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INVESTMENT CORPORATION

Finding Diversification: The Geometry of Time and Correlation

When someone says '*time is on their side*,' they're saying time is working in their favor, and almost always from a long-term perspective. The examples in investing are numerous: exponential growth through compounded interest, the wealth creating benefits of early savings for retirement, or the long-term merits of low volatility portfolio construction for greater compounded wealth. In fact, prudent investing is virtually synonymous with a long-term perspective. But are there instances when a shorter-term perspective also works in investors' favor? Can a short-term perspective improve diversification? The answer is yes, resiliently so, and the proof begins with a seemingly unrelated question about the coastline of Britain.

The following illustrates a question pondered by Benoit Mandelbrot: *'Does the length of Britain's coastline increase if one measures the distance using shorter units of measure?'*

We'll examine this phenomenon and prove a related principle – *diminishing correlation as one reduces investment holding period.*

Figure 1: Harnessing the Geometry of Scale for Better Portfolio Diversification

QUESTION: How long is the coast of Britain?
ANSWER: It depends on the granularity of one's measurements.

Similarly, when the concept of ***diminishing timescale*** *is applied to investing,* ***two useful byproducts*** *result:*

Observable opportunities increase

Correlation diminishes

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What Can the Coastline of Britain Teach Us About Time as a Portfolio Dimension?

Mandelbrot and the Significance of Scale

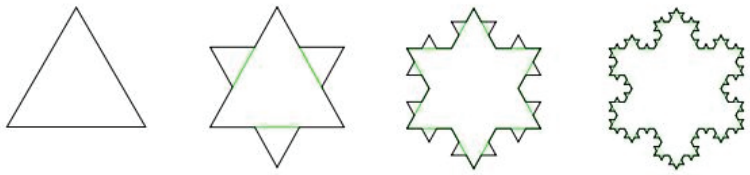
Born in 1924, Benoit Mandelbrot was an influential Franco-American mathematician and is recognized today as the father of fractal geometry. Mandelbrot's driving insight was that math and science did an insufficient job of explaining the natural complexity around him: things like the shapes of clouds, mountains or plants; or the structure of blood vessels or the lungs; or systems like the dispersion of galaxies in the universe.

Among his observations on this topic, Mandelbrot postulated that the length of an object is related to the scale of one's measurements. And in 1967, this exploration formed the basis for his first highly-publicized paper, *"How Long Is the Coast of Britain? Statistical Self-Similarity and Fractional Dimension."* This paradox is highlighted in **Figure 1**, and it shows that as the unit of measurement becomes smaller, the ruggedness of Britain's coastline becomes increasingly detailed. In short, *decreasing* scale *increases* the length of Britain's coastline itself. Mandelbrot's conclusion… the coastline of Britain may very well be infinite!

The Evolution of Fractal Geometry

Mandelbrot's observations led to the development of fractal geometry, a branch of mathematics with broad applicability in modeling complex real-life phenomena. The term "fractal" was first coined by Mandelbrot himself, and while detailed definitions vary, the term "fractal" generally refers to geometric shapes whose surface reveals an increasingly detailed pattern, and often in repetition. A simple visualization of fractal geometry in action is shown in **Figure 2**. Similar to the study of Britain's coastline, the perimeter length of each object in **Figure 2** increases with each additional "fracture."

Figure 2: Fractal Geometry Example



The above illustration is known as the Koch Snowflake, and it illustrates the fractal transformation of a simple equilateral triangle as one uncovers greater and greater detail, in this case, repetitive detail.

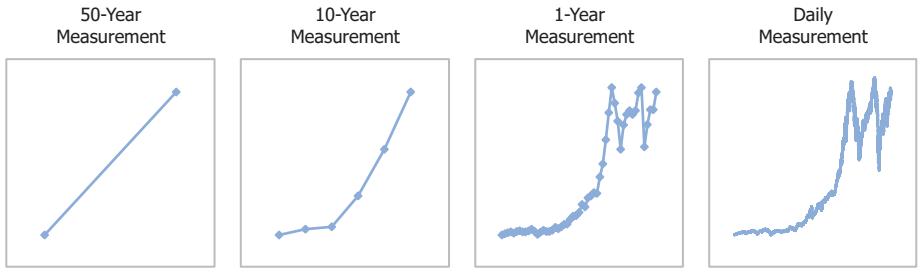
Relating Fractals to Investment Return Potential and Diversification

But while fractals, geometry, and coastlines are all interesting, how do these concepts apply to financial markets and portfolio management? To demonstrate, let's explore the relationship between fractals and return potential by trading our study of the British coastline for the S&P 500.

Over the 50-year period from 1963–2012 the S&P 500 rose from an adjusted closing price of 62.7 all the way to 1426.2– in other words, a total compounded return of 2,175%. (For now, let's assume no dividend reinvestment, related taxes, or fees… we'll address these later). So thinking about this number, 2,175%, what does it represent? Total return, yes, but what else? How can we apply Mandelbrot's insights?

While 2,175% is indeed the buy-and-hold return over the entire 50-year period studied, it represents just one (and the most broad) point-to-point measurement of the total distance traveled by the index. What if, instead of looking over a single 50-year period, investors studied the S&P 500 using increments of decades, years or days, with each up and down movement adding to the total distance traveled? A sample visual highlighting the S&P 500's total distance traveled over increasingly shorter measurement periods is shown in **Figure 3**.

Figure 3: Performance Detail (i.e., "coastline") Improves With Decreasing Investment Holding Periods (S&P 500, 1963 – 2012)



Past performance is not necessarily indicative of future results.

As investors well know, shrinking timescales provide more granular market detail.

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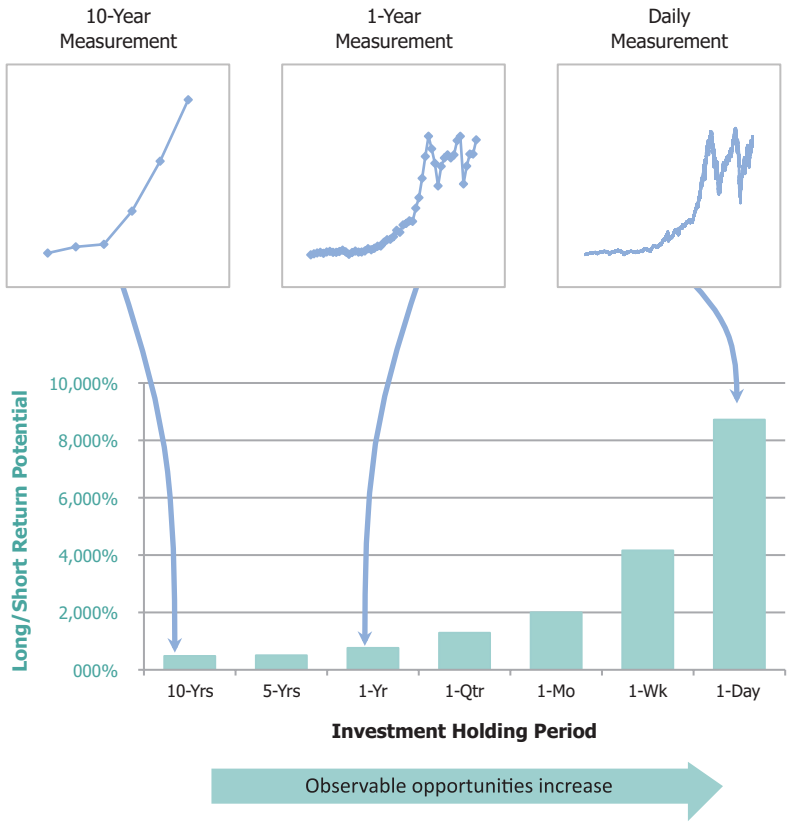
Figure 4 expands on this relationship by showing the *cumulative* distance traveled by the S&P 500 over increasingly shorter measurement periods.[1] But is an exponential increase in cumulative return potential realistic?

"Few" Free Lunches

Of course, almost nothing in this world is free, and there is indeed more to this story.

As might be expected, while the opportunity set increases, harnessing these opportunities also comes with escalating costs. Stubbornly interfering with our theoretical rise toward infinite returns are the frictional realities of taxes and transaction costs. But neither of these costs is as detrimental as the lost

Figure 4: Observable Return Opportunities (i.e., *cumulative* distance traveled) Increases With Decreasing Investment Holding Periods (S&P 500, 1963– 2012)



Past performance is not necessarily indicative of future results.

Similar to Mandelbrot's assertion that the coastline of Britain may very well be infinite, one can similarly observe increasingly large potential return opportunities when comparing long-only performance vs. absolute price movement (i.e., long and short).

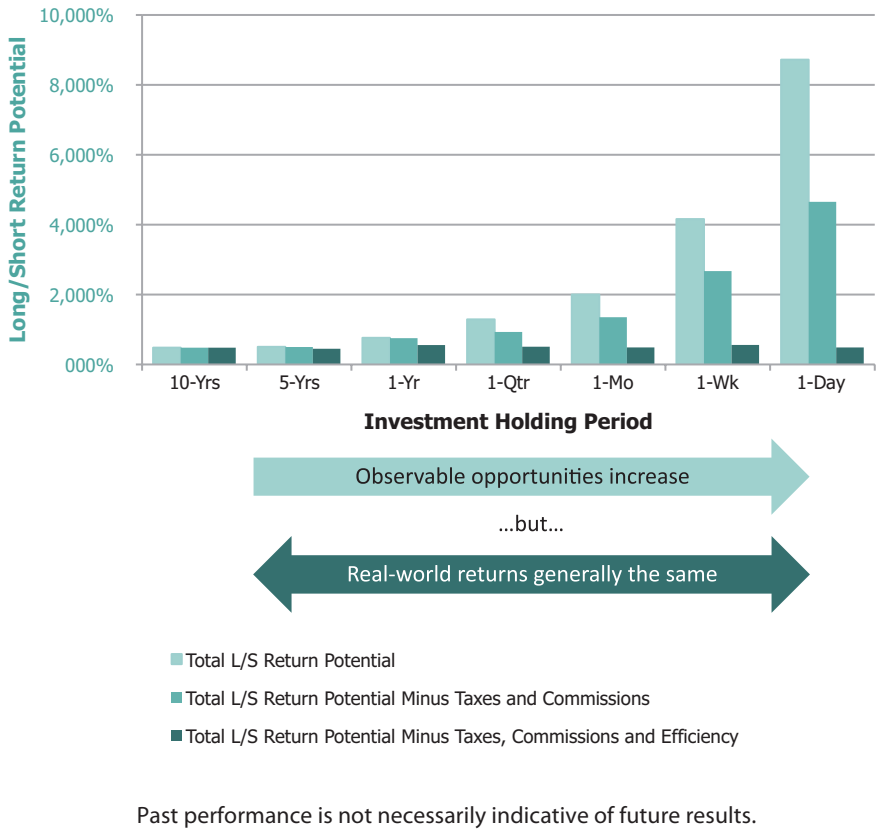
[1] Returns are summed to remove the increasingly large impact of compounding over these shorter time windows, whereas the 50-year return value cited on the previous page was compounded.

timing efficiency that comes with trading over increasingly shorter investment horizons. If defined here as one's ability to correctly predict the next market move, it is easy to see how lost efficiency swiftly erodes the observed opportunity.

For example, what would you say if asked whether the S&P 500 will be higher or lower 50 years from now? We're guessing nearly 100% would predict higher. Certainly this has been true in all preceding 50-year periods, and only the most resolute doomsayers would predict otherwise. But what if we shortened the interval to the next 10-years? 1-year? 1-month? or 1 -day?

With each shortened interval, one's certainty is reduced, which explains why capturing these opportunities becomes increasingly difficult (i.e., less "efficient"). So unlike Mandelbrot's assertion that the coastline of Britain may well be infinite, real-world investment returns are not.

Figure 5: Observed Return Potential vs. Real-World Expected Return Potential (S&P 500, 1963 – 2012)



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Unlike Mandelbrot's assertion that the coastline of Britain may well be infinite, real-world investment returns are not.

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But does this mean all is lost? Not necessarily. Assuming the necessary investments in personnel, systems, infrastructure, and risk management, one can improve efficiency at capturing returns over shorter and shorter investment periods. But realistically, it is difficult to maintain pace with the exponential rise in required efficiency to achieve incremental investment value. To illustrate, let's assume roughly equivalent net returns across investment horizons ranging from years through weeks and days, as depicted as the dark green bars in **Figure 5**.

If one assumes return magnitude is generally equivalent across various investment holding periods, why should investors contemplate time-based diversification in their portfolios? The answer lies in the non-correlated pattern of returns between longer and shorter holding period investments.

The Real Diversification Prize: Achieving Non-Correlation through Time

Detailing the Breakdown

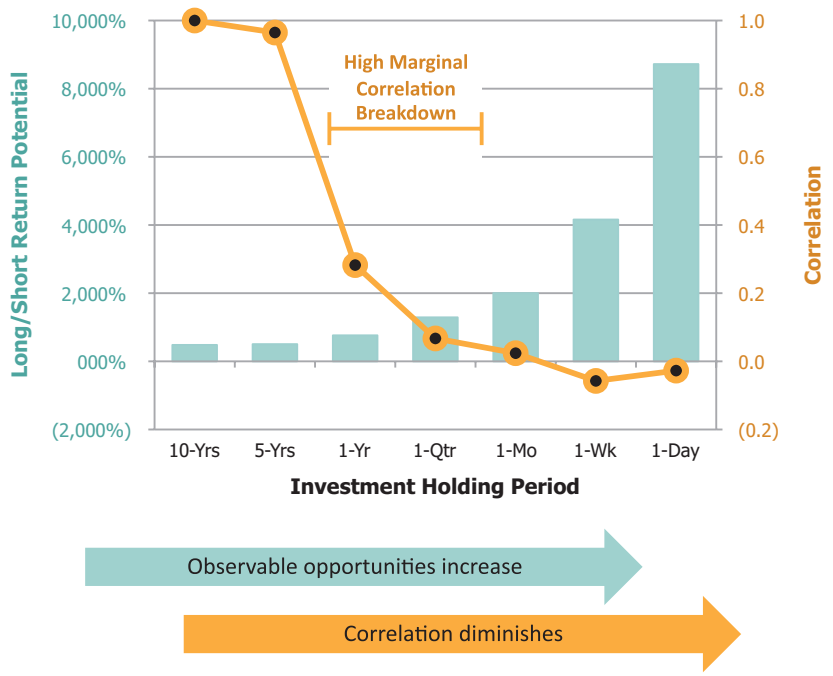
We titled the last section *"Few Free Lunches"* because *almost* nothing in this world is free. As managers specializing in alternative investment strategies, however, we believe that the application of non-correlated return streams that also preserve return potential is one of the easiest ways for investors to enhance risk-adjusted returns and elevate wealth compounding over the long-term. So with return potential as just one ingredient in the portfolio construction process, how might *correlations* respond to varying investment horizons?

To explore this dynamic, lets again use 50 years of the S&P 500 as our primary dataset and take measurements of the index over increasingly shorter holding periods, with each up and down movement adding to the cumulative distance traveled. Next, we perform correlations within each timeframe comparing the long-only investment return experience versus the return potential for the long/short investor.

These results appear as the gold line in **Figure 6** which shows that as investment horizon decreases, so too does an investment's correlation to its long-only counterpart. To provide some insights as to why this relationship exists, let's first take a step back and review performance of the S&P 500 through the lens of its widest measurement interval in our sample case, 10-years.

Over the past 50-years, the S&P 500 has achieved a positive return at each 10-year measurement period. In other words, there was no incremental return opportunity from being short because the S&P 500's total long-only distance was *the same* as its absolute long/short distance. As such, the S&P 500's absolute long/short return correlation to its long-only return is a perfect 1.0.

Figure 6: Correlation Breakdown Over Shortening Investment Horizons
(S&P 500, 1963 – 2012)



Past performance is not necessarily indicative of future results.

The correlation coefficient between long-only and absolute price movement (i.e., long and short) drops significantly as one moves from long to short holding period windows.

But what if we took our measurement at the end of each year? Although the S&P 500 has only been down just 26% of the time in 50 years when measured over 1-year intervals, referring back to **Figure 6** notice how dramatically the correlation relationship falls. Deconstructing the measurement period further, the S&P 500 has fallen in 47% of daily occurrences over the past 50 years, resulting in an absolute return correlation to a long-only counterpart of (0.03). In other words, using our single-market analysis here, ***non-correlation is achieved by both the frequency and magnitude of the long/short return opportunity relative to its long-only counterpart.***

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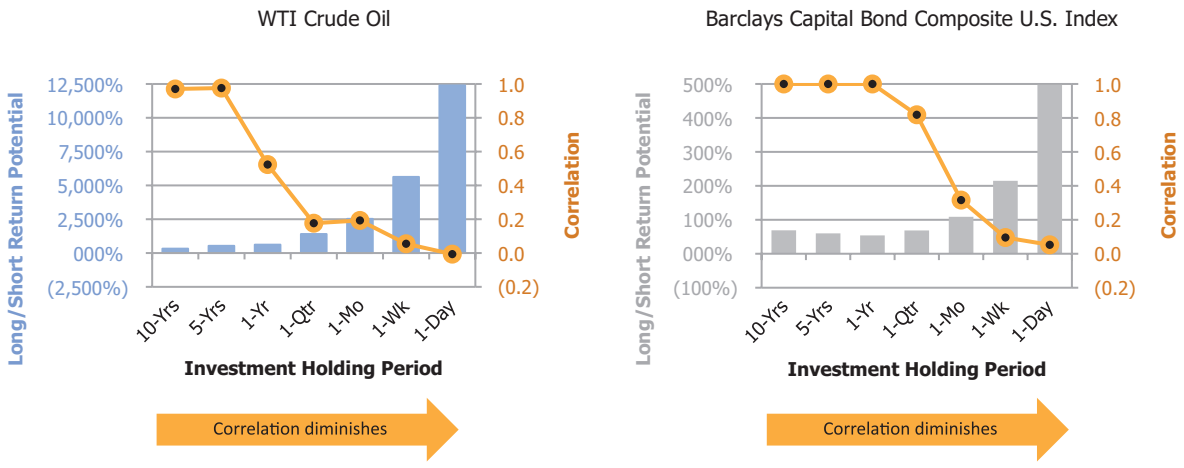
Mathematical Truth, or Red Herring?

Figure 6 indicates that correlation reliably breaks down as investment horizons shorten. But is this relationship a mathematical truth or the product of selection bias? Perhaps this phenomenon is unique to our dataset, in this case, the S&P 500. To further test this correlation breakdown, we ran our analysis again, this time using data for crude oil and a composite of U.S. bonds. These results appear in **Figure 7**.

Figure 7: Correlation Breakdown Over Shortening Investment Horizons
WTI Crude Oil (1983 – 2012) and Composite U.S. Bonds (2003 – 2012)



Past performance is not necessarily indicative of future results.

The above charts support the findings in **Figure 6** using two different markets, demonstrating a reliable breakdown in correlation due solely to a change in investment holding period.

As shown, these two additional markets also show the reliable breakdown of correlation with increasingly shortened investment horizons. If one continues this process over hundreds or even thousands of freely traded markets, one sees the mathematical relationship show through again and again. And so, although Mandelbrot's infinite coastline postulate does not translate into infinite achievable returns as holding periods

shorten, we have shown that investment holding period alone can be a reliable source of portfolio diversification.

Our two follow-up markets offer an additional insight as well. In the specific cases here, since bonds have exhibited a more positively skewed return distribution over smaller timeframes (at least in the recent historical period), it takes incrementally smaller measurement periods for the correlation relationship to break down. Crude oil, being more cyclical in nature and slightly more elevated on the volatility spectrum, sees its correlation break down much faster. These insights lead to yet another truism: ***the more volatile a given market for a given return, the more quickly its correlation breaks down with time-based strategies***.

Time as an Ingredient within the Portfolio Construction Process

So as correlations break down over shorter investment horizons, one clearly sees the benefit of integrating time-based diversification into the portfolio construction process. And just like other key tenants of portfolio construction, a diversified approach to holding periods can be critical to an investor's pursuit of true diversification. But how can investors *access* such non-correlative benefits?

Having previously discussed the potential costs from seeking returns across increasingly shorter investment horizons, it's not as easy as simply ramping up trading activity (note that we strongly advise against this!). That said, a number of readily accessible alternative investment strategies have made the necessary investments in personnel, research, and infrastructure to harness return potential and achieve true diversification across varying investment horizons. In fact, diversifying by timeframe is a foundational technique used by alternative strategies to provide the most robust diversification benefit. **Figure 8** provides a general classification of these alternative strategies according to their average investment holding period and corresponding time-based diversification benefit.[2]

As shown in **Figure 8**, certain buy-and-hold strategies with longer investment horizons maintain relatively high correlations to their traditional counterparts as they align their common capture market-based return "betas", thus providing little in the way of time-based diversification. On the other hand, more actively managed strategies (such as managed futures, relative value and macro) capitalize on opportunities in ranging

[2] For a dedicated analysis of the cross-correlation relationships between 24 commonly used traditional and alternative asset classes, see Welton's previously released paper, "Diversification: Often Discussed, but Frequently Misunderstood."

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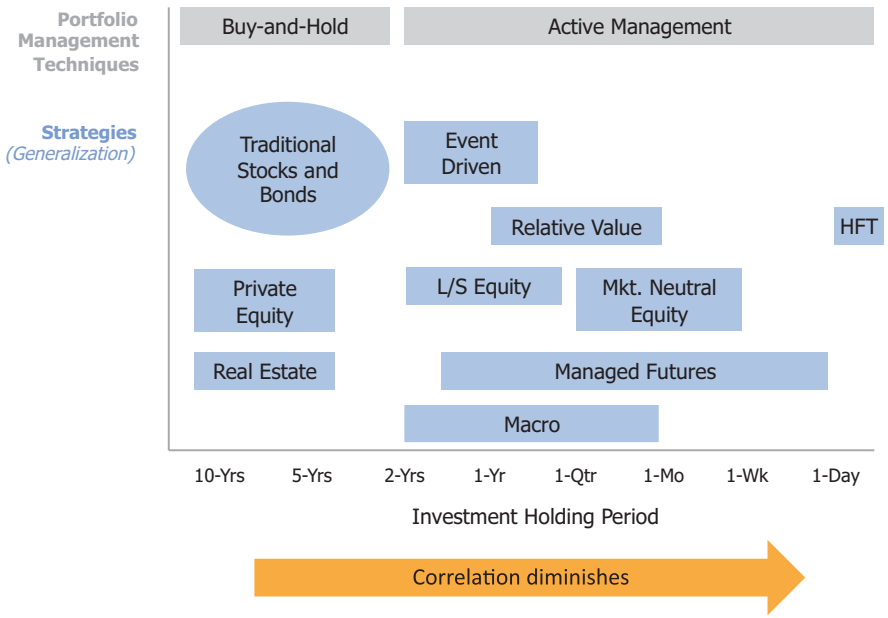
but increasingly shorted investment horizons, providing investors with desirable correlative benefits. And while extreme short-term and high frequency trading ("HFT") strategies can further enhance a portfolio's diversification profile quite valuably, such strategies also tend to be highly capacity constrained which limits their ability to manage large pools of capital. Fortunately, much of the non-correlative benefit has already occurred by the time strategies trade within the 1-year to 1-week timeframe.

Time-based diversification is probably not an established consideration in many investors' portfolio construction process. The mathematics of fractal geometry, however, suggest it warrants consideration. To assist, the following plot loosely categorizes portfolio management techniques and strategies across the holding period spectrum.

Figure 8: Loose Categorization of Portfolio Management Techniques and Investment Strategies by Holding Period



Past performance is not necessarily indicative of future results.

Conclusion

The capital markets will remain in an endless cycle of give and take, with varying levels of force, vigor, and predictability. Correlations rise, correlations fall, volatility spikes, volatility subsides. Each of these behaviors is almost as consistently inconsistent as returns themselves, and investors perhaps ill-equipped to handle the unexpected are increasingly aware of the need for truly diversifying return sources.

And while many will search far and wide across markets for diversifying solutions, a study of the time fractals within markets and their relationship to return characteristics offers some important insights. In fact, our analysis shows that the concept of time is one of the most reliable, and perhaps most overlooked, sources of diversification when utilized effectively with long/short directional strategies.

Of course, almost nothing comes for free, and achieving this natural non-correlation comes with potential costs. But as the return opportunity remains vast, those strategies with rigorous processes to identify and harness recurrent behaviors at shorter timeframes may maintain or even increase return potential over time, all-the-while delivering the real prize of enhanced portfolio diversification. And with heightened levels of non-correlation with increasingly shorter time intervals as a mathematical truism (given volatility other than zero), it is the implementation of these very time-tested and time-based alternative strategies that may offer investors more reliable portfolio allocation tools leading to better growth over time.

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