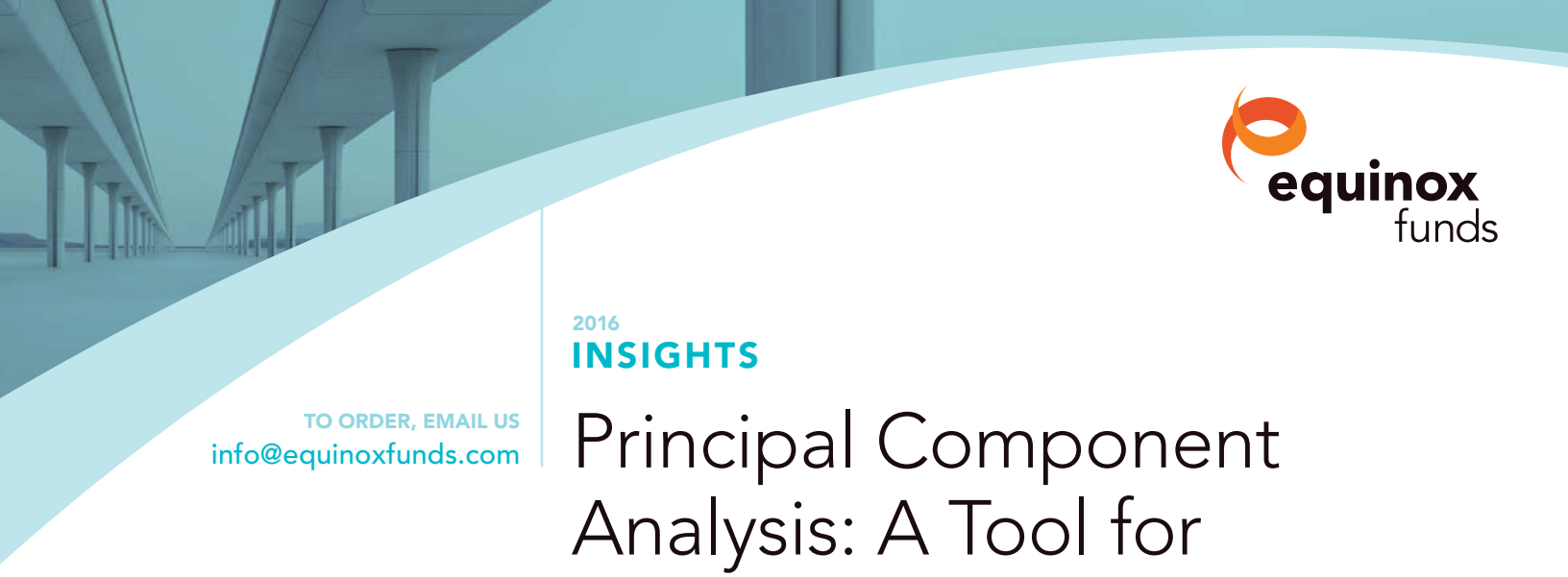

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Principal Component Analysis: A Tool for Analyzing and Describing CTA Programs

Although most CTAs provide convincing explanations to help distinguish their trading programs from others, the differences among trading styles are often not as apparent as investors may expect.

HIGHLIGHTS

- Principal Component Analysis (PCA) is a technique for identifying and describing patterns in "higher dimensional data"
- Sample PCA Output (Hypothetical) for Ten CTA Programs

While the vast majority of Commodity Trading Advisors ("CTAs") tend to be intermediate to long-term diversified trend-followers, there are, in fact, a multitude of different CTA trading styles.

One of the challenges in building a diversified multi-CTA portfolio is accounting for and seeking to take advantage of these differences among CTAs.[1]

In constructing a diversified portfolio of equity managers (stock-pickers), the approach generally used is to bucket managers into "style boxes" based on market capitalizations (Large Cap, Mid Cap, Small Cap) and the fundamental characteristics (Value, Growth, Core) of the investible universe of stocks, then choose one or more managers from each style box to achieve diversification. In the case of CTAs, it is not as simple to come up with this type of classification. CTA programs differ from each other in terms of the markets they trade, the time-frames over which they trade, as well as their trading styles (trend-following, spread-trading, discretionary trading, contrarian, pattern recognition, etc.). Although most CTAs provide convincing explanations to help distinguish their own trading program from others, the differences among trading styles are often not as apparent as investors may expect.

Ultimately, differences among programs should become evident in their "return patterns." In analyzing returns, certain tools or techniques can be used to help distinguish between seemingly similar CTA programs, so that truly diversified CTA portfolios may be constructed.

[1] *For more information about managed futures, CTAs, and trend-following, please see Equinox's Insights: "Managed Futures: Diversification within the Asset Class" and "CTA Trading Styles."*

Definitions of Terms and Indices can be found on page 7.

Correlation of returns is one example of such a tool. A correlation coefficient is a measure of the extent to which the return streams of two assets are similar to each other, in the sense that a high (low) return on one program is associated with a high (low) return on the other. A correlation coefficient close to 1.0 indicates that returns have tended to move together very closely; a value close to −1.0 indicates returns have tended to move opposite to each other, and a value close to zero indicates no identifiable pattern of dependence.

Although widely used, correlation analysis does have several limitations. Correlation coefficients tend to vary over time, generally increasing during times of market stress. It is also a "one dimensional" measure that does not fully explore the complete set of data in an effort to detect complex underlying patterns, which may reveal interesting facts about the assets being examined and compared. For example, correlation analysis only compares two CTA programs at a time. If there is a group of CTA programs similar to each other in some ways (for example, they are all trend-followers) but different in other ways (for example, some are shorter term-traders than others) this information may not always be captured by looking at pairwise correlation coefficients.

What would be beneficial, therefore, is a "multi-dimensional" or "multi-factor" analysis that would identify attributes along which CTA programs are similar to or differ from each other. To illustrate what is meant by factors or attributes, let us assume an investor wishes to buy a stock. Some of the important dimensions (or attributes) along which stocks differ from each other may include: Price/Earnings Ratio, Market Capitalization, Dividend Payout, Earnings Growth Rate, Beta, Quality of Management, and Franchise Value. Some of these may be observable, while others may not.

For CTA programs, the dimensions we are interested in have to do with how they potentially earn returns: markets traded, time-frames, trading styles, etc. While some of these are observable, many rely on information the CTAs provide, and investors need to find their own way of trying to analyze and describe CTA programs. One statistical technique that has met with some success in this endeavor is Principal Component Analysis. PCA is a technique for identifying and describing patterns in "higher dimensional data," i.e., data having a large number of attributes. In addition to finance, economics and marketing, it has been applied in fields such as face recognition and image compression.

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In order to illustrate how PCA works, consider a group of ten CTA programs for which we have sixty months of historical return data. Let us view each of the sixty months as one "dimension" of our data set. Suppose six of the ten programs had high positive returns during a certain month, while the other four were significantly negative. Obviously, market conditions during that month must have affected various CTA program returns differently. We are interested in learning what the six programs that were up for the month might have in common, and why the remaining four programs were down. Treating each month as a "dimension" of the data, we have a sixty-dimensional data set with 10 data points for each dimension. In any month, we might expect CTA programs similar to each other—such as long-term trend following

program—to have generally similar returns, while those programs different from long-term trend following—such as spread traders—would tend to have returns that are dissimilar. How can we analyze and express this underlying structure?

PCA is a technique that helps to reveal this structure in a way that best explains the variability in the data. It does this by aggregating the data and determining common "factors" called "principal components" that drive returns. For example, there may be other months where six of the ten programs tend (on average) to have similar returns. Suppose, for example, that, unknown to the analyst, the most important driver of trend-following CTA program returns is their tendency to have high returns during months in which the equity markets fall by more than 5% and the VIX® index[2] increases by more than 3%.

While PCA is not able to identify the underlying reason for the similarity in the returns of these six CTA programs, it nonetheless tends to "bucket" them together. This will be manifested in the form of high "principal component loadings" for these six programs on the (as-yet unidentified) same principal component. An analyst familiar with some of these programs, e.g., five out of the six, may realize that they are all diversified intermediate to long term trend-followers. In this case, the analyst has made two discoveries: the principal component under consideration appears to represent a "trend-following" factor, and the sixth program, with which the analyst was not as familiar, is likely to be a trend-following program like the other five. Note that underlying the trend-following factor could be a whole host of more fundamental market variables.

In this way, PCA attempts to reduce the original sixty-dimensional data set to a smaller and more manageable number of principal components.[3] The goal of PCA is to extract the most important information from a multivariate (10 CTA programs), multi-dimensional (60 months) data set by identifying a small number of important dimensions or principal components that explain as much of the variability in the data as possible. One of the attractive features of PCA is that it reveals the order of importance of these "factors," even though it does not actually name or identify them, that being left to the analyst to tackle.

The output of PCA is somewhat more complex to analyze and interpret than a correlation analysis. Assume the first four principal components are judged to explain most of the variability in the data.[4] The PCA output will tell us what the "loadings" of the ten CTA programs are on each of these four principal components. In Table 1 on the next page, we show a hypothetical PCA output for ten CTA programs. One of the challenges faced by the analyst is that the output does not explicitly identify what each principal component represents. This needs to be done by the analyst based on prior knowledge and insights gleaned from various trading programs. For example, we see that three of the CTA programs have high loadings on Principal Component 1: QCM, Winton, and Chesapeake. Knowing the nature of these programs, it seems plausible to claim that this component represents a "Long-Term Trend Following" factor. We could then conclude that Quantica, without knowing much about this program, is also most likely a trend-following program. Note that it is more of a stretch to draw a similar conclusion based on correlation analysis!

[2]Ticker symbol for the Chicago Board Options Exchange Market Volatility Index, a popular measure of the implied volatility of S&P 500® index options. Often referred to as the fear index or the fear gauge, it represents one measure of the market's expectation of stock market volatility over the next 30 day period.

[3]One important property of PCA is that these viewpoints or "principal components" are uncorrelated with each other. The number of meaningful principal components is significantly less than the number of original variables. The first principal component accounts for as much of the variability in the data as possible, and each succeeding component describes the data in more detail, but with diminishing marginal importance.

[4]Although there are objective criteria that are helpful in deciding how many principal components are meaningful, some discretion and judgment on the part of the analyst remain necessary

Sample PCA output (hypothetical) for ten CTA programs

	PRINCIPAL COMPONENT 1	PRINCIPAL COMPONENT 2	PRINCIPAL COMPONENT 3	PRINCIPAL COMPONENT 4
	"LONG-TERM TREND-FOLLOWING"	*"DISCRETIONARY TRADING"*	*"SPREAD TRADING"*	*"SHORT-TERM TRADING"*
JOHN LOCKE	0.45	0.01	-0.04	0.53
MESIROW	0.08	0.81	0.13	0.23
QCM	0.81	-0.05	0.02	0.12
QIM	0.20	0.12	-0.02	0.74
QUANTICA	0.79	0.06	0.04	-0.05
TIVERTON	0.46	0.74	0.13	-0.16
WINTON	0.82	0.03	-0.06	0.12
JE MOODY	0.04	-0.01	0.84	-0.14
EMIL VAN ESSEN	-0.17	0.05	0.78	0.01
CHESAPEAKE	0.73	-0.13	0.06	0.11

It may not be surprising that QCM, Winton and Chesapeake all exhibit high loadings under Principal Component 1 since they are all long-term trend followers.

Since Quantica exhibits the same trait, it is quite likely also a long term-trend following CTA program.

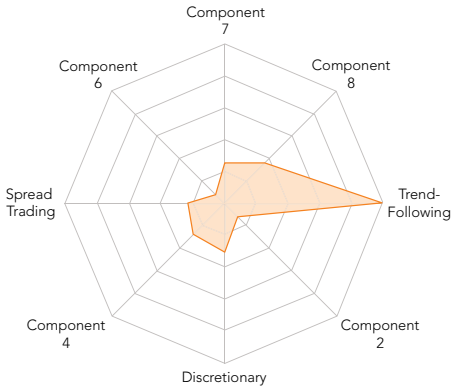
Proceeding in this fashion, the analyst seeks to identify other factors. It is important to note that the table above is hypothetical and purely intended to illustrate the general PCA procedure. In practice, it may not always be possible to positively "name" more than a small number of principal components.

Admittedly, it would be helpful if we could represent the PCA output graphically. However, it is difficult to depict a four-dimensional PCA output graphically in a two-dimensional chart or figure. As a compromise, we find that the use of "radar charts" best illustrates similarities and differences between CTA programs. For example, on the next page are two hypothetical CTA programs from a PCA in which as many as eight principal components were deemed to be significant. The first program depicted in Example 1 is close to pure trend-following while the second, in Example 2, is almost purely discretionary. The values plotted along each axis of the radar chart are the principal component loadings for each CTA program. Several of the axes are not specifically labeled, as these "factors" are not as easily identified as are trend-following, discretionary trading and spread trading. In practice, many CTA programs do not correspond to a single factor (or a small number of factors), because they have high loadings on multiple principal components (see, for example, John Locke in Table 1 above).

Sample Radar Charts

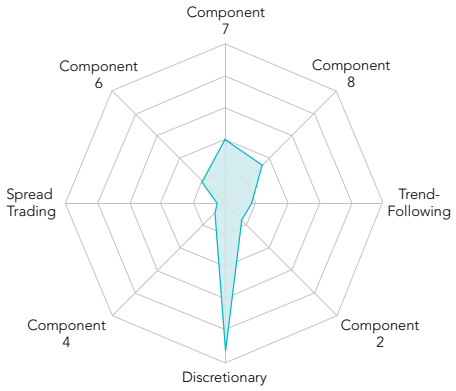
EXAMPLE 1

For a hypothetical trend-following CTA program



EXAMPLE 2

For a hypothetical discretionary CTA program



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Because it is not possible to plot PCA output on a multi-dimensional graph, on the next page, we present a way to show how multiple CTA programs can be compared visually by plotting them on a stylized two-dimensional chart. Trading styles are represented by four axes, with some caveats. There are more than four trading styles; hence, while (intermediate to long-term) trend-following and short-term trading can be depicted along the two horizontal axes, other trading styles need to be combined. Along the upper vertical axis, we show some actual discretionary traders, as well as some other CTAs who appear to resemble this trading style. Along the lower vertical axis, we depict CTAs who trade commodities and/or spreads. Note that the distance of a CTA from the origin (the point of intersection of the axes) represents the CTA program's target volatility. For example, among spread/commodity traders, Emil van Essen has a higher target volatility compared to JE Moody. Similarly, KeyQuant's target volatility is higher than that of Aspect, although both are trend-followers. Overall, the chart serves as a useful stylistic representation of CTA program trading styles in conjunction with their target volatilities.

CONCLUSION: Analyzing and interpreting PCA output is more art than science. Used skillfully, it can, in many cases, provide useful information about how CTA programs differ from one another. This information can provide useful input when describing CTA programs and in constructing diversified multi-CTA portfolios, as it helps to identify those programs that appear different from most others. This, presumably, reflects different ways of earning potential returns, a desirable characteristic.

CTA trading styles

CTA style is represented by distance from an axis. CTA target volatility is represented by the distance from the origin.

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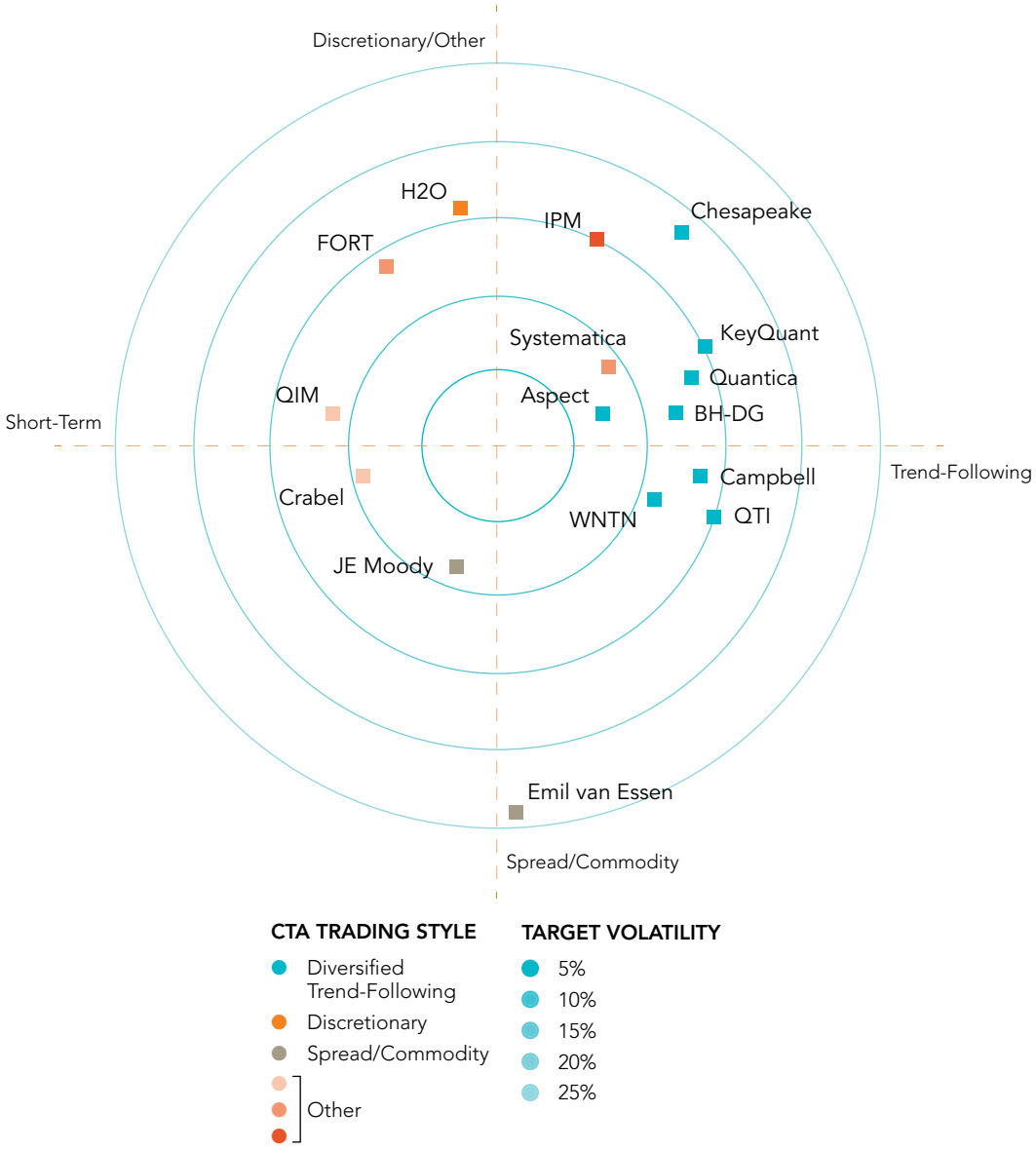

APPENDIX

DEFINITIONS

Beta is a measure of the volatility, or systematic risk, of a security or a portfolio in comparison to the markets as a whole.

Commodity trading advisors ("CTAs") are traders who may invest in more than 150 global futures markets. They seek to generate profit in both bull or bear markets, due to their ability to go long (buy) futures positions, in anticipation of rising markets, or go short (sell) futures positions, in anticipation of falling markets.

Contrarian, unlike trend-following models, which generate buy (sell) signals in the early stage of an upward (or downward) trend, contrarian models generate buy (or sell) signals at the end of the turning point of a downward (or upward) trend.

Core refers to the main strengths or strategic advantages of a business. Core competencies are the combination of pooled knowledge and technical capacities that allow a business to be competitive in the marketplace. Theoretically, a core competency should allow a company to expand into new end markets as well as provide a significant benefit to customers. It should also be hard for competitors to replicate.

Correlation Coefficient is a statistical measure of how two investments move in relation to each other. A correlation of +1.0 implies that as one investment moves, either up or down, the other investment will move lockstep, in the same direction. A correlation of -1.0 means that if one investment moves in either direction the other investment will move in the opposite direction. A correlation of 0 indicates that the movements of the investments have no correlation; they are completely random.

Discretionary trading is a trading approach that uses fundamental analysis of underlying economic factors.

Dividend payout (Dividend) is the percentage of earnings paid to a company's shareholders in dividends.

Earnings growth rate is the percentage gain in net income over time.

A **futures contract** is an agreement between two parties to buy or sell a specified asset for an agreed upon price, with delivery and payment occurring at a specified future date. The contracts are negotiated at a futures exchange, which acts as an intermediary between the two parties. The party agreeing to buy the underlying asset in the future, with the expectation that the asset will rise in value, is said to be "long", and the party agreeing to sell the asset in the future, with the expectation that the asset will fall in value, is said to be "short".

Growth is a strategy whereby an investor seeks out holdings with what they deem good growth potential. For example, a growth stock is defined as a company whose earnings are expected to grow at an above-average rate compared to its industry or the overall market.

Intermediate trend-following focuses on the average time period between short-term and long-term (approximately four-five months).

Large Cap is a term used by the investment community to refer to companies with a market capitalization value of more than $10 billion. Large cap is an abbreviation of the term "large market capitalization". Market capitalization is calculated by multiplying the number of a company's shares outstanding by its stock price per share.

Loading is the correlation a particular CTA program has to a particular principal component or factor.

Long-term trend-following is a strategy that uses long-term indicators and averages, general three to six months or longer.

Market-cap weighting strategy is a strategy that employs a stock market index weighted by the marketing capitalization if each stock in said index; larger companies account for a greater portion of the index.

Mid Cap refers to a company with a market capitalization between $2 and $10 billion, which is calculated by multiplying the number of a company""s shares outstanding by its stock price. Mid cap is an abbreviation for the term "middle capitalization".

Pattern recognition is defined as the categorization of input data into identifiable classes via the extraction of significant futures or attributes of the data from a background of irrelevant detail.

Price to earnings ratio (P/E Ratio) is a valuation of a company's current share price compared to its per-share earnings.

Short-term trend-following (same as Global Macro) is a strategy that focuses on the short-term (generally less than three months).

Small Cap refers to stocks with a relatively small market capitalization. The definition of small cap can vary among brokerages, but generally it is a company with a market capitalization of between $300 million and $2 billion.

Spread trading is a trading strategy of simultaneously buying a particular security and selling a related security against it.

Definitions continued on back.

The purchase of a managed futures investment involves a high degree of risk.

Specifically, you should be aware that, in addition to normal investment risks, managed futures investments entail certain risks, including, in all or some cases:

- Managed futures often engage in leveraging and other speculative investment practices that may increase the risk of investment loss.
- Managed futures can be highly illiquid.
- Managed futures are not required to provide periodic pricing or valuation information to investors.
- Managed futures may involve complex tax structures and delays in distributing important tax information.
- Managed futures are not subject to the same regulatory requirements as mutual funds.
- Managed futures often charge high fees.

APPENDIX CONTINUED

DEFINITIONS

Standard deviation measures the degree of variation of monthly returns around the mean (average) return. The higher the volatility of the investment returns, the higher the standard deviation will be.

A **trend-following strategy** seeks to capitalize on momentum or price trends across global asset classes by taking either long or short positions as a trend is underway. Price trends are created when investors are slow to act on new information or sell prematurely and hold on to losing investments to long. Price trends continue when investors continue to buy and investment that is going up in price or sell an investment that is going down in price.

Value is the monetary, material or assessed worth of an asset, good or service. In accounting, value describes what something is worth in terms of something else. For example, the value of a loaf of bread might be $3; the $3 for the loaf of bread would represent the generally accepted worth of the bread.

Volatility is a measure of fluctuation in the value of an asset or investment. Lower volatility improves the stability and lowers the risk of an investment portfolio. Including managed futures as part of a diversified portfolio helps to stabilize the overall ups and downs of your investments.

INDEX DESCRIPTIONS

The **S&P 500® Total Return Index** is widely regarded as the best single gauge of the US equities market. This world-renowned Index includes 500 leading companies in leading industries of the US economy. Although the S&P 500® focuses on the large cap segment of the market, with approximately 75% coverage of US equities, it is also an ideal proxy for the total market. Total return provides investors with a price-plus-gross cash dividend return. Gross cash dividends are applied on the ex-date of the dividend. Source: standardandpoors.com.

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