

To Bit or Not to Bit: What Should Investors Make of Bitcoin Mania?

Fourth Quarter 2017

Bitcoin and other cryptocurrencies are receiving intense media coverage, prompting many investors to wonder whether these new types of electronic money deserve a place in their portfolios.

Cryptocurrencies such as bitcoin emerged only in the past decade. Unlike traditional money, no paper notes or metal coins are involved. No central bank issues the currency, and no regulator or nation state stands behind it.

Instead, cryptocurrencies are a form of code made by computers and stored in a digital wallet. In the case of bitcoin, there is a finite supply of 21 million,¹ of which more than 16 million are in circulation.² Transactions are recorded on a public ledger called blockchain.

People can earn bitcoins in several ways, including buying them using traditional fiat currencies³ or by “mining” them—receiving newly created bitcoins for the service of using powerful computers to compile recent transactions into new blocks of the transaction chain through solving a highly complex mathematical puzzle.

For much of the past decade, cryptocurrencies were the preserve of digital enthusiasts and people who believe the age of fiat currencies is coming to an end. This niche appeal is reflected in their market value. For example, at a market value of \$16,000 per bitcoin,⁴ the total value of bitcoin in circulation is less than one tenth of 1% of the aggregate value of global stocks and bonds. Despite this, the sharp rise in the market value of bitcoins over the past weeks and months have contributed to intense media attention.

What are investors to make of all this media attention? What place, if any, should bitcoin play in a diversified

portfolio? Recently, the value of bitcoin has risen sharply, but that is the past. What about its future value?

You can approach these questions in several ways. A good place to begin is by examining the roles that stocks, bonds, and cash play in your portfolio.

EXPECTED RETURNS

Companies often seek external sources of capital to finance projects they believe will generate profits in the future. When a company issues stock, it offers investors a residual claim on its future profits. When a company issues a bond, it offers investors a promised stream of future cash flows, including the repayment of principal when the bond matures. The price of a stock or bond reflects the return investors demand to exchange their cash today for an uncertain but greater amount of expected cash in the future. One important role these securities play in a portfolio is to provide positive expected returns by allowing investors to share in the future profits earned by corporations globally. By investing in stocks and bonds today, you expect to grow your wealth and enable greater consumption tomorrow.

Government bonds often provide a more certain repayment of promised cash flows than corporate bonds. Thus, besides the potential for providing positive expected returns, another reason to hold government bonds is to reduce the uncertainty of future wealth. And inflation-linked government bonds reduce the uncertainty of future inflation-adjusted wealth.

1. Source: Bitcoin.org.

2. As of December 14, 2017. Source: Coinmarketcap.com.

3. A currency declared by a government to be legal tender.

4. Per Bloomberg, the end-of-day market value of a bitcoin exceeded \$16,000 USD for the first time on December 7, 2017.

To Bit or Not to Bit

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Holding cash does not provide an expected stream of future cash flow. One US dollar in your wallet today does not entitle you to more dollars in the future. The same logic applies to holding other fiat currencies — and holding bitcoins in a digital wallet. So we should not expect a positive return from holding cash in one or more currencies unless we can predict when one currency will appreciate or depreciate relative to others.

The academic literature overwhelmingly suggests that short-term currency movements are unpredictable, implying there is no reliable and systematic way to earn a positive return just by holding cash, regardless of its currency. So why should investors hold cash in one or more currencies? One reason is because it provides a store of value that can be used to manage near-term known expenditures in those currencies.

With this framework in mind, it might be argued that holding bitcoins is like holding cash; it can be used to pay for some goods and services. However, most goods and services are not priced in bitcoins.

A lot of volatility has occurred in the exchange rates between bitcoins and traditional currencies. That volatility implies uncertainty, even in the near term, in the amount of future goods and services your bitcoins can purchase. This uncertainty, combined with possibly high transaction costs to convert bitcoins into usable currency, suggests that the cryptocurrency currently falls short as a store of value to manage near-term known expenses. Of course, that may change in the future if it becomes common practice to pay for all goods and services using bitcoins.

If bitcoin is not currently practical as a substitute for cash, should we expect its value to appreciate?

SUPPLY AND DEMAND

The price of a bitcoin is tied to supply and demand. Although the supply of bitcoins is slowly rising, it may reach an upper limit, which might imply limited future supply. The future supply of cryptocurrencies, however, may be very flexible as new types are developed and innovation in technology makes many cryptocurrencies close substitutes for one another, implying the quantity of future supply might be unlimited.

Regarding future demand for bitcoins, there is a non-zero probability⁵ that nothing will come of it (no future demand) and a non-zero probability that it will be widely adopted (high future demand).

Future regulation adds to this uncertainty. While recent media attention has ensured bitcoin is more widely discussed today than in years past, it is still largely unused by most financial institutions. It has also been the subject of scrutiny by regulators. For example, in a note to investors in 2014, the US Securities and Exchange Commission warned that any new investment appearing to be exciting and cutting-edge has the potential to give rise to fraud and false “guarantees” of high investment returns.⁶ Other entities around the world have issued similar warnings. It is unclear what impact future laws and regulations may have on bitcoin’s future supply and demand (or even its existence). This uncertainty is common with young investments.

All of these factors suggest that future supply and demand are highly uncertain. But the probabilities of high or low future supply or demand are an input in the price of bitcoins today. That price is fair, in that investors willingly transact at that price. One investor does not have an unfair advantage over another in determining if the true probability of future demand will be different from what is reflected in bitcoin’s price today.

5. Describes an outcome that is possible (or not impossible) to occur.

6. “Investor Alert: Bitcoin and Other Virtual Currency-Related Investments,” SEC, 7 May 2014.

To Bit or Not to Bit

(continued from page 5)

WHAT TO EXPECT

So, should we expect the value of bitcoins to appreciate? Maybe. But just as with traditional currencies, there is no reliable way to predict by how much and when that appreciation will occur. We know, however, that we should not expect to receive more bitcoins in the future just by holding one bitcoin today. They don't entitle holders to an expected stream of future bitcoins, and they don't entitle the holder to a residual claim on the future profits of global corporations.

None of this is to deny the exciting potential of the underlying blockchain technology that enables the trading of bitcoins. It is an open, distributed ledger that can record transactions efficiently and in a verifiable and permanent way, which has significant implications for banking and other industries, although these effects may take some years to emerge.

When it comes to designing a portfolio, a good place to begin is with one's goals. This approach, combined with an understanding of the characteristics of each eligible security type, provides a good framework to decide which securities deserve a place in a portfolio. For the securities that make the cut, their weight in the total market of all investable securities provides a baseline for deciding how much of a portfolio should be allocated to that security.

Unlike stocks or corporate bonds, it is not clear that bitcoins offer investors positive expected returns. Unlike government bonds, they don't provide clarity about future wealth. And, unlike holding cash in fiat currencies, they don't provide the means to plan for a wide range of near-term known expenditures. Because bitcoin does not help achieve these investment goals, we believe that it does not warrant a place in a portfolio designed to meet one or more of such goals.

If, however, one has a goal not contemplated herein, and you believe bitcoin is well suited to meet that goal, keep in mind the final piece of our asset allocation framework: What percentage of all eligible investments do the value of all bitcoins represent? When compared to global stocks, bonds, and traditional currency, their market value is tiny. So, if for some reason an investor decides bitcoins are a good investment, we believe their weight in a well-diversified portfolio should generally be tiny.⁷

Because bitcoin is being sold in some quarters as a paradigm shift in financial markets, this does not mean investors should rush to include it in their portfolios. When digesting the latest article on bitcoin, keep in mind that a goals-based approach based on stocks, bonds, and traditional currencies, as well as sensible and robust dimensions of expected returns, has been helping investors effectively pursue their goals for decades.

7. Investors should discuss the risks and other attributes of any security or currency with their advisor prior to making any investment.

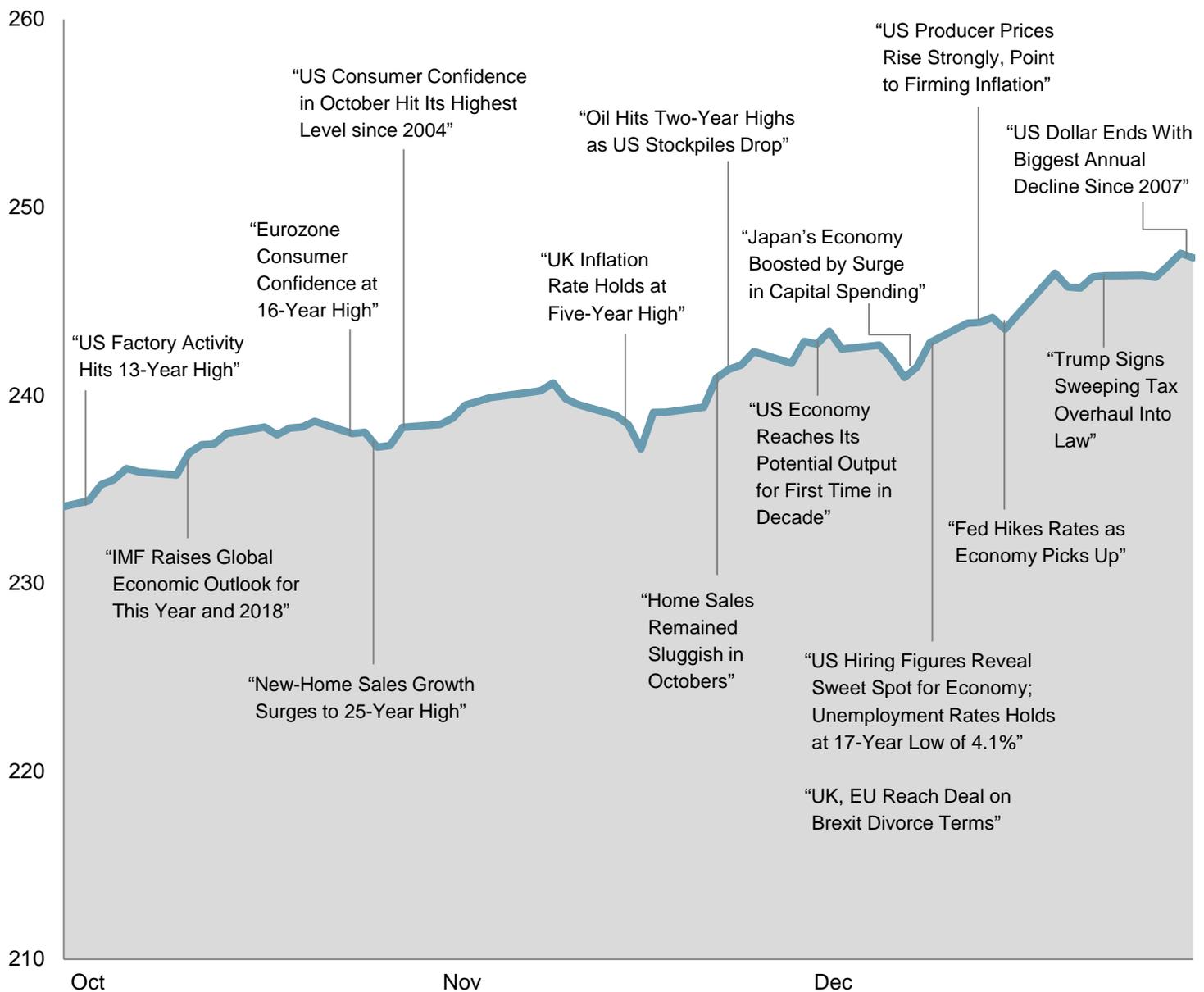
Source: Dimensional Fund Advisors LP.

The opinions expressed are those of the author and are subject to change. The commentary above pertains to bitcoin cryptocurrency. Certain bitcoin offerings may be considered a security and may have different attributes than those described in this paper. Dimensional does not offer bitcoin.

This material is not to be construed as investment advice or a recommendation to buy or sell any security or currency. Investing involves risks including possible loss of principal. Stocks are subject to market fluctuation and other risks. Bonds are subject to increased risk of loss of principal during periods of rising interest rates and other risks. There is no assurance that any investment strategy will be successful. Diversification does not assure a profit or protect against loss.

World Stock Market Performance

MSCI All Country World Index with selected headlines from Q4 2017



These headlines are not offered to explain market returns. Instead, they serve as a reminder that investors should view daily events from a long-term perspective and avoid making investment decisions based solely on the news.

Graph Source: MSCI ACWI Index [net div.], MSCI data © MSCI 2018, all rights reserved. It is not possible to invest directly in an index. Performance does not reflect the expenses associated with management of an actual portfolio. Past performance is not a guarantee of future results.

World Stock Market Performance

MSCI All Country World Index with selected headlines from past 12 months

Short Term (Q1 2017–Q4 2017)



These headlines are not offered to explain market returns. Instead, they serve as a reminder that investors should view daily events from a long-term perspective and avoid making investment decisions based solely on the news.

Graph Source: MSCI ACWI Index [net div.]. MSCI data © MSCI 2018, all rights reserved.

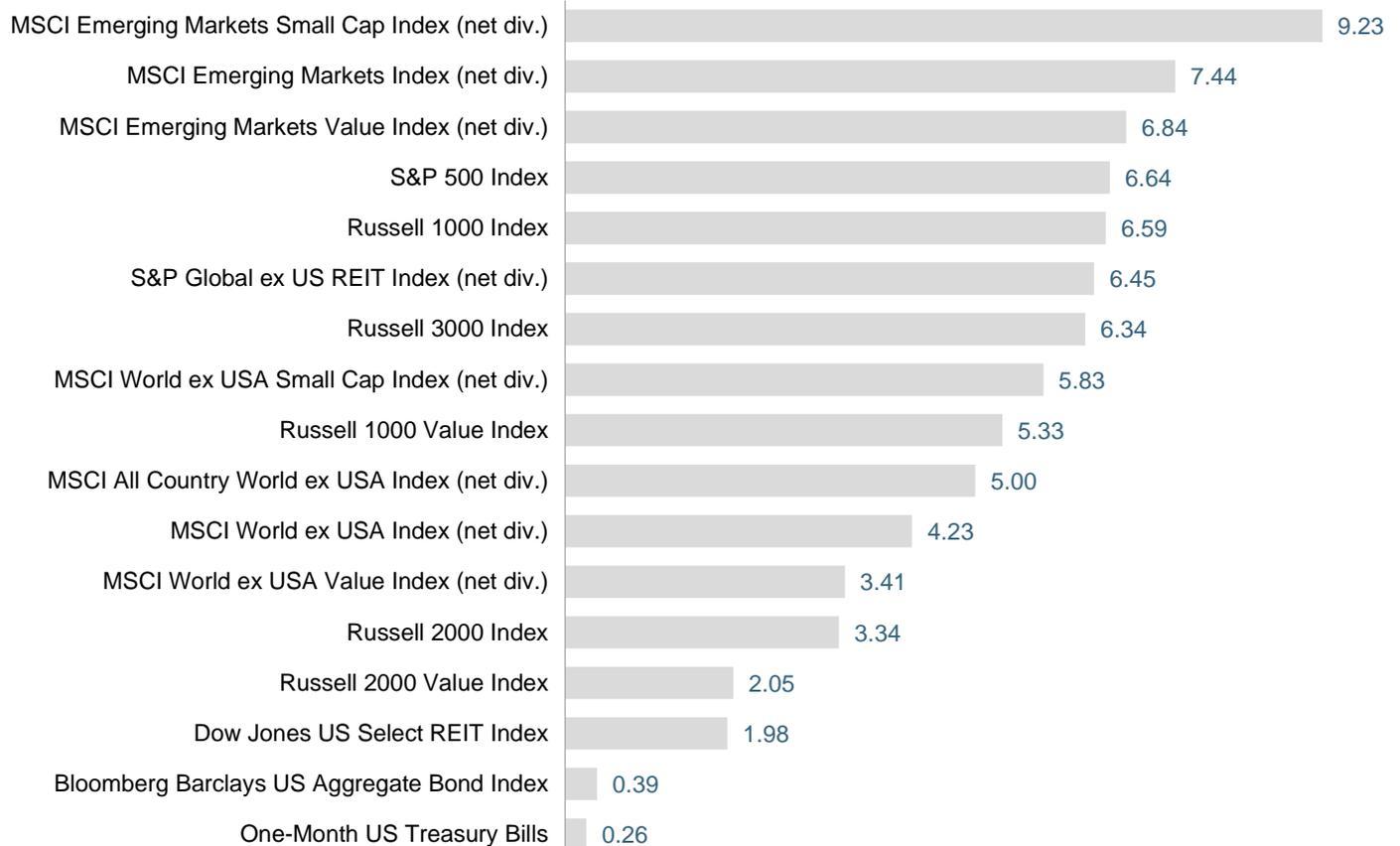
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World Asset Classes

Fourth Quarter 2017 Index Returns (%)

Looking at broad market indices, emerging markets outperformed US and non-US developed markets during the quarter.

The value effect was negative in the US, non-US developed markets, and emerging markets. Small caps outperformed large caps in non-US developed markets and emerging markets but underperformed in the US.



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US Stocks

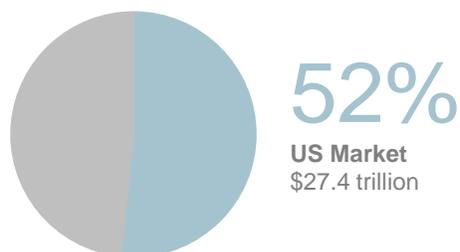
Fourth Quarter 2017 Index Returns

The US equity market posted a positive return for the quarter, outperforming non-US developed markets but underperforming emerging markets.

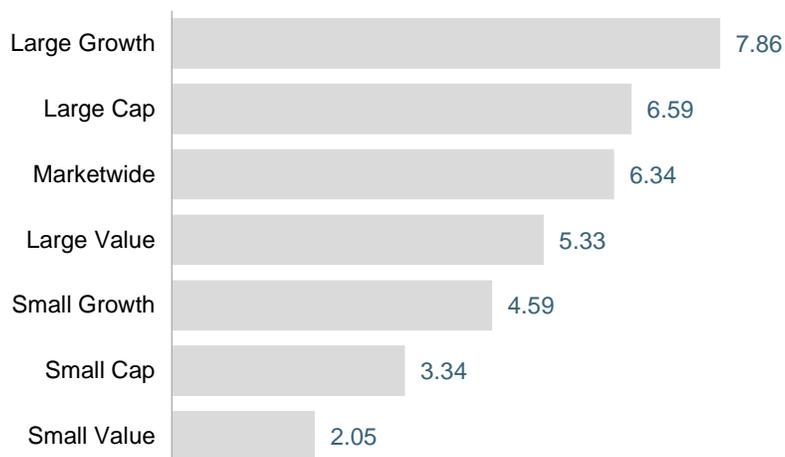
Value underperformed growth in the US across large and small cap indices.

Overall, small caps in the US underperformed large caps.

World Market Capitalization—US



Ranked Returns for the Quarter (%)



Period Returns (%)

Asset Class	1 Year	3 Years*	5 Years*	10 Years*
Large Growth	30.21	13.79	17.33	10.00
Small Growth	22.17	10.28	15.21	9.19
Large Cap	21.69	11.23	15.71	8.59
Marketwide	21.13	11.12	15.58	8.60
Small Cap	14.65	9.96	14.12	8.71
Large Value	13.66	8.65	14.04	7.10
Small Value	7.84	9.55	13.01	8.17

* Annualized

Past performance is not a guarantee of future results. Indices are not available for direct investment. Index performance does not reflect the expenses associated with the management of an actual portfolio. Market segment (index representation) as follows: Marketwide (Russell 3000 Index), Large Cap (Russell 1000 Index), Large Cap Value (Russell 1000 Value Index), Large Cap Growth (Russell 1000 Growth Index), Small Cap (Russell 2000 Index), Small Cap Value (Russell 2000 Value Index), and Small Cap Growth (Russell 2000 Growth Index). World Market Cap represented by Russell 3000 Index, MSCI World ex USA IMI Index, and MSCI Emerging Markets IMI Index. Russell 3000 Index is used as the proxy for the US market. Frank Russell Company is the source and owner of the trademarks, service marks, and copyrights related to the Russell Indexes. MSCI data © MSCI 2018, all rights reserved.

International Developed Stocks

Fourth Quarter 2017 Index Returns

In US dollar terms, developed markets underperformed the US and emerging markets during the quarter.

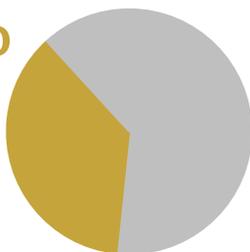
Looking at market indices, the value effect was negative.

Small caps outperformed large caps in non-US developed markets.

World Market Capitalization— International Developed

37%

**International
Developed
Market**
\$19.4 trillion



Ranked Returns (%)



Period Returns (%)

Asset Class	1 Year	3 Years*	5 Years*	10 Years*
Small Cap	31.04	12.96	11.37	5.16
Growth	27.61	8.38	8.22	2.36
Large Cap	24.21	7.36	7.46	1.87
Value	21.04	6.26	6.64	1.32

* Annualized

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Emerging Markets Stocks

Fourth Quarter 2017 Index Returns

In US dollar terms, emerging markets outperformed the US and non-US developed markets during the quarter.

Looking at broad market indices, the value effect was negative.

Small caps outperformed large caps in emerging markets.

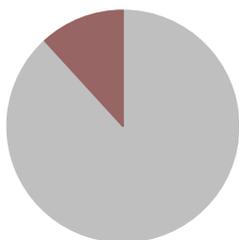
Ranked Returns (%)



World Market Capitalization— Emerging Markets

12%

Emerging Markets
\$6.2 trillion



Period Returns (%)

Asset Class	1 Year	3 Years*	5 Years*	10 Years*
Growth	46.80	11.88	6.85	2.35
Large Cap	37.28	9.10	4.35	1.68
Small Cap	33.84	8.44	5.41	2.78
Value	28.07	6.21	1.75	0.91

* Annualized

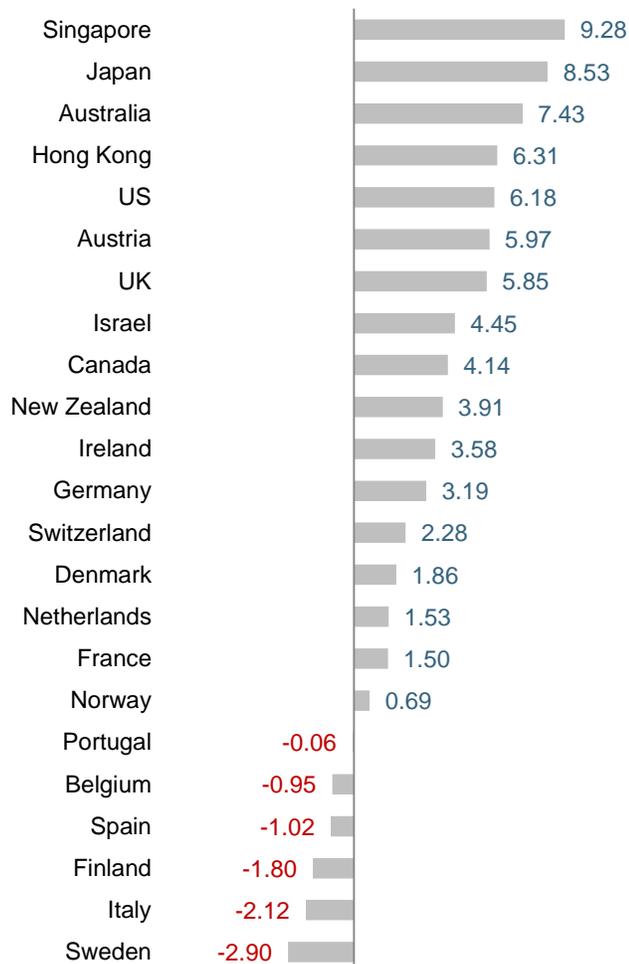
Past performance is not a guarantee of future results. Indices are not available for direct investment. Index performance does not reflect the expenses associated with the management of an actual portfolio. Market segment (index representation) as follows: Large Cap (MSCI Emerging Markets Index), Small Cap (MSCI Emerging Markets Small Cap Index), Value (MSCI Emerging Markets Value Index), and Growth (MSCI Emerging Markets Growth Index). All index returns are net of withholding tax on dividends. World Market Cap represented by Russell 3000 Index, MSCI World ex USA IMI Index, and MSCI Emerging Markets IMI Index. MSCI Emerging Markets IMI Index used as the proxy for the emerging market portion of the market. MSCI data © MSCI 2018, all rights reserved. Frank Russell Company is the source and owner of the trademarks, service marks, and copyrights related to the Russell Indexes.

Select Country Performance

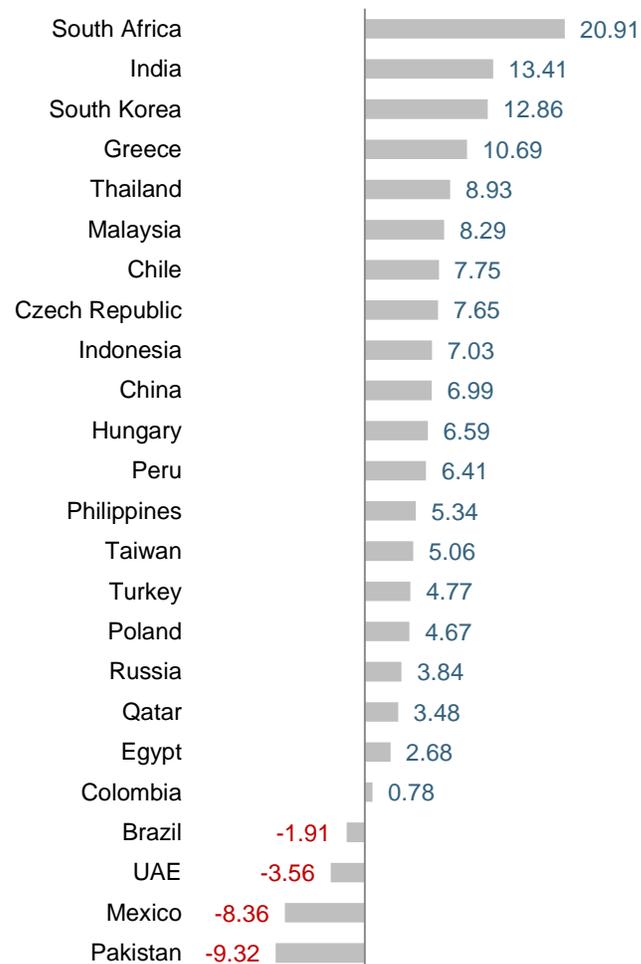
Fourth Quarter 2017 Index Returns

In US dollar terms, Singapore and Japan recorded the highest country performance in developed markets, while Sweden and Italy posted the lowest returns for the quarter. In emerging markets, South Africa and India posted the highest country returns, while Pakistan and Mexico had the lowest performance.

Ranked Developed Markets Returns (%)



Ranked Emerging Markets Returns (%)



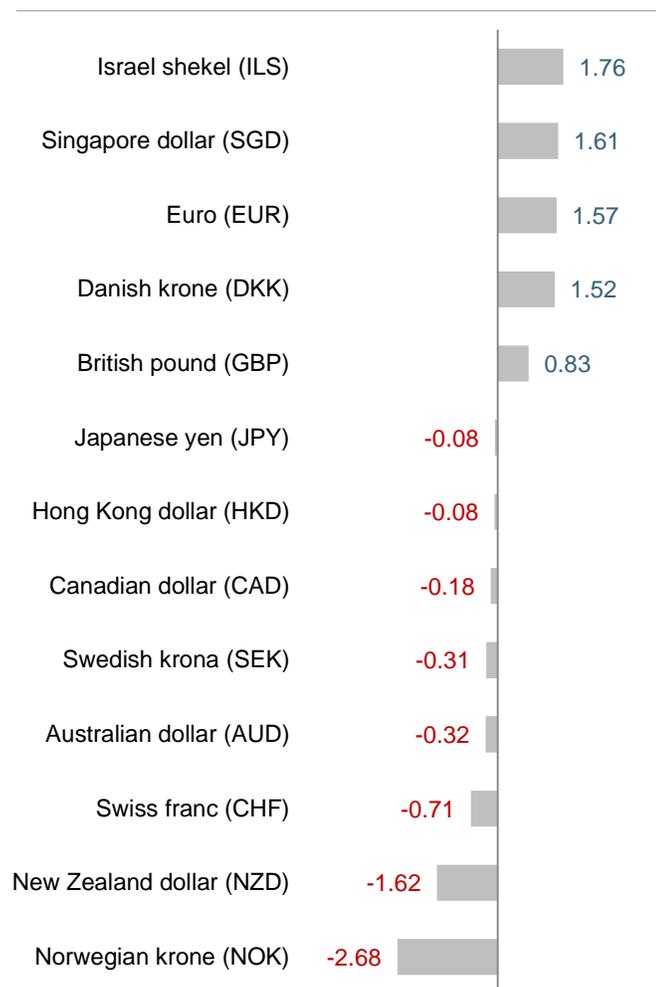
Past performance is not a guarantee of future results. Indices are not available for direct investment. Index performance does not reflect the expenses associated with the management of an actual portfolio. Country performance based on respective indices in the MSCI World ex US IMI Index (for developed markets), MSCI USA IMI Index (for US), and MSCI Emerging Markets IMI Index. All returns in USD and net of withholding tax on dividends. MSCI data © MSCI 2018, all rights reserved. UAE and Qatar have been reclassified as emerging markets by MSCI, effective May 2014.

Select Currency Performance vs. US Dollar

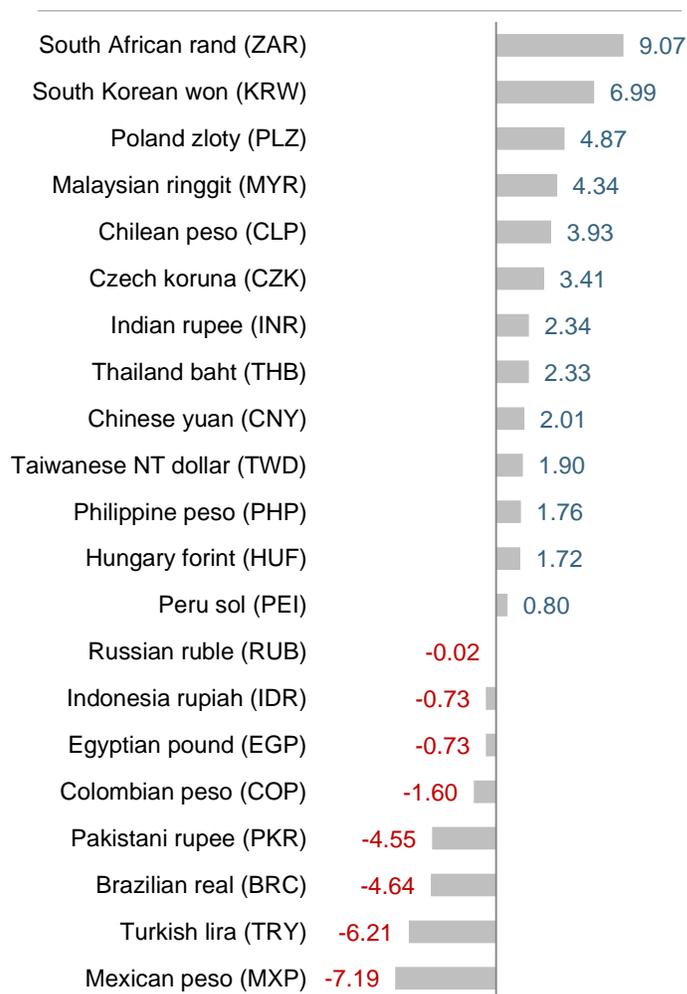
Fourth Quarter 2017

In developed markets, the Israeli shekel and the Singapore dollar both appreciated over 1.6%, while the Norwegian krone depreciated approximately 3% during the quarter. In emerging markets, the South African rand appreciated more than 9%, while the Mexican peso depreciated over 7%.

Ranked Developed Markets Returns (%)



Ranked Emerging Markets Returns (%)

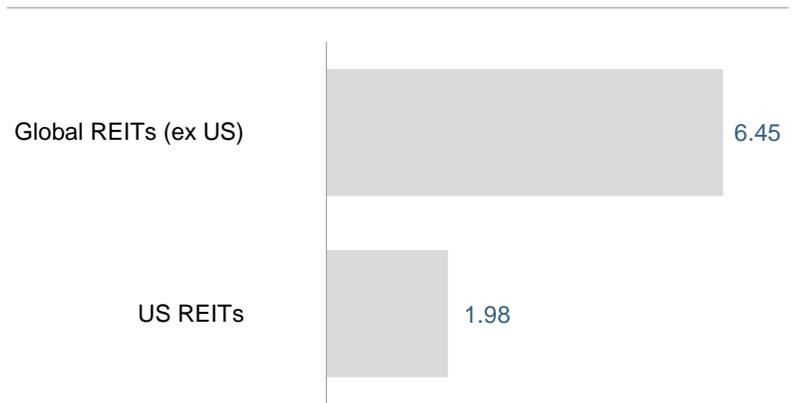


Real Estate Investment Trusts (REITs)

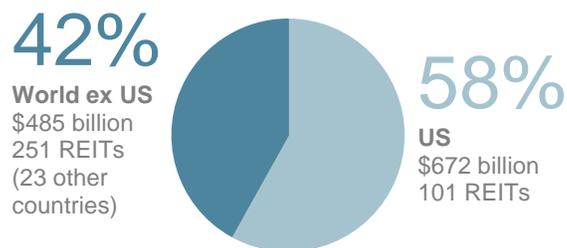
Fourth Quarter 2017 Index Returns

Non-US real estate investment trusts outperformed US REITs.

Ranked Returns (%)



Total Value of REIT Stocks



Period Returns (%)

Asset Class	1 Year	3 Years*	5 Years*	10 Years*
Global REITs (ex US)	15.64	4.78	5.49	2.05
US REITs	3.76	4.97	9.09	7.07

* Annualized

Past performance is not a guarantee of future results. Indices are not available for direct investment. Index performance does not reflect the expenses associated with the management of an actual portfolio. Number of REIT stocks and total value based on the two indices. All index returns are net of withholding tax on dividends. Total value of REIT stocks represented by Dow Jones US Select REIT Index and the S&P Global ex US REIT Index. Dow Jones US Select REIT Index used as proxy for the US market, and S&P Global ex US REIT Index used as proxy for the World ex US market. Dow Jones US Select REIT Index data provided by Dow Jones ©. S&P Global ex US REIT Index data provided by Standard and Poor's Index Services Group © 2018.

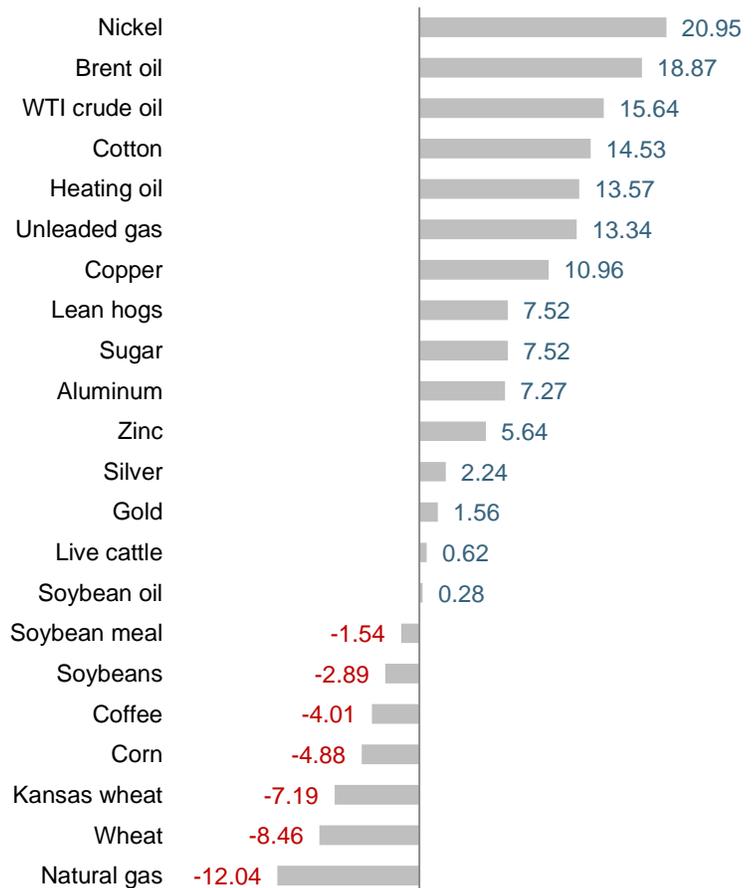
Commodities

Fourth Quarter 2017 Index Returns

The Bloomberg Commodity Index Total Return gained 4.71% in the fourth quarter, bringing the 2017 total annual return to 1.70%.

Petroleum led quarterly performance. Brent crude oil returned 18.87%, and WTI crude oil gained 15.64%. Grains was the worst-performing complex, with Chicago wheat and Kansas wheat declining by 8.46% and 7.19%, respectively.

Ranked Returns for Individual Commodities (%)



Period Returns (%)

Asset Class	1 Year	3 Years*	5 Years*	10 Years*
Commodities	1.70	-5.03	-8.45	-6.83

* Annualized

Fixed Income

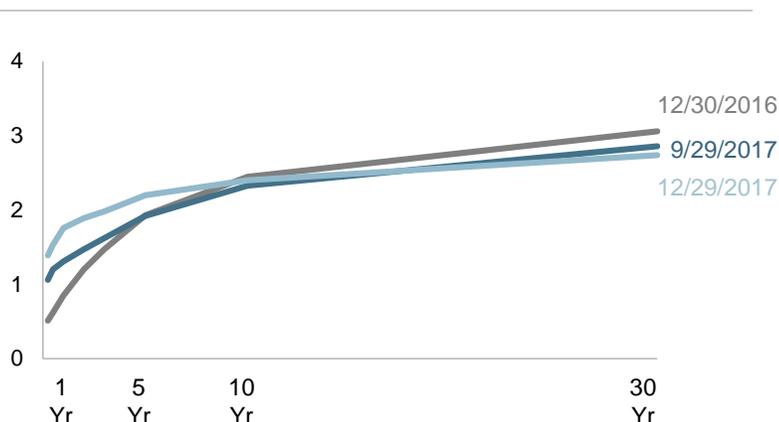
Fourth Quarter 2017 Index Returns

Interest rate changes across the US fixed income market were mixed during the fourth quarter. The yield on the 5-year Treasury note rose 28 basis points (bps), ending at 2.20%. The yield on the 10-year Treasury note increased 7 bps to 2.40%. The 30-year Treasury bond yield decreased 12 bps to finish at 2.74%.

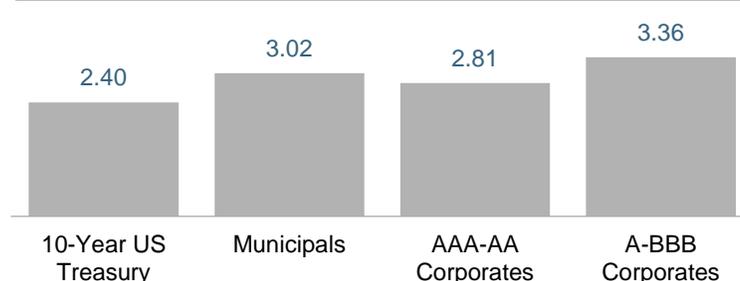
In terms of total returns, short-term corporate bonds declined 0.04% during the quarter but increased 1.85% for the year. Intermediate-term corporate bonds gained 0.17% for the quarter and 3.92% for the year.

The total returns for short-term municipal bonds were -0.65% for the quarter and 1.61% for the year. Intermediate-term municipal bonds fell 0.09% for the quarter but gained 4.70% for the year. Revenue bonds outperformed general obligation bonds for the year.

US Treasury Yield Curve (%)



Bond Yields across Issuers (%)



Period Returns (%)

Asset Class	* Annualized			
	1 Year	3 Years*	5 Years*	10 Years*
Bloomberg Barclays Long US Government Bond Index	8.53	2.85	3.49	6.49
Bloomberg Barclays US Corporate High Yield Index	7.50	6.35	5.78	8.03
Bloomberg Barclays Municipal Bond Index	5.45	2.98	3.02	4.46
Bloomberg Barclays US Aggregate Bond Index	3.54	2.24	2.10	4.01
Bloomberg Barclays US TIPS Index	3.01	2.05	0.13	3.53
Citi World Government Bond Index 1-5 Years (hedged to USD)	1.13	1.21	1.23	2.13
ICE BofAML 3-Month US Treasury Bill Index	0.86	0.41	0.27	0.39
ICE BofAML 1-Year US Treasury Note Index	0.57	0.49	0.38	0.90

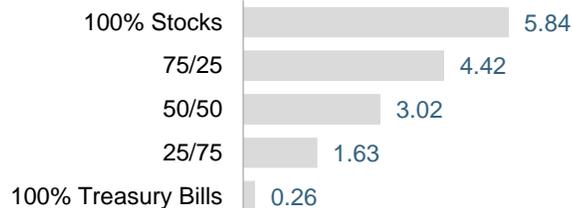
Past performance is not a guarantee of future results. Indices are not available for direct investment. Index performance does not reflect the expenses associated with the management of an actual portfolio. Yield curve data from Federal Reserve. State and local bonds are from the S&P National AMT-Free Municipal Bond Index. AAA-AA Corporates represent the Bank of America Merrill Lynch US Corporates, AA-AAA rated. A-BBB Corporates represent the Bank of America Merrill Lynch US Corporates, BBB-A rated. Bloomberg Barclays data provided by Bloomberg. US long-term bonds, bills, inflation, and fixed income factor data © Stocks, Bonds, Bills, and Inflation (S&BBI) Yearbook™, Ibbotson Associates, Chicago (annually updated work by Roger G. Ibbotson and Rex A. Sinquefeld). Citi fixed income indices © 2018 by Citigroup. ICE BofAML index data © 2018 ICE Data Indices, LLC. The S&P data are provided by Standard & Poor's Index Services Group.

Impact of Diversification

Fourth Quarter 2017 Index Returns

These portfolios illustrate the performance of different global stock/bond mixes and highlight the benefits of diversification. Mixes with larger allocations to stocks are considered riskier but have higher expected returns over time.

Ranked Returns (%)

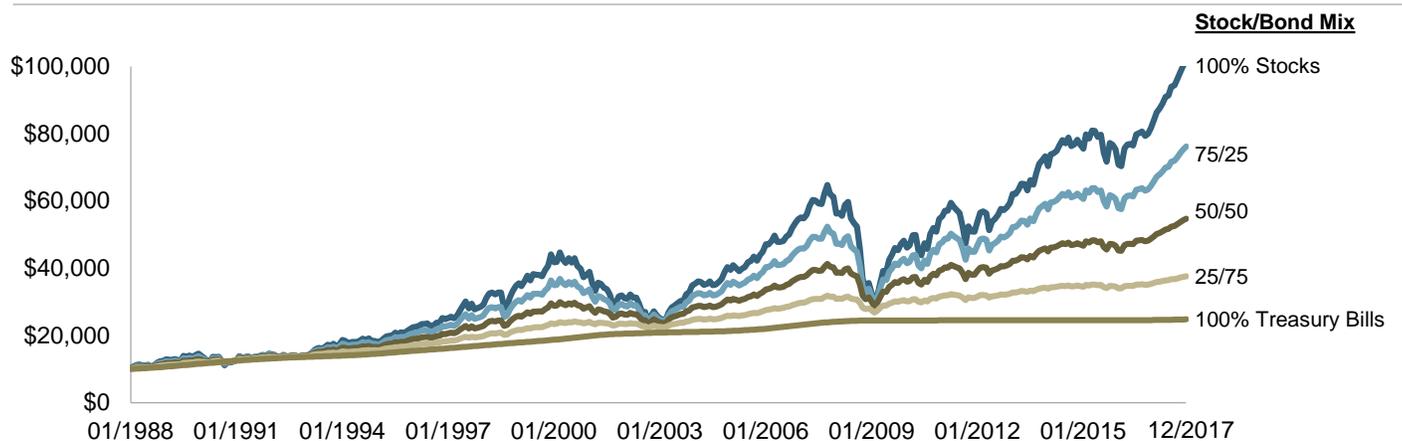


Period Returns (%)

* Annualized

Asset Class	1 Year	3 Years*	5 Years*	10 Years*	10-Year STDEV ¹
100% Stocks	24.62	9.89	11.40	5.22	16.80
75/25	18.23	7.54	8.59	4.26	12.59
50/50	12.14	5.15	5.79	3.11	8.38
25/75	6.33	2.75	3.00	1.78	4.18
100% Treasury Bills	0.80	0.34	0.21	0.30	0.16

Growth of Wealth: The Relationship between Risk and Return



1. STDEV (standard deviation) is a measure of the variation or dispersion of a set of data points. Standard deviations are often used to quantify the historical return volatility of a security or portfolio.

Diversification does not eliminate the risk of market loss. Past performance is not a guarantee of future results. Indices are not available for direct investment. Index performance does not reflect expenses associated with the management of an actual portfolio. Asset allocations and the hypothetical index portfolio returns are for illustrative purposes only and do not represent actual performance. Global Stocks represented by MSCI All Country World Index (gross div.) and Treasury Bills represented by US One-Month Treasury Bills. Globally diversified allocations rebalanced monthly, no withdrawals. Data © MSCI 2018, all rights reserved. Treasury bills © Stocks, Bonds, Bills, and Inflation Yearbook™, Ibbotson Associates, Chicago (annually updated work by Roger G. Ibbotson and Rex A. Sinquefeld).