since digital assets are imperfectly correlated with one another, they can be combined to build portfolios with higher risk-adjusted returns.

We conclude our historical analysis by looking at the return contribution from digital assets relative to the capital-at-risk during the period:

FIGURE 9: **HYPOTHETICAL SIMULATED PORTFOLIO RISK & RETURN ATTRIBUTION**[14]
December 31, 2016 through May 31, 2018
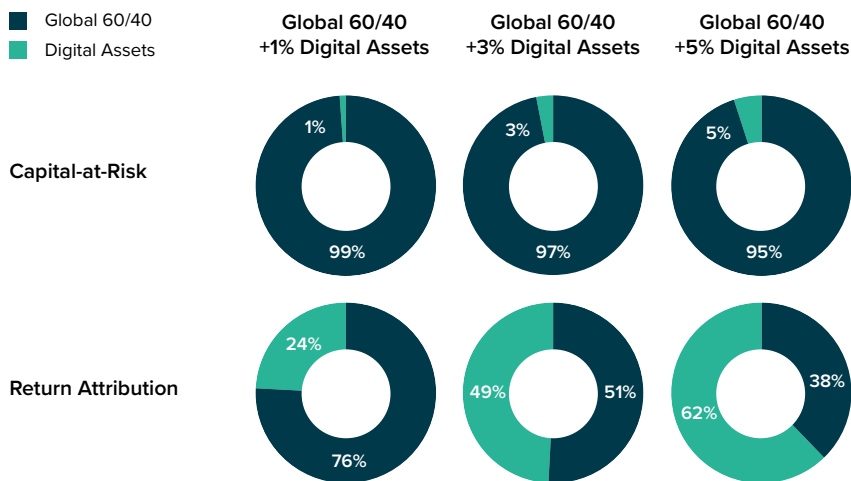
As the previous charts show:

- Adding a 1% digital asset allocation to the Global 60/40 drove approximately 24% of the hypothetical simulated portfolio's return for the period under analysis.
- Adding a 3% digital asset allocation to the Global 60/40 drove roughly 49% of the hypothetical simulated portfolio's return for the period under analysis.
- Adding a 5% digital asset allocation to the Global 60/40 drove approximately 62% of the hypothetical simulated portfolio's return for the period under analysis.

It's worth highlighting that we also ran hypothetical simulations over longer timeframes, dating back to September 2013. In doing so, we used the data available for the digital assets included in this analysis that existed at the time. The results were broadly consistent in that the hypothetical simulated portfolios containing both Bitcoin and an equal-weighted mix of digital assets had higher risk-adjusted returns than the standalone Global 60/40.

Investing for the Future

Examining historical performance is one way to test our hypothesis about the role that digital assets can play in portfolio construction, but it doesn't tell us much about what we should expect in the future if the risk and return dynamics of the asset class change. We believe that most people would agree that the historical return/risk profile for digital assets is unsustainable and that future equilibrium will likely be a different story. Unfortunately, due to their limited trading history, we don't yet know what the equilibrium return/risk profile looks like.

FIGURE 10: **LONG-TERM EXPECTED ASSET CLASS VOLATILITIES**[15]
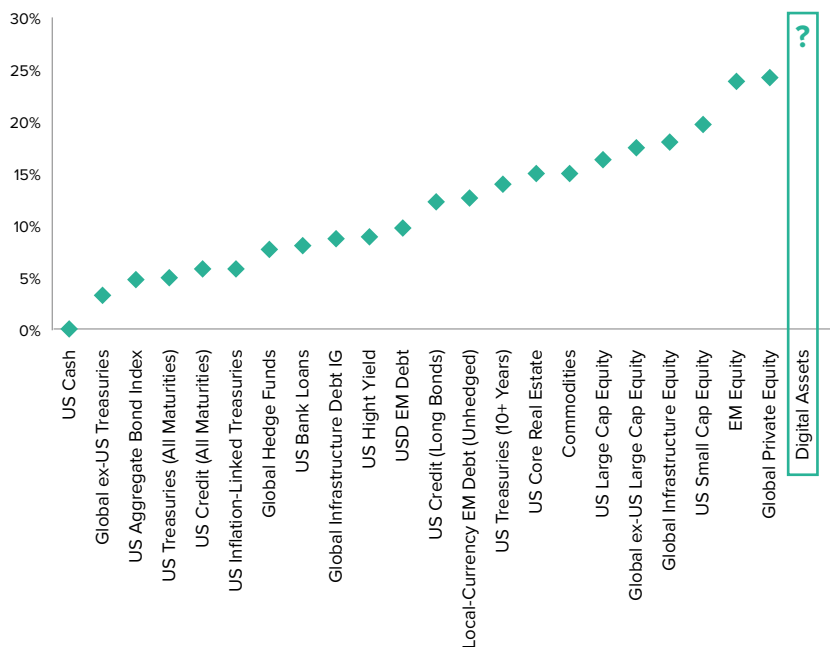
While the long-run volatilities of asset classes can differ substantially, there is consistency when looking across their Sharpe ratios. As you can see from Figure 11, the equilibrium Sharpe ratio across asset classes is generally between 0.25 – 0.35.[16]

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15. Source: BlackRock: Asset Class Beta Return And Long-Term Volatility And Correlation Assumptions. May 2018. For a complete review of BlackRock's Long-Term Capital Market Assumption Disclosures, visit: https://www.blackrock.com/institutions/en-au/insights/research-and-insights/blackrock-capital-markets-assumptions.
16. Source: BlackRock Asset Class Beta Return And Long-Term Volatility And Correlation Assumptions. May 2018. For a complete review of BlackRock's Long-Term Capital Market Assumption Disclosures, visit: https://www.blackrock.com/institutions/en-au/insights/research-and-insights/blackrock-capital-markets-assumptions.

FIGURE 11: **LONG-TERM EXPECTED ASSET CLASS SHARPE RATIOS**[17]

Average: 0.3

Asset Class	Sharpe Ratio
Global ex-US Treasuries	0.10
US Aggregate Bond Index	0.25
US Treasuries (All Maturities)	0.15
US Credit (All Maturities)	0.32
US Inflation-Linked Treasuries	0.14
Global Hedge Funds	0.25
US Bank Loans	0.21
Global Infrastructure Debt IG	0.29
US Hight Yield	0.36
USD EM Debt	0.36
US Credit (Long Bonds)	0.33
Local-Currency EM Debt (Unhedged)	0.33
US Treasuries (10+ Years)	0.17
US Core Real Estate	0.21
Commodities	0.15
US Large Cap Equity	0.34
Global ex-US Large Cap Equity	0.34
Global Infrastructure Equity	0.36
US Small Cap Equity	0.31
EM Equity	0.29

One way to interpret this consistency is that the relative risk and return preferences of investors are reflected almost uniformly across asset classes over time. In other words, for accepting a certain level of risk (i.e., volatility) investors will generally require the proportionate level of return.

Using this insight, we can make relatively conservative assumptions about the long-term expected risk and return profile of digital assets to estimate the impact that a small allocation (5%) could have on wealth creation when coupled with a Global 60/40 portfolio.

We think it is reasonable to assume that digital assets will continue to be the most volatile asset class for quite some time. However, we assume that the equilibrium volatility will dampen to around 35%. In this scenario, we'd expect digital assets to have an annualized excess return of approximately 10.5%, based on a Sharpe ratio of 0.3.

Although the average correlation of digital assets to other asset classes appears to be around zero today, we think that correlations could increase as more managers allocate to digital assets over time. Our basis for this is that managers must often make decisions about how they allocate between cash and risk assets, particularly in a liquidity crisis. Since digital assets clearly fit into the "risk" bucket, this relationship could drive their correlations to other risk assets higher. Still, we continue to believe that a high proportion of the returns for the digital asset class will be driven by idiosyncratic factors. For this reason, we assume an equilibrium correlation of 0.2.

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17. See previous footnote.

Now that we've established our equilibrium assumptions, we can create an investment scenario that almost all investors face: saving for retirement.

Assuming $100,000 of starting capital and annual contributions of $18,500 per year, we outline what the *Global 60/40 (95%) + Digital Assets (5%)* hypothetical simulated portfolio would look like from a return/risk perspective, as well as the impact this would have on retirement savings over different time horizons.

FIGURE 12: **HYPOTHETICAL SIMULATED PORTFOLIO[18]**

HYPOTHETICAL PORTFOLIO ASSUMPTIONS	
Starting Capital (USD)	$100,000
Annual Contribution (USD)	$18,500
Equilibrium Correlation Coefficient	0.20
Global 60/40 Capital Allocation (%)	95%
Digital Assets Capital Allocation (%)	5%

| HYPOTHETICAL PORTFOLIO ASSUMPTIONS			
Portfolio Component	Expected Risk (%)	Expected Excess Return (%)	Expected Sharpe Ratio
Global 60/40	10.0%	5.2%	0.52
Digital Assets	35.0%	10.5%	0.30
Global 60/40 (95%) + Digital Assets (5%)	**10.0%**	**5.5%**	**0.55**

Based on the assumed risk, return, and correlation dynamics of the Global 60/40 and digital assets, we determine that the *Global 60/40 (95%) + Digital Assets (5%)* hypothetical simulated portfolio would generate roughly 30 bps of additional return on an annualized basis when compared to the Global 60/40, at the same level of risk. While this might seem small, the effect of compound returns on wealth can make this meaningful over time.

In the following charts, we map out a 40-year timeframe and calculate the surplus that the *Global 60/40 (95%) + Digital Assets (5%)* hypothetical simulated portfolio would have delivered over the Global 60/40 in dollar-terms. We can also see how the surplus might vary at different points along the curve, relative to an investor's time horizon.

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18. HYPOTHETICAL SIMULATED PERFORMANCE RESULTS HAVE CERTAIN INHERENT LIMITATIONS. There is no guarantee that the market conditions during the past period will be present in the future. Rather, it is most likely that the future market conditions will differ significantly from those of this past period, which could have a materially adverse impact on future returns. Unlike an actual performance record, simulated results do not represent actual trading or the costs of managing the portfolio. Also, since the trades have not actually been executed, the results may have under or over compensated for the impact, if any, of certain market factors, such as lack of liquidity. Simulated trading programs in general are also subject to the fact that they are designed with the benefit of hindsight. NO REPRESENTATION IS BEING MADE THAT ANY ACCOUNT WILL OR IS LIKELY TO ACHIEVE PROFITS OR LOSSES SIMILAR TO THOSE SHOWN. PAST PERFORMANCE IS NOT INDICATIVE OF FUTURE RESULTS.
Source: AQR Perspective: Risk Parity Is Even Better Than We Thought. Cliff Asness, June 1, 2015. https://www.aqr.com/Insights/Perspectives/Risk-Parity-Is-Even-Better-Than-We-Thought. Hypothetical assumptions for the Global 60/40 Portfolio are sourced from AQR.
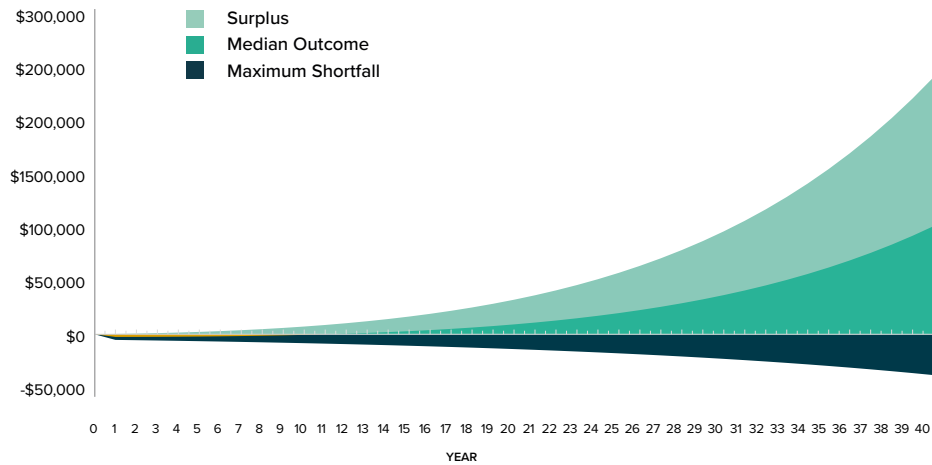
FIGURE 13: **HYPOTHETICAL SIMULATED PORTFOLIO GROWTH IN USD AT SAME VOLATILITY**[19]
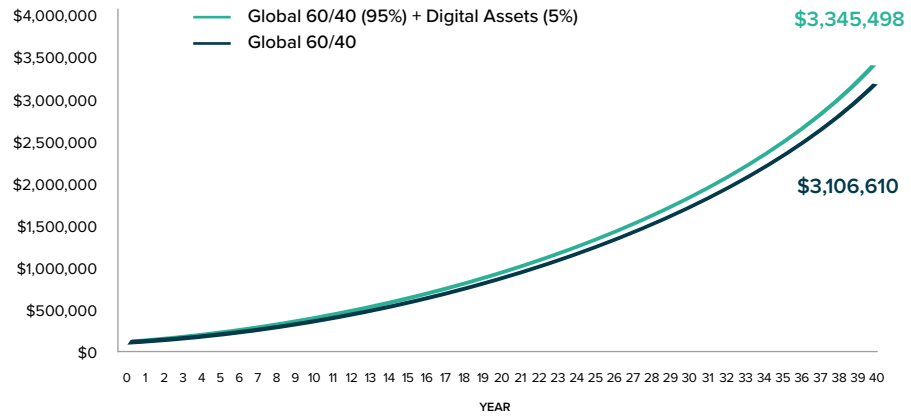
Furthermore, we can calculate the worst-case scenario for the *Global 60/40 (95%) + Digital Assets (5%)* hypothetical simulated portfolio relative to the Global 60/40 by assuming that the value of digital assets drops to $0 in Year 1, when the impact on compound wealth would be greatest.

Below we've charted the maximum shortfall, estimated surplus, and median outcome for the *Global 60/40 (95%) + Digital Assets (5%)* hypothetical simulated portfolio relative to the Global 60/40 based on our assumptions.

FIGURE 14: **ESTIMATED SURPLUS VS. MAXIMUM SHORTFALL IN USD**[20]

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19. See previous footnote.
20. See previous footnote.

The results were as follows:

- In the maximum shortfall scenario, the *Global 60/40 (95%) + Digital Assets (5%)* hypothetical simulated portfolio would generate a total value of $3,068,626 versus $3,106,610 for the Global 60/40 at the end of the 40-year period. This indicates a maximum shortfall of $37,984, or roughly 1.2% less than the dollar value of the Global 60/40 at the time of retirement.

- In the surplus scenario, if digital assets perform in line with the return/risk profile we have outlined, the ending value of the *Global 60/40 (95%) + Digital Assets (5%)* hypothetical simulated portfolio would be $3,345,498 versus $3,106,610 for the Global 60/40, a surplus of $238,889. This is nearly 8% higher than the dollar value of the Global 60/40 at the time of retirement, and more than 6X the absolute value of the maximum shortfall.

- Finally, the median outcome is net positive, and asymmetric relative to the maximum shortfall. Another way to interpret this is that there is higher return potential per unit of capital-at-risk. Given that the median outcome is 2.6X the absolute value of the maximum shortfall, digital assets could be a mispriced risk exposure. For that reason, it may make sense for investors to allocate to these assets if properly sized within their portfolios.

Although we believe this analysis is relatively conservative, we encourage investors to use this framework and test their own set of assumptions.

Conclusion

At Grayscale, we were early investors in digital assets because we have long believed in their potential to capture share of some of the largest markets in the world (e.g., store-of-value), improve the efficiency of our global financial system, and create business models that democratize information and value in incredible new ways. We also recognized that because of their highly unique set of properties, they offer a distinct return stream, allowing them to play a diversifying role in investor portfolios.

Our motivation for creating this paper was twofold. First, we wanted to stress-test our hypothesis that digital assets fit squarely within Modern Portfolio Theory, a time-tested and proven approach that many investors are using today to build better portfolios. Second, we wanted to share our analytical framework with those who might benefit from understanding it to determine the optimal digital asset allocation within their own portfolios.

It's still early in the lifecycle of digital assets, but we believe our multifaceted approach to assess their investability makes a compelling case for investors to have some portion of their portfolio allocated to this new asset class. A lot can happen over the next few years, but remember: diversification is a "free lunch" and asset allocation is all about the long-game. We invite you to join us on the journey to a new frontier.

About Grayscale Investments

Grayscale Investments, LLC ("Grayscale") is the world's largest digital currency asset manager, with a proven track record and unrivaled experience. We give investors the tools to make informed investing decisions in a burgeoning asset class. As part of Digital Currency Group, Grayscale accesses the world's biggest network of digital currency intelligence to build better investment products. We have removed the barrier to entry so that institutions and investors can benefit from exposure to digital currencies. Now, forward-thinking investors can embrace a digital future within an institutional grade investment.

Grayscale is headquartered in New York City. For more information on Grayscale, please visit, please visit www.grayscale.co or follow us on Twitter @GrayscaleInvest.

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The hypothetical simulated performance results are based on a model that used inputs that are based on assumptions about a variety of conditions and events and provides hypothetical not actual results. As with all mathematical models, results may vary significantly depending upon the value of the inputs given, so that a relatively minor modification of any assumption may have a significant impact on the result. Among other things, the hypothetical simulated performance calculations do not take into account all aspects of the applicable asset's characteristics under certain conditions, including characteristics that can have a significant impact on the results. Further, in evaluating the hypothetical simulated performance results herein, each prospective investor should understand that not all of the hypothetical assumptions used in the model are described herein, and conditions and events that are not accounted for by the model may have a significant adverse effect on the performance of the assets described herein. Prospective investors should consider whether the behavior of these assets should be tested based on different and/or additional assumptions from those included in the information herein.

IN ADDITION TO OTHER DIFFERENCES, PROSPECTIVE INVESTORS IN A PRODUCT SHOULD NOTE THE FOLLOWING POTENTIALLY SIGNIFICANT DIFFERENCES BETWEEN THE ASSUMPTIONS MADE IN THE HYPOTHETICAL SIMULATED PERFORMANCE RESULTS INCLUDED HEREIN AND THE CONDITIONS UNDER WHICH A PRODUCT WILL PERFORM, WHICH COULD CAUSE THE ACTUAL RETURN OF SUCH PRODUCT TO DIFFER CONSIDERABLY FROM RETURNS SET FORTH BY THE HYPOTHETICAL SIMULATED PERFORMANCE, TO BE MATERIALLY LOWER THAN THE RETURNS AND TO RESULT IN LOSSES OF SOME OR ALL OF THE INVESTMENT BY PROSPECTIVE INVESTORS:

FOR EXAMPLE, EACH TRUST WILL HOLD ONLY ONE DIGITAL ASSET, WHEREAS THE HYPOTHETICAL SIMULATED PERFORMANCE RESULTS ARE INTENDED TO SHOW HYPOTHETICAL PERFORMANCE OF AN INVESTMENT MULTIPLE DIGITAL ASSETS. IN ADDITION, THE GENERAL MARKET DATA USED IN THE HYPOTHETICAL SIMULATED PERFORMANCE RESULTS DO NOT REFLECT ACTUAL TRADING ACTIVITY AND COULD NOT BE REPLICATED BY A PRODUCT IN ITS ACTUAL TRANSACTIONS. If actual trading activity was executed at levels that differed significantly from the general market data used in the hypothetical simulated performance, the actual returns achieved would have varied considerably from the results of the hypothetical simulated performances and could have been substantially lower and could result in significant losses.

IN ADDITION, THE HYPOTHETICAL SIMULATED PERFORMANCE RESULTS DO NOT ASSUME ANY GAINS OR LOSSES FROM TRADING AND THEREFORE DO NOT REFLECT THE POTENTIAL LOSSES, COSTS AND RISKS POSED BY TRADING AND HOLDING ACTUAL ASSETS.

The hypothetical simulated performance results do not reflect the impact the market conditions may have had upon a Product were it in existence during the historical period selected. The hypothetical simulated performance results do not reflect any fees incurred by a Product. If such amounts had been included in the hypothetical simulated performance, the results would have been lowered.

AS A RESULT OF THESE AND OTHER DIFFERENCES, THE ACTUAL RETURNS OF A PRODUCT MAY BE HIGHER OR LOWER THAN THE RETURNS SET FORTH IN THE HYPOTHETICAL SIMULATED PERFORMANCE RESULTS, WHICH ARE HYPOTHETICAL AND MAY NEVER BE ACHIEVED. Reasons for a deviation may also include, but are by no means limited to, changes in regulatory and/or tax law, generally unfavorable market conditions and the Risk Factors set forth below.

Certain Risk Factors

Each Product is a private, unregistered investment vehicle and not subject to the same regulatory requirements as exchange traded funds or mutual funds, including the requirement to provide certain periodic and standardized pricing and valuation information to investors. There are substantial risks in investing in a Product or in digital assets directly, including but not limited to:

- **PRICE VOLATILITY**
  Digital assets have historically experienced significant intraday and long-term price swings. In addition, none of the Products currently operates a redemption program and may halt creations from time to time or, in the case of Grayscale Bitcoin Trust (BTC), periodically. There can be no assurance that the value of the common units of fractional undivided beneficial interest ("Shares") of any Product will approximate the value of the digital assets held by such Product and such Shares may trade at a substantial premium over or discount to the value of the digital assets held by such Product. At this time, none of the Products is operating a redemption program and therefore Shares are not redeemable by any Product. Subject to receipt of regulatory approval from the SEC and approval by Grayscale, in its sole discretion, any Product may in the future operate a redemption program. Because none of the Products believes that the SEC would, at this time, entertain an application for the waiver of rules needed in order to operate an ongoing redemption program, none of the Products currently has any intention of seeking regulatory approval from the SEC to operate an ongoing redemption program.

- **MARKET ADOPTION**
  It is possible that digital assets generally or any digital asset in particular will never be broadly adopted by either the retail or commercial marketplace, in which case, one or more digital assets may lose most, if not all, of its value.

- **GOVERNMENT REGULATION**
  The regulatory framework of digital assets remains unclear and application of existing regulations and/or future restrictions by federal and state authorities may have a significant impact on the value of digital assets.

- **SECURITY**
  While each Product has implemented security measures for the safe storage of its digital assets, there have been significant incidents of digital asset theft and digital assets remains a potential target for hackers. Digital assets that are lost or stolen cannot be replaced, as transactions are irrevocable.

- **TAX TREATMENT OF VIRTUAL CURRENCY**
  For U.S. federal income tax purposes, Digital Large Cap Fund will be a passive foreign investment company (a "PFIC") and, in certain circumstances, may be a controlled foreign corporation (a "CFC"). Digital Large Cap Fund will make available a PFIC Annual Information Statement that will include information required to permit each eligible shareholder to make a "qualified electing fund" election (a "QEF Election") with respect to Digital Large Cap Fund. Each of the other Products intends to take the position that it is a grantor trust for U.S. federal income tax purposes. Assuming that a Product is properly treated as a grantor trust, Shareholders of that Product generally will be treated as if they directly owned their respective pro rata shares of the underlying assets held in the Product, directly received their respective pro rata shares of the Product's income and directly incurred their respective pro rata shares of the Product 's expenses. Most state and local tax authorities follow U.S. income tax rules in this regard. Prospective investors should discuss the tax consequences of an investment in a Product with their tax advisors.

- **NO SHAREHOLDER CONTROL**
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GRAYSCALE

General Inquiries:

info@grayscale.co

Address: 250 Park Ave S 5th floor, New York, NY 10003

Phone: (212) 668-1427

@GrayscaleInvest