Follow the Leader:

S&P 500 as a Driver of Global Implied Volatilities

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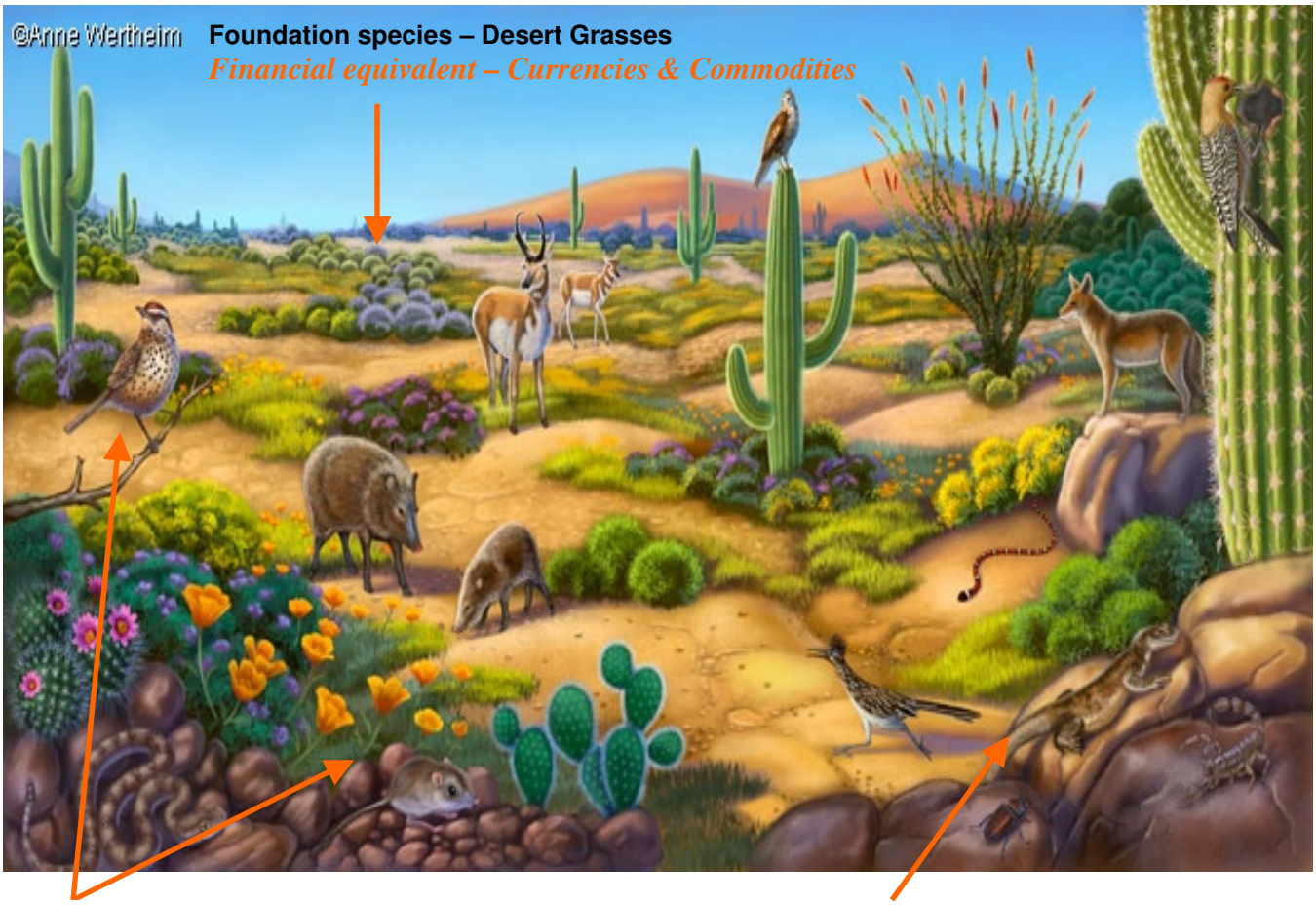
"Look deep into nature and then you will understand everything better."
- Einstein

INTRODUCTION:

Financial markets have grown dramatically in complexity over the past decade – or so the modern world would like us to believe. If we view the financial markets as a giant ecosystem in which all components are inter-related to one another, then under this analogy we can see that the underlying components of the financial markets have, in fact, stayed intact for years.

The first part of this paper is centred on understanding our financial markets as a giant ecosystem analogous to an ecosystem found in nature, and draws parallels between each of the components in a natural ecosystem and our financial system. The second part of this paper discusses how the most important species in our ecosystem, the S&P 500, drives implied volatilities of all other major futures markets around the globe.

Let's examine the ecosystem below taken from the desert, and take an in-depth look at each of the species present in such an ecosystem:



Foundation species: Foundation species is a species that plays a central role in sustaining an ecosystem, and are often producers. Foundation species create complex habitats in which associated organisms find refuge from biological and physical stress. They provide structure to a community. If there is enough variety of foundation species, then a loss of a single species may not adversely affect the ecosystem in the long-run but can create a disturbance to the ecosystem in the short-term.

Examples of a foundation species located in the desert are the desert grasses. These grasses provide food and shelter for animals, however, there is a wide variety of desert grass species, and as a result, the loss of a single grass species will unlikely adversely affect the desert's ecosystem.

What is the financial equivalent of a *foundation species* ? Well, the "producers" of the financial ecosystem are the commodity markets. Commodity markets have an underlying hard asset, and typically are flocked to during times of stress. Due to the vast number of commodity futures, the loss of a single commodity future is unlikely to create a permanent disturbance to the financial markets, although it certainly may temporarily dislocate the financial markets.

Indicator species: An indicator species is a species whose status provides information on the overall condition of the ecosystem and of other species in the ecosystem. Ecologists monitor indicator species to predict future changes in the conditions of a particular ecosystem. Indicator species are very valuable as an early warning system for potential problems.

An example of an indicator species found in the desert is the lizard. Lizards were used to monitor the effects of oil pollution in Kuwait years after the Gulf War, as their tissue was tested for unusually high proportions of hydrocarbons, which ultimately demonstrated that the sites were still contaminated more than a decade after the Gulf War.

What is the financial equivalent of an *indicator species* ? The indicator species of our financial ecosystem is the Fixed Income markets. An upwards sloping yield curve reflects a healthy overall economic climate, as banks can accept deposits at a low interest rate and lend money at a much higher rate, effectively earning the spread. Conversely, an inverted yield curve is a preliminary sign that our financial ecosystem is unhealthy, and has a strong historical track record of foreboding a recession.

Keystone species: A keystone species is a species on which other species in an ecosystem largely depend, such that if this species were removed from the ecosystem, the ecosystem would change drastically. Also, a keystone species has a disproportionate effect on other organisms within the system.

An example of a keystone species found in a desert are kangaroo rats - studies have shown that if you remove kangaroo rats from a desert, then the desert soon ceases to exist. In areas without kangaroo rats, grasses begin to fill in between the shrubs, large-seeded plants replaced plants with smaller seeds, and the

number of other rodents increases significantly. The desert effectively transforms itself into a dry grassland under the absence of kangaroo rats.

Another example of a keystone species in a desert is the hummingbird – the hummingbird pollinates the other plants in the desert, like the cactus, so without the hummingbird many plants would die. Consequently, the lives of many animals would be endangered since animals rely on these plants for shelter and food, which would then have catastrophic effects for the entire ecosystem.

What is the financial equivalent of a *keystone species* ? The keystone species of our financial ecosystem is none other than the S&P 500 futures. The S&P 500 drives the other "species" in the financial ecosystem, which is demonstrated below.

BACKGROUND:

At first glance, there is no fundamental reason why the direction of the S&P 500 should impact the implied volatility of a completely different market with a completely different set of fundamentals, such as Crude Oil or Euro. The inverse relationship between the S&P and the VIX is well-documented – when the S&P 500 increases, the VIX decreases and the vice-versa. However, the underlying instrument of the VIX is the S&P 500 itself – there is no seemingly no logical reason why an increase in the S&P 500 would cause the implied volatility of an unrelated market such as Crude Oil or Euro, to fall.

In order to test these relationships, a composite volatility index is created which is designed to track the change in implied volatility of global futures markets. This composite volatility index consists of five constituents – with each constituent representing the leading futures market * from each sector – namely, Crude Oil (Energies), Euro (Currencies), Gold (Metals), TY Note (Fixed Income), Corn (Agriculture). Then, the relationship between the S&P 500 and the implied volatilities of global futures markets is tested by regressing the percentage change in the S&P 500 against the percentage change in the composite volatility index across a variety of time frames. The percentage change in the composite volatility index is computed by taking the average percentage change of the at-the-money implied volatility for the five aforementioned markets.

The results of the regression are listed in the figures below. Note that all results reflect the regression of the S&P 500 against each of the five leading markets, and most importantly, the S&P 500 against the composite volatility index, which is the last line in the table and highlighted in grey.

*Note: the leading futures market from each sector was derived by first computing the volume-weighted dollar volatility for each respective futures market – we refer to this number as the "critical mass" of a respective market. The market with the highest "critical mass" in each sector was selected as the leading futures market. The dollar volatility was computed using the Wilder True Range (ticks) multiplied by the dollar value per tick.

Figure 1: Results of regression of the S&P 500 against composite volatility index, and five constituents of the composite volatility index across various time periods. The data used in the regression extends from 1999 – 2016.

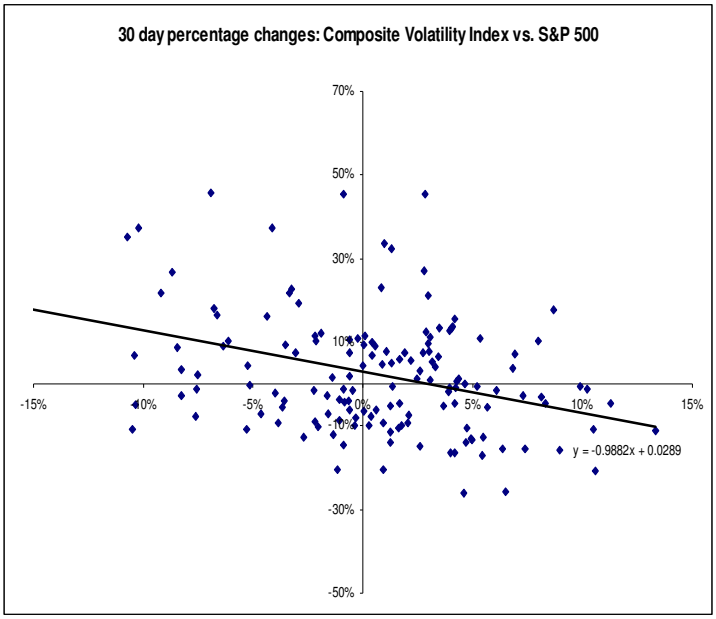
T- statistic of regression coefficient

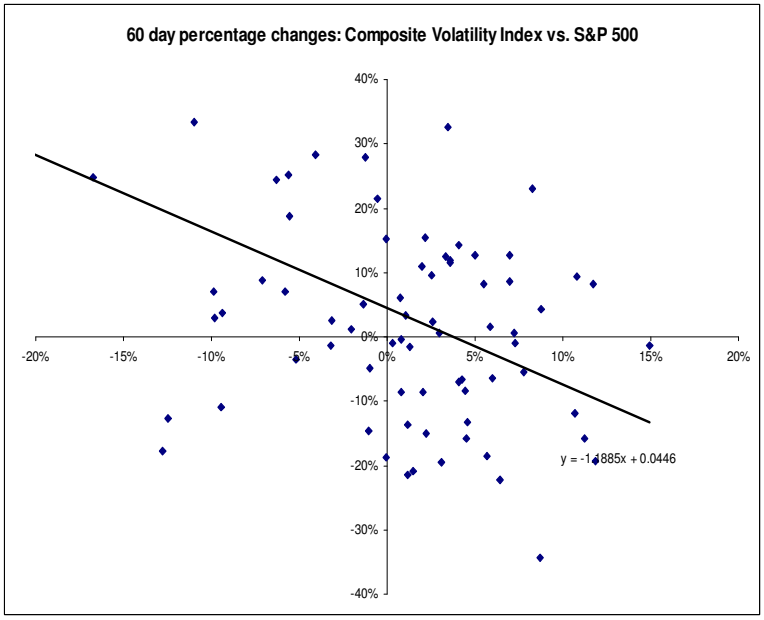
	30 day	60 day	90 day	120 day	1 month	3 month	6 month
Implied Volatility - CrudeOil	-1.6	-3.8	-2.2	-1.9	-3.4	-2.0	-1.5
Implied Volatility - Euro	-1.6	-3.0	-2.5	-3.6	-4.7	-3.7	-2.5
Implied Volatility - Gold	-3.5	-2.7	-1.5	-0.7	-4.2	-2.8	-0.5
Implied Volatility - TYNotes	-2.5	-2.4	-2.6	-1.1	-3.4	-2.2	-1.5
Implied Volatility - Corn	-1.0	-0.3	0.0	0.8	-0.6	-0.7	-0.4
Implied Volatility - Composite Index	**-4.7**	**-3.9**	**-2.8**	**-2.3**	**-6.0**	**-3.7**	**-2.4**

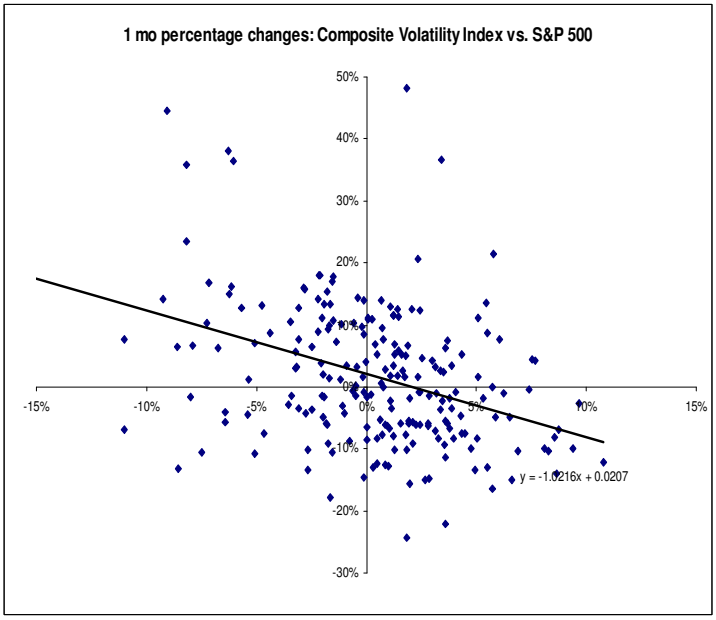
Regression coefficient

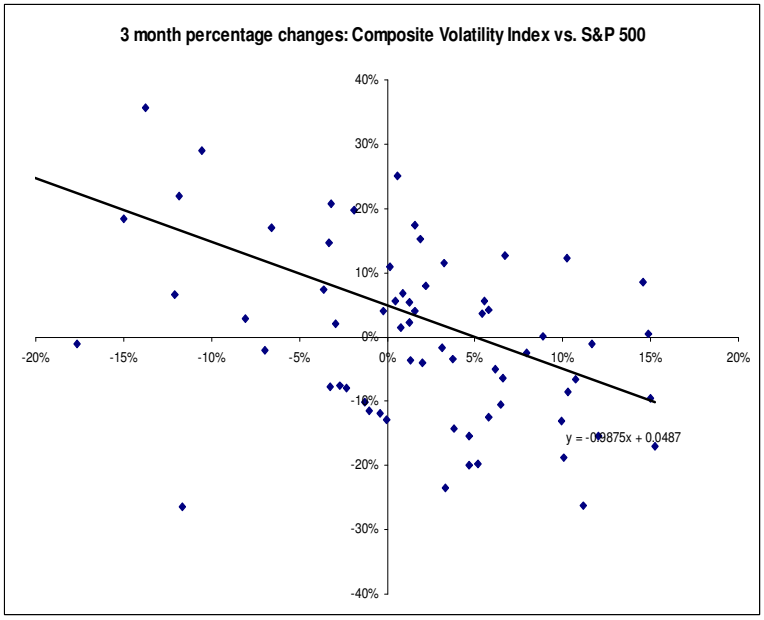
	30 day	60 day	90 day	120 day	1 month	3 month	6 month
Implied Volatility - CrudeOil	-0.56	-1.61	-1.05	-1.15	-1.01	-0.90	-1.09
Implied Volatility - Euro	-0.49	-1.43	-1.01	-1.73	-1.23	-1.14	-1.48
Implied Volatility - Gold	-1.29	-1.13	-0.94	-0.37	-1.44	-1.28	-0.32
Implied Volatility - TYNotes	-0.77	-0.83	-0.97	-0.45	-0.88	-0.59	-0.62
Implied Volatility - Corn	-0.35	-0.13	0.00	0.41	-0.19	-0.37	-0.31
Implied Volatility - Composite Index	**-0.99**	**-1.19**	**-0.84**	**-0.78**	**-1.02**	**-0.99**	**-1.01**

Figure 2: Scatterplots of Composite Volatility Index vs. S&P 500 across various time periods. The data used in the scatterplots extends from 1999 – 2016.









DISCUSSION:

The relationship between the S&P 500 and the Composite Volatility Index demonstrates statistical significance across all time frames that were tested.

Perhaps even more striking is that the regression coefficient is negative for all five individual constituent markets across all time frames tested, with the exception of corn which has a slightly positive t-stat at the 90d and 120d time period- ultimately, of the 42 regression coefficients, 40 of them are negative (see Figure 1). This demonstrates the consistency with which the S&P 500 impacts the implied volatilities of global futures markets.

The regression coefficient is approximately –1.0 across all time frames – this indicates that a 10% increase in the S&P 500 results in a corresponding 10% *decrease* in implied volatilities of futures markets around the globe. Similarly, a 10% decrease in the S&P 500 results in a 10% *increase* in global implied volatilities.

There are various implications to this research. First, this research suggests that the typical managed futures portfolio is *less* diversified than one realizes, as our research demonstrates that nearly all managed futures programs to some extent thrive on volatility. It is widely believed that the implied volatility of the various futures markets behave differently, but this research clearly demonstrates that the S&P 500 is a common driver behind the implied volatility of a broad spectrum of futures markets.

This research also suggests that a typical trend-following portfolio may be *significantly less* diversified than one realizes, as the profitability of a trend-following strategy on a respective futures market can be represented as a long options straddle in which profits are earned if there are large price movements in either direction. If the volatility of the respective futures market is partially driven by the price movement of the S&P 500, clearly there are far less independent components in a trend-following portfolio than one realizes.

Second, this research suggests that the S&P 500 deserves a higher weighting in a futures portfolio due to the disproportionate role it plays in driving the implied volatility of the other futures markets.

Third, this research partially explains the under-performance of trend-following strategies during an equity bull market. It is commonly believed that a trend following strategy should be able to produce profits during a roaring bull market for equities due to the fact that such a strategy will be long equities during such a move. The flaw with this reasoning is that it fails to take into consideration the impact that a rising equity market has on the remainder of the futures markets around the globe. As this research demonstrates, a bull market for the S&P 500

results in a contraction of implied volatilities of futures markets around the world, which subsequently affects the ability of these markets to undergo sustained trends.

Lastly, using implied volatility as a proxy for fear in a respective market, this research demonstrates that a declining S&P 500 creates fear across *all* futures markets around the globe – similarly, when the S&P 500 goes up it creates an absence of fear across global futures markets.

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- Fung, W., and Hsieh, D., 2001. "The Risk in Hedge Fund Strategies: Theory and Evidence from Trend Followers," The Review of Financial Studies 2, 313-341.

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