Is Beta Dead for Commodities?

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Published in

The Journal of Investing

Volume 26, Issue 4, Winter 2017, Pages 16-26

https://doi.org/10.3905/joi.2017.26.4.016

Commodities and their relation

to stock market returns

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To be submitted to Journal of Investing

http://www.iijournals.com/toc/joi/current/

This version: May 19, 2016

The close ties between daily movements of commodities and stock markets, which have persisted mostly uninterrupted since the financial crisis, have frayed.

The Wall Street Journal, March 31, 2013.

INTRODUCTION AND LITERATURE REVIEW

Commodity investments have received a lot of attention in the newspapers the last years. Bloomberg [2016] describes the rise and fall of the Blenheim Capital Management, a hedge fund run by the successful manager Willem Kooyker. At its height in 2011, Blenheim was the world's largest commodity focused hedge fund, with $9.1 billion in assets. Followed by years of negative returns, its assets have fallen nearly 85 percent to $1.5 billion, and many investors (including New Zealand pension fund) have pulled money out. The question whether to invest long-only in commodities seems not to be easily answered.

Financial Times [2015] discusses the conflicting views on this issue with references to the key academic debate. One view is that investors should receive a risk premium by long only commodity investing since producers (e.g. farmers and oil companies) are willing to pay a price insuring a price fall. (see e.g. Gorton and Rouwenhorst [2005, 2006], Gorton et al. [2012], Rouwenhorst and Tang [2012]). Over the long run these find similar returns for commodities as for stocks. On the other hand, some claim that the main source of commodity investor's return comes from the term structure of futures prices and this require a lot of skills to predict. Under this view one should not expect commodity returns to be similar to stock returns (see e.g. Erb and Harvey [2006,2016]).

Even though commodities "stand alone" could not provide risk adjusted return above stocks, they might still be included in investment portfolios if the correlation with stocks is low enough. Investigating the correlation between commodities and stocks is therefore an important issue. Some years ago, Wall Street Journal [2013] question the claims of many that correlation between commodities and stocks had increased permanently. In this article they observe that the close ties between daily movements of commodities and stocks has broken down. It is still however an open question whether equities and commodities as a whole started to move more in sync after the large inflow of investment capital to commodity futures markets. A heated debate among academics and policymakers[1] is whether this "financialization" of commodity markets has influenced the price dynamics of commodity markets and increased their correlation with stocks (hence, reduced the diversification effect of commodities). Support for this view are for example found by Tang and Xiong [2012], Cheng and Xiong [2013], Silvennoinen and Thorp [2013], and Henderson et al. [2014]. On the other hand, papers that do not support the commodity financialization hypothesis are found by Stoll and Whaley [2010], Dwyer et al. [2011], Saunders and Irwin [2011], Irwin and Saunders [2011, 2012a,b], Demirer et. al. [2013], Steen and Gjolberg [2013, 2014b], and Hamilton and Wu [2015]2 and others.

In this paper we restrict ourselves to investigate the dynamics of correlation between a selected group of commodities and stocks. Our analysis extends previous research in various ways:

- Many of the recent studies do not include the last years of data. In our paper we apply weekly data from front futures contract at CME Group covering the period 1990 to 2015. We include futures of S&P 500 and a wide range of 19 different commodities covering aggriculturals, softs, metals, and energy.

- Rather than just focusing on correlation, we investigate the commodity beta[3] that is decomposed into (1) The correlation between commodity returns and stock returns, and (2) The relative volatility between commodity returns and stock returns. Correlation between stocks and commodities might be low, but the relative volatility between them might still be high, significantly reducing the diversification effect of commodities. We are surprised that very few papers investigate this issue as we do in this paper.

- As indicated in several studies, these measures varies over (1) type of commodity and (2) time. In order to investigate this, we apply models of exponential weighted moving average (EWMA) of correlation, relative volatility, and beta. EWMA have the benefit of putting an exponential decaying weights on previous observations (and not equal like in a rolling window). Furthermore; with this method we do not to choose (an arbitrage) window size like we do when choosing a rolling window. We ask the questions; How do the beta/correlation/relative volatility for different commodities vary across commodities? and How do the beta/correlation/relative volatility for a given commodity vary over time?

Our findings indicate that risk characteristics differs a lot across commodities and are different from stocks, the static correlation between commodities and stocks varies but are in general low. We do find that commodity risk characteristics and correlation with stocks varies a lot over time. Slightly more than half of the commodity betas and correlations have reverted back to or below the long term level, while the relative volatility to stocks is now at its mean level. Our findings do not in general give support to "finanzialization" of commodities since the "spike" in correlation seems temporarily plus the fact that futures return distributions are different (and change differently) than stocks. We believe the different commodity characteristics (and the changes) are due to commodity specific demand/supply conditions, storage properties, general risk aversion, and market regimes. Whether to include commodities or not in stock & bond portfolios are not explicitly addressed here, but our results indicates at least that correlation and relative volatility between stocks and commodities have in general reverted back to the long term static levels.

In section two of the paper we describe our data and perform descriptive analysis. In section three we describe how to decompose the beta into correlation and relative volatility. We also describe the EWMA method for these measures. In section four we perform both static and dynamic analysis and discuss the results. In section five we discuss how our main results contribute to the financialization debate and implications for portfolio diversification. We also provide some ideas for further work[4].

DATA AND DESCRIPTIVE STAT ISTICS

In this study we use front futures contracts from CME collected by the Quandl database[5]. We use weekly settle prices from the first week of April 1990 to the last week of December 2015. The contacts cover S&P500 and 19 different commodities. The commodities are cotton, corn, wheat, soybean, rough rice, soybean meal, soybean oil, cocoa, coffee, orange juice, sugar, lean hogs, feeder cattle, copper, gold, silver, crude oil, heating oil, and natural gas. In Quandl we apply the Stevensen Continuous Database. The adjustment for "roll-overs" are performed using a calendar weighted method. A transition from one contract to the next is applied using a weighted-average combined prices during a pre-determined transition window right around the roll date.

Exhibit 1 and 2 graph the development of commodity prices and returns respectively for the different series.

[Exhibit 1]

[Exhibit 2]

The period from 1990 to 2015 covers many events that have had major impacts on both supply and demand in the financial market as well as in the commodity markets. The ERM crises 1992, Peso crises 1995, Asian crisis in 1997–1998, the dot-com bubble bursting around 2000, the terror attacks on 9/11 2001, Hurricane Katrina in the Gulf of Mexico in 2005, and the boom and bust of the world economy from 2003 to the financial crises in 2008 are some of the major events that in several ways have had an influence on commodity prices. The same applies to the wars that have taken place during this period (e.g., Balkan, Kuwait, Iraq and Afghanistan) and some extreme weather conditions (e.g. the very dry weather and wild fires in Russia in 2010 and the extreme heat in the US corn belt in 2012). These and several other events influenced the pricing to various extents across different commodities. One observation that can already been made from the graphs (Exhibit 1 and 2) is the different price dynamics of the different commodities. For example natural gas have a very different dynamics compared to gold regarding both trend structures in prices as well as relative price changes (returns).

To further elaborate on the different daily return characteristics of commodities, we present descriptive statistics in Exhibit 3,4, and 5 for the whole period 1990 to 2015.

[Exhibit 3 in here]

[Exhibit 4 in here]

[Exhibit 5 in here]

Exhibit 3 shows the standard deviations, min & max, skewness, and excess kurtosis for the different commodities together with stocks. Apart from feeder cattle and gold, commodity futures returns have higher volatility than stocks (natural gas got roughly 3 times the volatility). The extreme max/min range of weekly commodity returns are highest for natural gas (+41% to -23%) and coffee (+43% to -19%) and lowest for gold (+12% to -10%). Stocks have the range -22% to +12% of extreme weekly returns. Most commodity future return distributions are skewed to the left. Silver lowest at -0.95. Coffee highest at +0.60. Stocks have -0.75. All commodity futures return distributions have fatter tail compare to a normal distribution but lower than stocks (excess kurtosis 7.7). Silver highest at 6.4. Exhibit 4 shows the correlation of weekly returns of stocks with the respective commodities. The observation is that commodity return correlation with stocks are generally low and for some commodities near 0 (natural gas, gold, lean hogs). Copper have the highest number at 0.30.

From the static analysis of commodity returns we make the following observations:

- Futures return distribution have very different characteristics compare to stocks
- Correlation with stocks are generally low, for several commodities close to 0.

A natural question arise: Do these characteristics also change over time? In exhibit 5,6,7, and 8 we have split the data into the different decades. The first period is from week 16 1990 to Week 52 1999, the second period is from week 1 2000 to week 52 2009, and the third period is from week 1 2010 to week 52 2015. Standard deviations, min & max, skewness, excess kurtosis, and correlations was calculated for each period.

Stock volatility went up then down from 90s-00s-10s. 14 out of 19 commodities did also. Cotton, Wheat, and Silver increased volatility in both periods. Coffee volatility went down in both periods. Orange Juice went down then up. The range of extreme (max-min returns) went up then down for stocks. 12 out of 19 commodities did also. Sugar and Silver increased the range in both periods. The range for Corn, Orange Juice, lean Hogs, and Crude Oil went down in both periods. Cotton and Cocoa went first down then up. Skewness for stocks stayed around zero then went negative in the two following periods. Corn, soybeans, feeder cattle, copper, silver, heating oil, and crude oil had negative skewness for all periods. Rough rice had positive skewness for all periods. The rest of the commodities had periods with both negative and positive skewness. Kurtosis for stocks went up then down. 6 out of 19 commodities had a similar pattern. Corn, soybean meal, orange juice, wheat, cocoa, and gold fell monotonic in the periods. No commodity had a monotonic increasing kurtosis in the periods. Lean hogs, cotton, silver, heating oil, sugar, and coffee had decreasing kurtosis then increasing kurtosis in the periods. 13 out of 19 commodities had monotonic increasing correlation in the period. Lean hogs stayed around zero all periods. Corn, coffee, feeder cattle, and Natural gas had increasing correlation then falling. Orange juice had decreasing then increasing correlation with the stock market

From this dynamic analysis we draw the following general observations:

- Commodity futures return distribution changes over time
- Commodity futures correlation with stocks changes over time
- The changing characteristics depending on which commodity investigated[6]

METHODOLOGY

We first find the static beta between commodity returns and stock returns as:

$$\boldsymbol{r_{C,t} = \alpha + \beta r_{S,t} + e_t} \quad \mathbf{(1)}$$

where $\boldsymbol{r_{C,t}}$ is the weekly commodity return, $\boldsymbol{r_{S,t}}$ is the weekly stock return. $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ are parameters to be estimated from a simple linear regression model. $\boldsymbol{e_t}$ is error term in the regression. A beta of, let's say 0.4, measure that a 1% increase in the stock market will increase the commodity return by 0.4%.

This beta can be decomposed into a component of correlation and a component of relative volatility:

$$\boldsymbol{\beta = \frac{Cov(r_{S,t}, r_{C,t})}{V(r_{S,t})}} \ \mathbf{(2)}, \quad \boldsymbol{\rho = \frac{Cov(r_{S,t}, r_{C,t})}{\sqrt{V(r_{S,t})V(r_{C,t})}}} \ \mathbf{(3)}, \quad \boldsymbol{v = \frac{\sqrt{V(r_{C,t})}}{\sqrt{V(r_{S,t})}}} \ \mathbf{(4)}$$

Where;

$$\boldsymbol{\beta = \rho v} \ \mathbf{(5)}$$

When risk is measured by standard deviation the systematic risk component of commodity returns is $\boldsymbol{\beta\sqrt{V(r_{S,t})}}$ and the unsystematic risk component is $\sqrt{\boldsymbol{V(e_t)}}$.

By decomposing the beta this way, we are able to investigate whether the commodity return sensitivity is due to the correlation, relative volatility, or both.

We have also observed from the descriptive analysis that these measures vary over time. There are several ways of modelling time varying beta's for commodities such as equally weighted rolling regression, exponentially weighted rolling regression (EWMA), multivariate GARCH models, State Space Models using Kalman Filter, regime switch models and so on. As this research is more of an explorative study, we choose a simpler technique such as an EWMA approach to the modelling of dynamic betas. The benefit of using an EWMA compare to an equally weighted method are that we do not need to choose (an arbitrary) sample size, and that we put an exponential decaying weight to observations in the past.

We can express the time varying alpha and beta between commodity returns and stock returns as:

$$\boldsymbol{r_{C,t} = \alpha_t + \beta_t r_{S,t} + e_t} \quad (\mathbf{6})$$

The EWMA correlation, relative volatility and beta can be found by calculating the EWMA of the variances and co-variances in the following way:

EWMA Variance: $$\boldsymbol{V_t = (1-\lambda) r_{t-1}^2 + \lambda V_{t-1}} \quad (\mathbf{7})$$

EWMA Co-variance: $$\boldsymbol{Cov_t = (1-\lambda) r_{t-1} r_{t-1}^* + \lambda Cov_{t-1}} \quad \mathbf{(8)}$$

$\boldsymbol{\lambda}$ is a weighting parameter with «benchmark» value 0.94. $\boldsymbol{r_{t-1}^2}$ is the squared return in the previous period. $\boldsymbol{r_{t-1} r_{t-1}^*}$ is the cross product of return in the previous period for stocks and commodities. In the recursive estimation a starting value for $\boldsymbol{V_t}$ and $\boldsymbol{Cov_t}$ needs to be set for the first observation.

Having estimated the EWMA variances, we can estimate the EWMA correlation, relative volatility and beta as:

EWMA correlation: $$\boldsymbol{\rho_t = \frac{Cov_t(r_{S,t}, r_{C,t})}{\sqrt{V_t(r_{S,t}) V_t(r_{C,t})}}} \quad (\mathbf{9})$$

EWMA relative volatility: $$\boldsymbol{v_t = \frac{\sqrt{V_t(r_{C,t})}}{\sqrt{V_t(r_{S,t})}}} \quad (\mathbf{10})$$

EWMA beta: $$\boldsymbol{\beta_t = \rho_t v_t} \quad (\mathbf{11})$$

EMPIRICAL RESULTS

We first start out investigating the static beta, correlation, and relative volatilities for our dataset. The results of running equations (2), (3), and (4) in the previous section can be summarized in Exhibit 9:

[Exhibit 9 in here]

The beta's betas are in the range -0.02 (Gold) to 0.46 (Copper) and the correlations are in the range -0.02 (Gold) to 0.30 (Copper). Unconditional / long run beta and correlation is very low for most commodities. It is not surprising that industry metals has a high sensitivity to the stock market. Industry metals are linked to global economic growth /demand (and hence the stock market) than other commodities driven by more local demand conditions such as natural gas (which has an insignificant beta close to 0 and 0 correlation). Oil products on the other hand is a more global commodity with somewhat higher beta and correlation than other commodities. Precious metals such as gold is viewed by many investors as a "safe heaven" in times of financial turbulence. That shows up in both beta and correlation close to 0 as well. Commodities such as lean hogs and feeder cattle are driven by more local supply and demand conditions which again shows up in very low beta and correlations.

The relative volatilities are in the range 0.95 (Gold) to 2.99 (Natural Gas), i.e. there is a huge differences in relative volatilities (to the stock market) between commodities and most of the commodities have a higher volatility in stocks. The reason natural gas has 3 times the stock volatility is due to the fact that it is one of most difficult commodities to store. Change in the local supply conditions (e.g. clogging of a pipeline) or local demand condition (e.g. sudden unexpected cold weather) might have a dramatic effect on the volatility. Commodities that are easy to store such as gold has a lower volatility, in fact marginal lower than stocks.

We then investigate how these measures change over time. We calculate the dynamic beta, correlation, and relative volatilities for our dataset according to equations (9), (10), and (11) in the previous section. The results are found in Exhibit 10,11,12,13,14, and 15:

[Exhibit 10 in here]

[Exhibit 11 in here]

[Exhibit 12 in here]

[Exhibit 13 in here]

[Exhibit 14 in here]

[Exhibit 15 in here]

Each panel show the static correlation, beta, and relative volatility (straight line) for each commodity together with EWMA estimations (describe in the method chapter) of these measures for each commodity over the data sample period. The question to be asked is whether these conditional measures have reverted back to their un-conditional (long term) levels.

If we first investigate the time varying betas for the different commodities and find that:

- 5 out of the 19 commodities have a beta that is now reverted to the mean level. These are cotton, corn, wheat, coffee, and silver.
- 5 betas are now below the mean level. This is the case for rough rice, cocoa, orange juice, copper, and gold.
- 9 betas are above the long run mean level. This is the case for soybean, soybean oil, sugar, lean hogs, feeder cattle, crude oil, heating oil, and natural gas.

Next we investigate the time varying correlation estimates for the different commodities and find that:

- 7 of out of 19 commodity correlations with stocks are now at mean level (cotton, corn, wheat, rough rice, soybean oil, sugar, and silver).
- 4 correlations are now below mean level. These commodities are cocoa, orange juice, copper, and gold.
- 8 correlations are now above mean level. These commodities are soybean, soybean meal, coffee, lean hogs, feeder cattle, crude oil, heating oil, and natural gas.

Finally we investigate the time varying relative volatility (volatility of the commodity compare to stock market volatility) and find that:

- 13 relative volatilities are now at mean level. These are cotton, corn, wheat, soybean, rough rice, soybean meal, soybean oil, coffee, sugar, copper, gold, silver, heating oil.
- 2 relative volatilities are now below mean level (cocoa, natural gas).
- 4 relative volatilities are now above mean level (orange juice, lean hogs, feeder cattle, crude oil).

CONCLUSIONS

In this paper we investigate the relationship between a selected group of commodities and stocks. Our analysis has extended the previous research by including recent data, investigating the beta that is decomposed into the correlation between commodity returns and stock returns, and the relative volatility between commodity returns and stock returns, and finally analyzing time varying parameters in the period 1990 to 2015.

We find that risk characteristics differs a lot across commodities and are different from stocks. Static correlation between commodities and stocks varies but are in general low. Commodity risk characteristics and correlation with stocks varies a lot over time. Slightly more than half of the commodity betas and correlations have reverted back to or below the long term level, but there are also many which level is still above the mean level. For most commodities, the relative volatility to stocks is now at its mean level.

From the research we have performed we find it hard to give support to "finanzialization" of commodities since the "spike" in correlation seems temporarily plus the fact that futures return distributions are different (and change differently) than stocks. We believe the different characteristics (and the changes) are due to commodity specific demand/supply conditions, storage properties, general risk aversion, and market regimes. Further work will be to investigate what is driving the changing risk condition and correlation of commodities and from there specify models to explain these issues.

ACKNOWLEDGEMENT

We would like to thank participants from the NCCC-134 Applied Commodity Price Analysis, Forecasting and Market Risk Management conference in St Luis 18-19 April 2016 for helpful comments and suggestions for further work.

ENDNOTES

1) A related body of research investigate whether speculation influence the dynamics of levels and volatility in the commodity markets. Key references here are Hamilton [2008], Saunders and Irwin [2010], Stoll and Whaley [2010], Knittel and Pindyck [2013], and Buyuksahin and Robe [2014].

2) Both the media and the political environment where quick to conclude that index investors, hedge funds, and other "speculators" where the force behind a possible herd behavior of the commodity markets in the period around and after the financial crises. The US congress organized several hearings discussing the impact of index investors on commodity prices and whether one should implement different form of regulations. The testimonies of Michael W. Masters to the Committee on Agriculture, Nutrition and Forestry [Masters 2009a] and Commodities Futures Trading Commission [Masters [2009b] gives more details of this discussion.

3) The commodity beta measure how much the commodity return will fall/rise (in percent) if the overall stock market fall/rise one percent. In other words, it is the commodity returns regressed on stock returns in a single linear regression model.

4) Data and Excel Spreadsheet Applications covering the analysis in this paper can be retrieved by contacting the corresponding author.

5) See www.cmegroup.com and www.quandl.com for more information.

6) By varying the samples for descriptive analysis we also found that the measures are very sensitive to the sample period chosen

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Exhibit 1. S&P500 and commodity prices end of week (settle) from first week of April 1990 to last week of December 2015. Continuous front futures contracts from CME are concatenated using Stevenson continuous database in Quandl. A calendar weighted method are used during roll-overs of contracts.

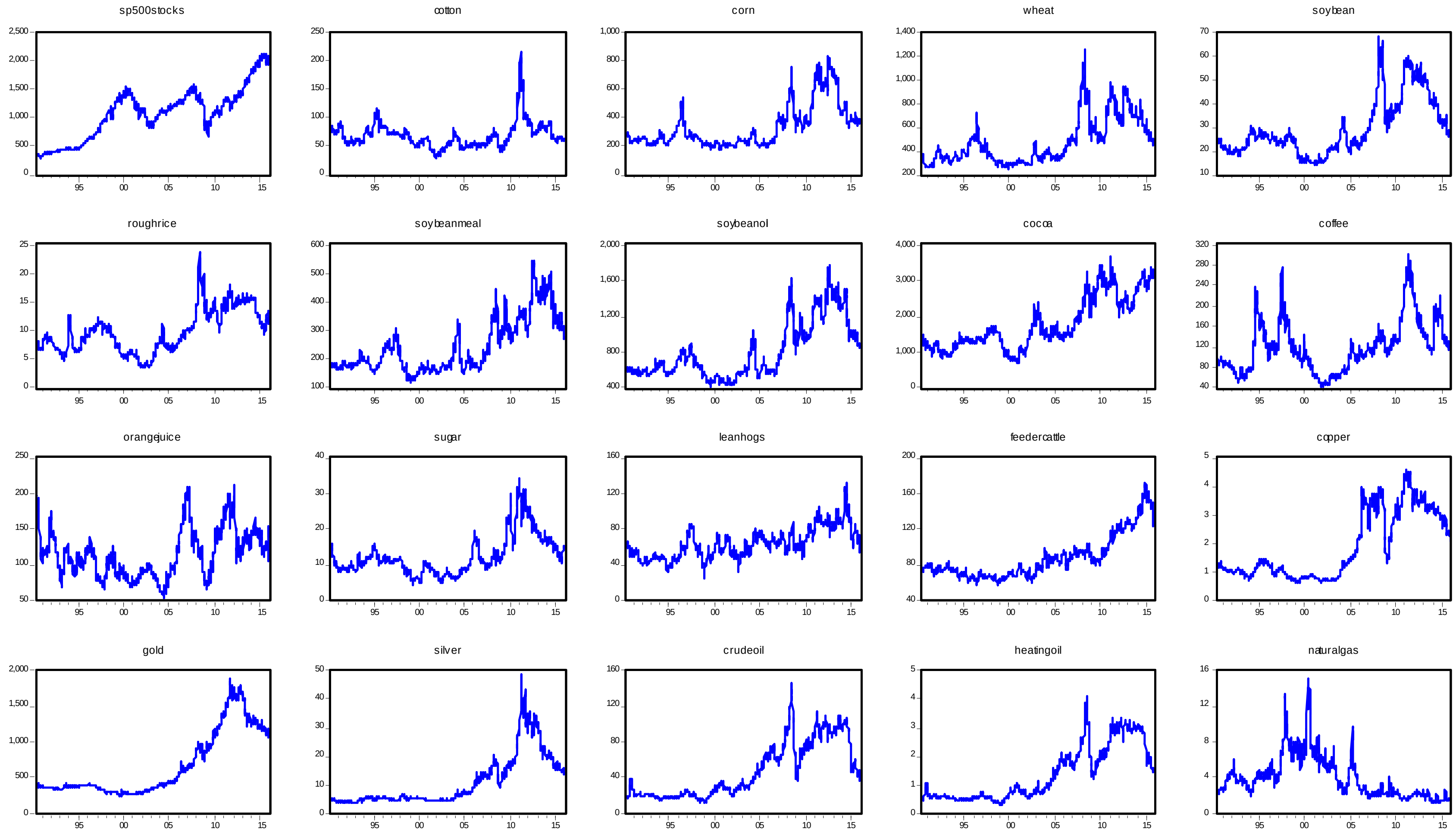

Exhibit 2. S&P500 and commodity returns from second week of April 1990 to last week of December 2015. Continuous front futures contracts from CME are concatenated using Stevenson continuous database in Quandl. A calendar weighted method are used during roll-overs of contracts.

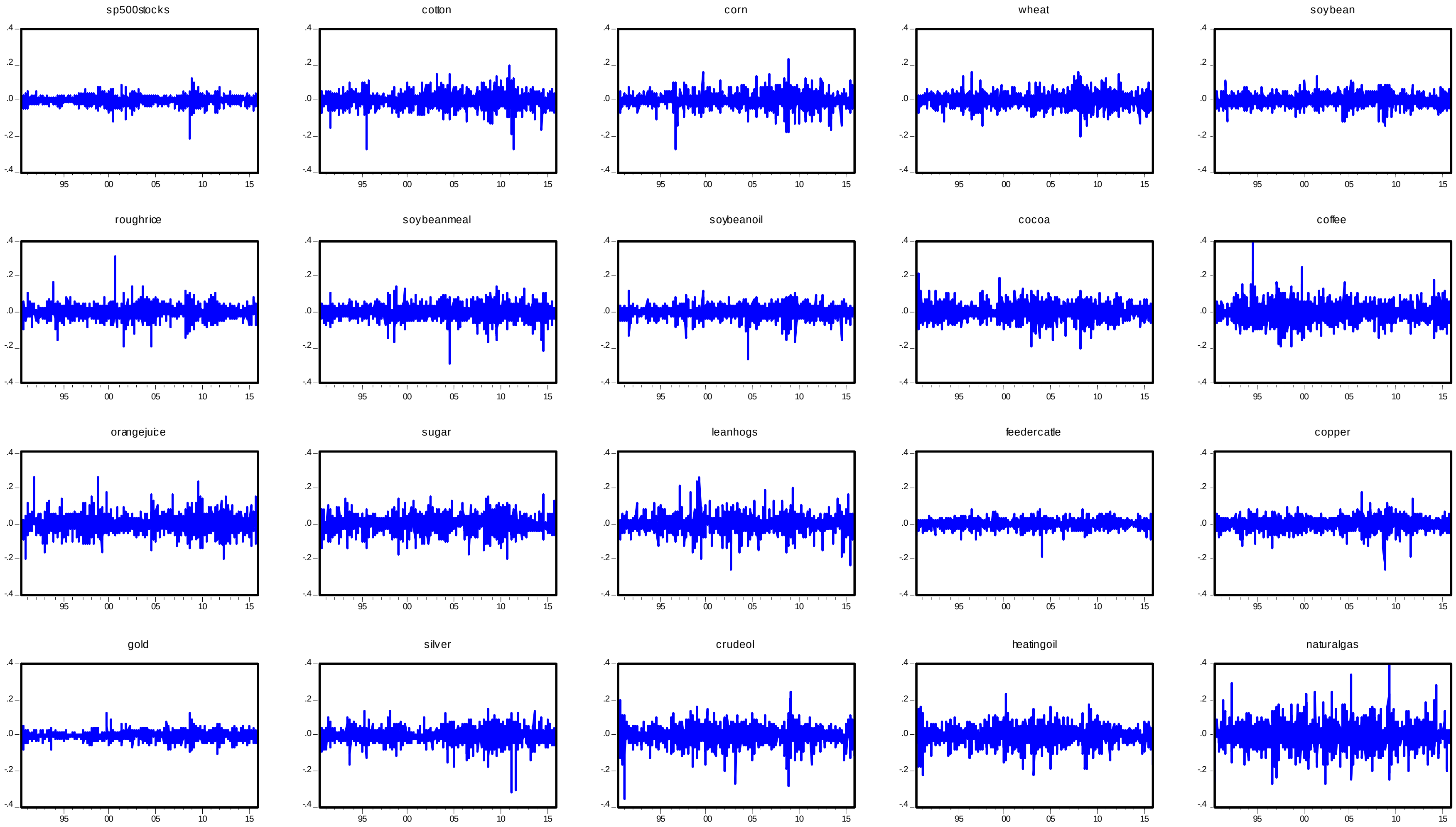

Exhibit 3. Standard deviation, min & max, skewness and excess kurtosis for daily returns S&P500 and commodities from second week of April 1990 to last week of December 2015. Continuous front futures contracts from CME are concatenated using Stevenson continuous database in Quandl. A calendar weighted method are used during roll-overs of contracts.

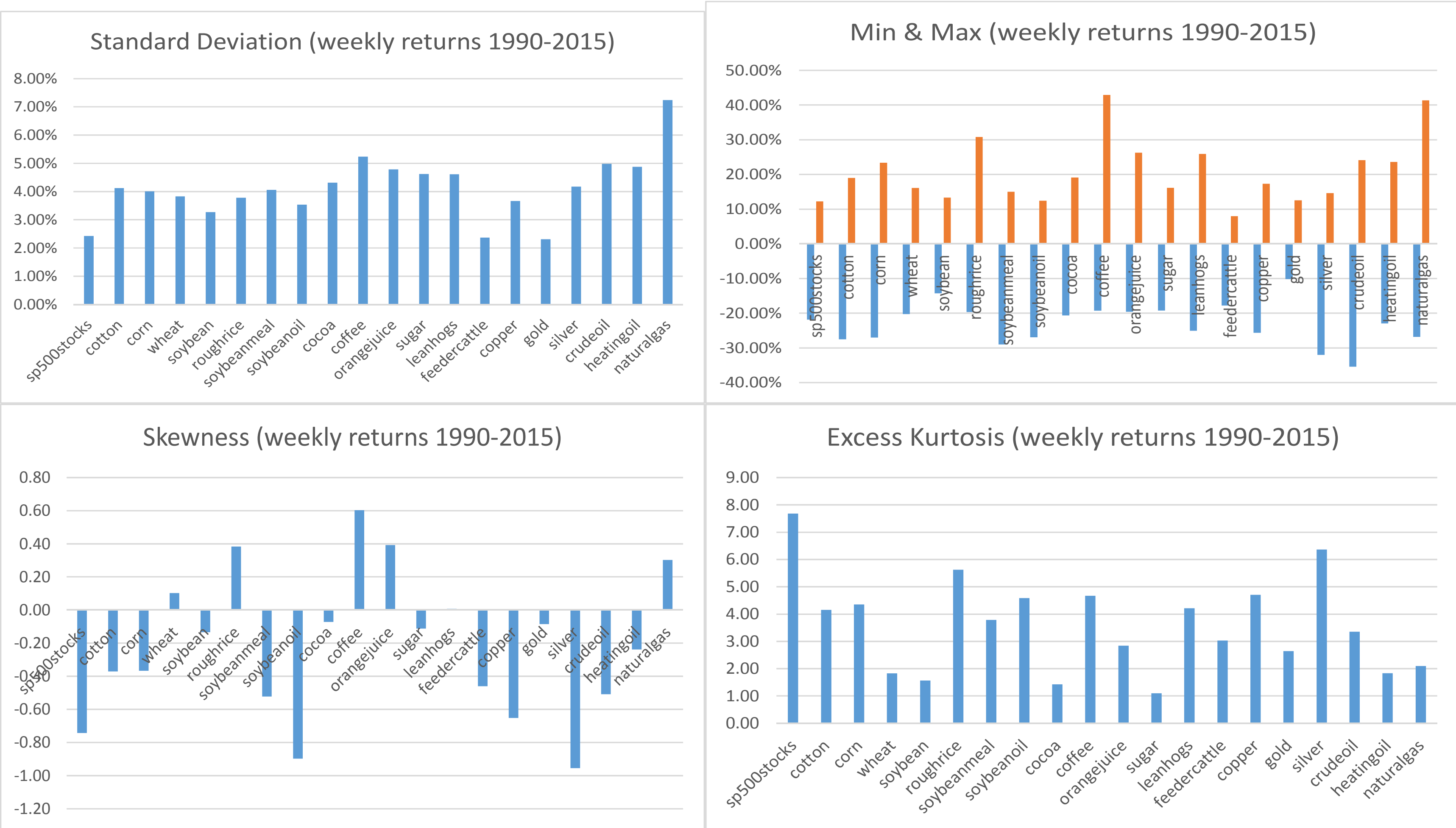

Exhibit 4. Correlation between S&P500 and commodities. Daily returns from second week of April 1990 to last week of December 2015. Continuous front futures contracts from CME are concatenated using Stevenson continuous database in Quandl. A calendar weighted method are used during roll-overs of contracts.

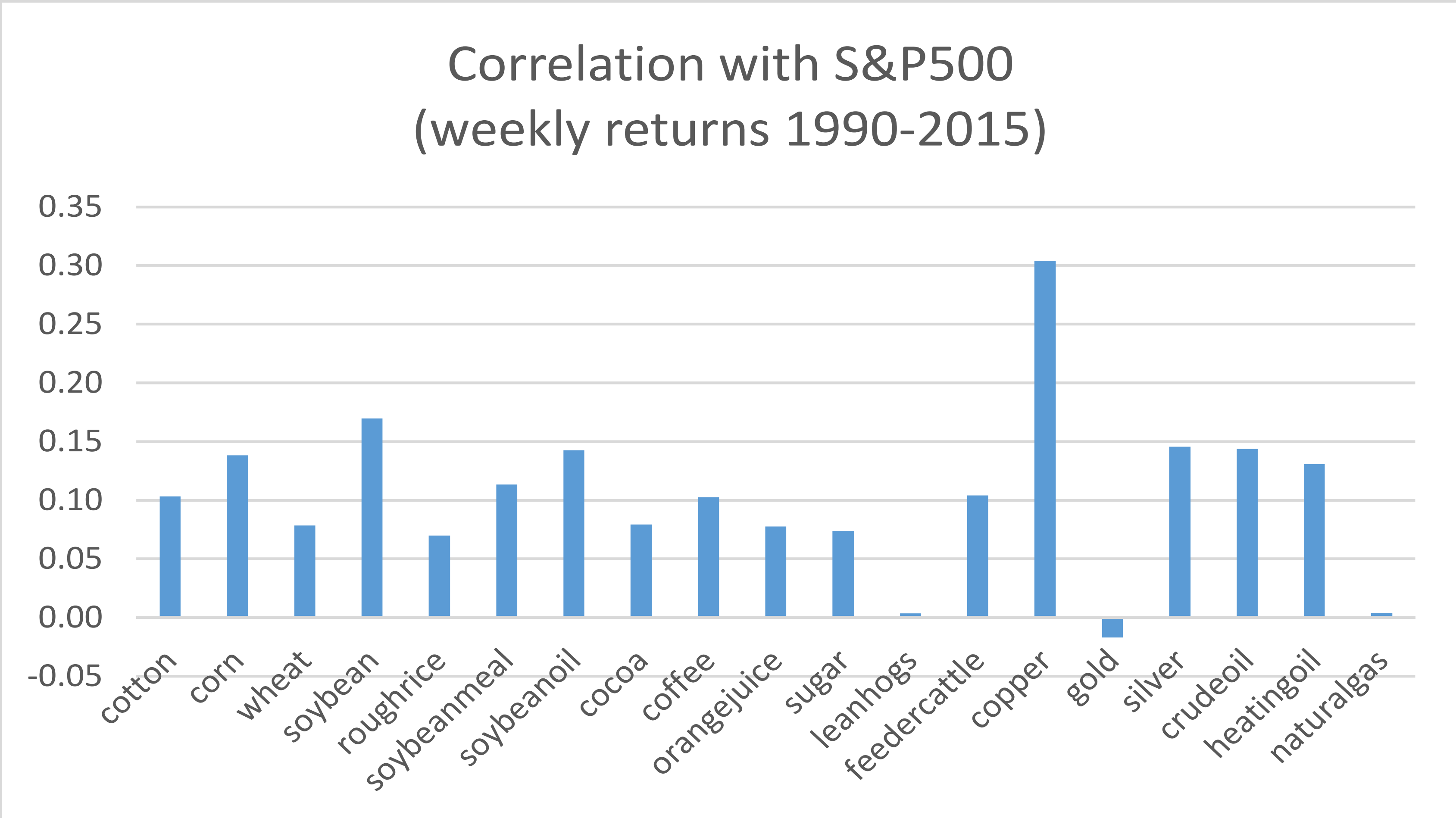

Exhibit 5. Standard deviation, min & max, skewness, excess kurtosis, and correlation for daily returns of S&P500 and commodities from second returns from second week of April 1990 to last week of December 2015. Data is split into three the periods as displayed. Continuous front futures contracts from CME are concatenated using Stevenson continuous database in Quandl. A calendar weighted method are used during roll-overs of contracts.

Return risk characteristics over time		**sp500stocks**				
Period (weekly return data)	Stdev	Min	Max	Skewness	Excess Kurtosis	Correlation stocks
1990Week16 - 1999Week52	1.99%	-6.85%	7.26%	0.01	0.79	1.00
2000Week1 - 2009Week52	2.92%	-21.82%	12.26%	-0.86	8.00	1.00
2010Week11 - 2015Week52	2.13%	-7.29%	7.52%	-0.42	1.41	1.00
Return risk characteristics over time		**corn**				
Period (weekly return data)	Stdev	Min	Max	Skewness	Excess Kurtosis	Correlation stocks
1990Week16 - 1999Week52	3.40%	-26.97%	15.51%	-1.19	11.09	0.04
2000Week1 - 2009Week52	4.36%	-17.90%	23.35%	-0.02	2.89	0.19
2010Week11 - 2015Week52	4.27%	-17.17%	12.92%	-0.34	1.98	0.14
Return risk characteristics over time		**soybean**				
Period (weekly return data)	Stdev	Min	Max	Skewness	Excess Kurtosis	Correlation stocks
1990Week16 - 1999Week52	2.89%	-11.94%	10.85%	0.11	0.89	0.00
2000Week1 - 2009Week52	3.80%	-14.26%	13.32%	-0.32	1.53	0.21
2010Week11 - 2015Week52	2.88%	-8.43%	10.08%	0.07	0.60	0.33
Return risk characteristics over time		**soybeanmeal**				
Period (weekly return data)	Stdev	Min	Max	Skewness	Excess Kurtosis	Correlation stocks
1990Week16 - 1999Week52	3.41%	-16.30%	14.94%	0.15	3.41	0.02
2000Week1 - 2009Week52	4.55%	-29.00%	15.03%	-0.82	3.98	0.14
2010Week11 - 2015Week52	4.15%	-21.31%	12.95%	-0.48	2.76	0.17
Return risk characteristics over time		**cocoa**				
Period (weekly return data)	Stdev	Min	Max	Skewness	Excess Kurtosis	Correlation stocks
1990Week16 - 1999Week52	3.98%	-9.34%	21.47%	0.90	3.16	-0.05
2000Week1 - 2009Week52	4.93%	-20.62%	13.73%	-0.43	1.00	0.12
2010Week11 - 2015Week52	3.68%	-9.84%	11.23%	0.03	0.32	0.18

Exhibit 6. Standard deviation, min & max, skewness, excess kurtosis, and correlation for daily returns of commodities from second returns from second week of April 1990 to last week of December 2015. Data is split into the periods as displayed. Continuous front futures contracts from CME are concatenated using Stevenson continuous database in Quandl. A calendar weighted method are used during roll-overs of contracts.

Return risk characteristics over time		**cotton**				
Period (weekly return data)	Stdev	Min	Max	Skewness	Excess Kurtosis	Correlation stocks
1990Week16 - 1999Week52	3.44%	-27.12%	10.85%	-1.03	8.55	0.00
2000Week1 - 2009Week52	4.35%	-12.85%	15.40%	0.15	0.56	0.13
2010Week11 - 2015Week52	4.71%	-27.51%	18.99%	-0.66	5.55	0.16
Return risk characteristics over time		**wheat**				
Period (weekly return data)	Stdev	Min	Max	Skewness	Excess Kurtosis	Correlation stocks
1990Week16 - 1999Week52	3.33%	-13.73%	16.07%	0.28	2.74	-0.02
2000Week1 - 2009Week52	4.09%	-20.23%	15.79%	-0.08	2.03	0.08
2010Week11 - 2015Week52	4.12%	-13.32%	15.07%	0.23	0.72	0.21
Return risk characteristics over time		**roughrice**				
Period (weekly return data)	Stdev	Min	Max	Skewness	Excess Kurtosis	Correlation stocks
1990Week16 - 1999Week52	3.43%	-15.43%	17.02%	0.43	3.29	0.03
2000Week1 - 2009Week52	4.37%	-19.69%	30.86%	0.34	6.37	0.06
2010Week11 - 2015Week52	3.24%	-8.98%	10.38%	0.16	0.54	0.18
Return risk characteristics over time		**soybeanoil**				
Period (weekly return data)	Stdev	Min	Max	Skewness	Excess Kurtosis	Correlation stocks
1990Week16 - 1999Week52	2.95%	-14.48%	12.44%	-0.26	3.47	0.01
2000Week1 - 2009Week52	4.11%	-26.91%	10.50%	-1.18	4.89	0.18
2010Week11 - 2015Week52	3.35%	-15.30%	9.21%	-0.69	2.24	0.23
Return risk characteristics over time		**coffee**				
Period (weekly return data)	Stdev	Min	Max	Skewness	Excess Kurtosis	Correlation stocks
1990Week16 - 1999Week52	6.25%	-19.25%	42.91%	0.89	5.70	0.00
2000Week1 - 2009Week52	4.57%	-14.61%	16.76%	-0.03	0.35	0.19
2010Week11 - 2015Week52	4.46%	-14.55%	18.63%	0.29	1.12	0.13

Exhibit 7. Standard deviation, min & max, skewness, excess kurtosis, and correlation for daily returns of commodities from second returns from second week of April 1990 to last week of December 2015. Data is split into the periods as displayed. Continuous front futures contracts from CME are concatenated using Stevenson continuous database in Quandl. A calendar weighted method are used during roll-overs of contracts.

Return risk characteristics over time	orangejuice					
Period (weekly return data)	Stdev	Min	Max	Skewness	Excess Kurtosis	Correlation stocks
1990Week16 - 1999Week52	4.86%	-19.59%	26.25%	0.62	4.41	0.09
2000Week1 - 2009Week52	4.52%	-14.58%	23.59%	0.49	2.53	0.05
2010Week11 - 2015Week52	5.08%	-19.47%	15.33%	-0.21	1.35	0.12
Return risk characteristics over time	**leanhogs**					
Period (weekly return data)	Stdev	Min	Max	Skewness	Excess Kurtosis	Correlation stocks
1990Week16 - 1999Week52	4.53%	-19.76%	25.96%	0.74	5.71	0.00
2000Week1 - 2009Week52	4.88%	-25.06%	20.01%	-0.24	2.82	-0.01
2010Week11 - 2015Week52	4.28%	-22.69%	16.29%	-0.77	5.01	0.05
Return risk characteristics over time	**copper**					
Period (weekly return data)	Stdev	Min	Max	Skewness	Excess Kurtosis	Correlation stocks
1990Week16 - 1999Week52	3.26%	-13.21%	9.37%	-0.39	0.95	0.03
2000Week1 - 2009Week52	4.18%	-25.64%	17.34%	-0.93	5.62	0.38
2010Week11 - 2015Week52	3.32%	-18.02%	13.96%	-0.20	3.52	0.51
Return risk characteristics over time	**silver**					
Period (weekly return data)	Stdev	Min	Max	Skewness	Excess Kurtosis	Correlation stocks
1990Week16 - 1999Week52	3.48%	-16.66%	14.29%	-0.03	2.68	0.04
2000Week1 - 2009Week52	4.36%	-17.92%	14.62%	-0.82	2.51	0.13
2010Week11 - 2015Week52	4.84%	-31.99%	13.35%	-1.59	10.85	0.32
Return risk characteristics over time	**heatingoil**					
Period (weekly return data)	Stdev	Min	Max	Skewness	Excess Kurtosis	Correlation stocks
1990Week16 - 1999Week52	4.70%	-22.91%	16.06%	-0.37	2.20	-0.03
2000Week1 - 2009Week52	5.62%	-21.91%	23.65%	-0.24	1.45	0.12
2010Week11 - 2015Week52	3.68%	-15.85%	11.73%	-0.44	1.75	0.48

Exhibit 8. Standard deviation, min & max, skewness, excess kurtosis, and correlation for daily returns of commodities from second returns from second week of April 1990 to last week of December 2015. Data is split into the periods as displayed. Continuous front futures contracts from CME are concatenated using Stevenson continuous database in Quandl. A calendar weighted method are used during roll-overs of contracts.

Return risk characteristics over time	**sugar**					
Period (weekly return data)	Stdev	Min	Max	Skewness	Excess Kurtosis	Correlation stocks
1990Week16 - 1999Week52	4.35%	-17.05%	14.37%	-0.37	1.34	-0.01
2000Week1 - 2009Week52	4.87%	-17.34%	15.86%	-0.08	0.69	0.11
2010Week11 - 2015Week52	4.61%	-19.21%	16.17%	0.05	1.36	0.13
Return risk characteristics over time	**feedercattle**					
Period (weekly return data)	Stdev	Min	Max	Skewness	Excess Kurtosis	Correlation stocks
1990Week16 - 1999Week52	2.25%	-9.17%	7.52%	-0.28	1.09	0.06
2000Week1 - 2009Week52	2.55%	-17.81%	8.02%	-0.77	4.85	0.13
2010Week11 - 2015Week52	2.26%	-8.28%	6.61%	-0.09	0.97	0.10
Return risk characteristics over time	**gold**					
Period (weekly return data)	Stdev	Min	Max	Skewness	Excess Kurtosis	Correlation stocks
1990Week16 - 1999Week52	1.74%	-7.79%	12.54%	0.40	7.50	-0.09
2000Week1 - 2009Week52	2.69%	-8.74%	12.35%	-0.21	1.59	-0.03
2010Week11 - 2015Week52	2.41%	-10.14%	6.63%	-0.39	1.08	0.12
Return risk characteristics over time	**crudeoil**					
Period (weekly return data)	Stdev	Min	Max	Skewness	Excess Kurtosis	Correlation stocks
1990Week16 - 1999Week52	4.87%	-35.44%	20.05%	-0.90	7.07	-0.03
2000Week1 - 2009Week52	5.57%	-28.80%	24.12%	-0.60	3.40	0.14
2010Week11 - 2015Week52	4.06%	-15.90%	11.47%	-0.56	1.73	0.47
Return risk characteristics over time	**naturalgas**					
Period (weekly return data)	Stdev	Min	Max	Skewness	Excess Kurtosis	Correlation stocks
1990Week16 - 1999Week52	6.78%	-26.80%	29.59%	-0.12	1.49	0.00
2000Week1 - 2009Week52	8.16%	-26.73%	41.38%	0.50	2.23	-0.03
2010Week11 - 2015Week52	6.28%	-19.94%	27.93%	0.21	1.86	0.11

Exhibit 9. The left panel shows the beta coefficient and its corresponding t-value from a single regression of commodity returns against the S&P500 returns. The whole dataset is used for estimation. The right panel shows how this static beta are decomposed into static correlation and relative volatility for each commodity. Continuous front futures contracts from CME are concatenated using Stevenson continuous database in Quandl. A calendar weighted method are used during roll-overs of contracts.

1990-2015	Beta	T Beta
cotton	0.18	3.68
corn	0.23	4.94
wheat	0.12	2.79
soybean	0.23	6.11
roughrice	0.11	2.48
soybeanmeal	0.19	4.05
soybeanoil	0.21	5.10
cocoa	0.14	2.81
coffee	0.22	3.65
orangejuice	0.15	2.77
sugar	0.14	2.63
leanhogs	0.01	0.13
feedercattle	0.10	3.71
copper	0.46	11.32
gold	-0.02	-0.60
silver	0.25	5.23
crudeoil	0.30	5.15
heatingoil	0.26	4.68
naturalgas	0.01	0.14

Commodity	Static Correlation	Static Relative Volatility	Static Beta
cotton	0.10	1.70	0.18
corn	0.14	1.65	0.23
wheat	0.08	1.58	0.12
soybean	0.17	1.35	0.23
roughrice	0.07	1.56	0.11
soybeanmeal	0.11	1.67	0.19
soybeanoil	0.14	1.46	0.21
cocoa	0.08	1.78	0.14
coffee	0.10	2.16	0.22
orangejuice	0.08	1.97	0.15
sugar	0.07	1.91	0.14
leanhogs	0.00	1.90	0.01
feedercattle	0.10	0.98	0.10
copper	0.30	1.51	0.46
gold	-0.02	0.95	-0.02
silver	0.15	1.72	0.25
crudeoil	0.14	2.06	0.30
heatingoil	0.13	2.01	0.26
naturalgas	0.00	2.99	0.01

Exhibit 10. Each panel show the static correlation, beta, and relative volatility (straight line) for each commodity together with exponential weighted estimations (using a lambda of 0.94) of these measures for a given commodity. The whole dataset is used for estimation. Continuous front futures contracts from CME are concatenated using Stevenson continuous database in Quandl. A calendar weighted method are used during roll-overs of contracts.

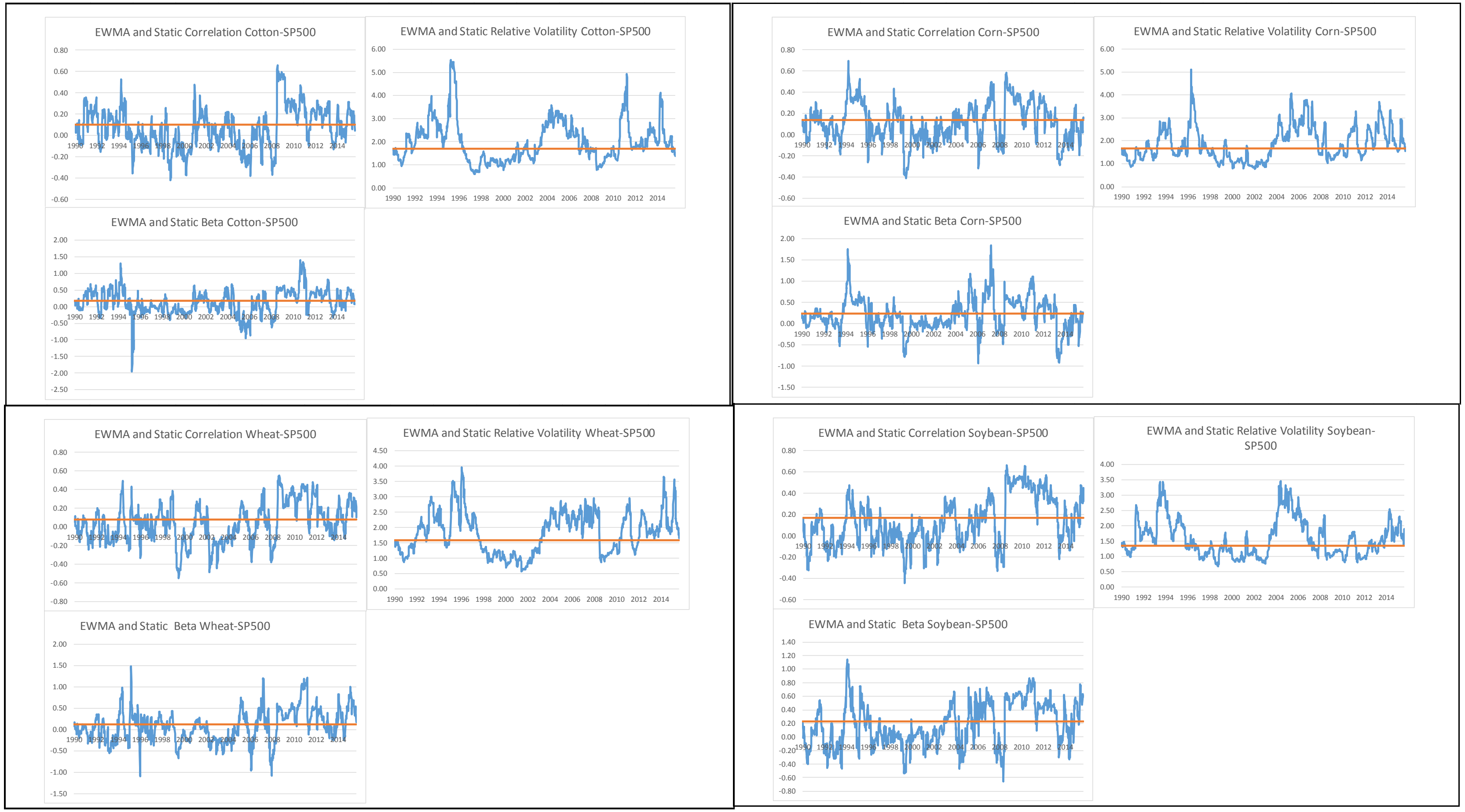

Exhibit 11. Each panel show the static correlation, beta, and relative volatility (straight line) for each commodity together with exponential weighted estimations (using a lambda of 0.94) of these measures for a given commodity. The whole dataset is used for estimation. Continuous front futures contracts from CME are concatenated using Stevenson continuous database in Quandl. A calendar weighted method are used during roll-overs of contracts.

Exhibit 12. Each panel show the static correlation, beta, and relative volatility (straight line) for each commodity together with exponential weighted estimations (using a lambda of 0.94) of these measures for a given commodity. The whole dataset is used for estimation. Continuous front futures contracts from CME are concatenated using Stevenson continuous database in Quandl. A calendar weighted method are used during roll-overs of contracts.

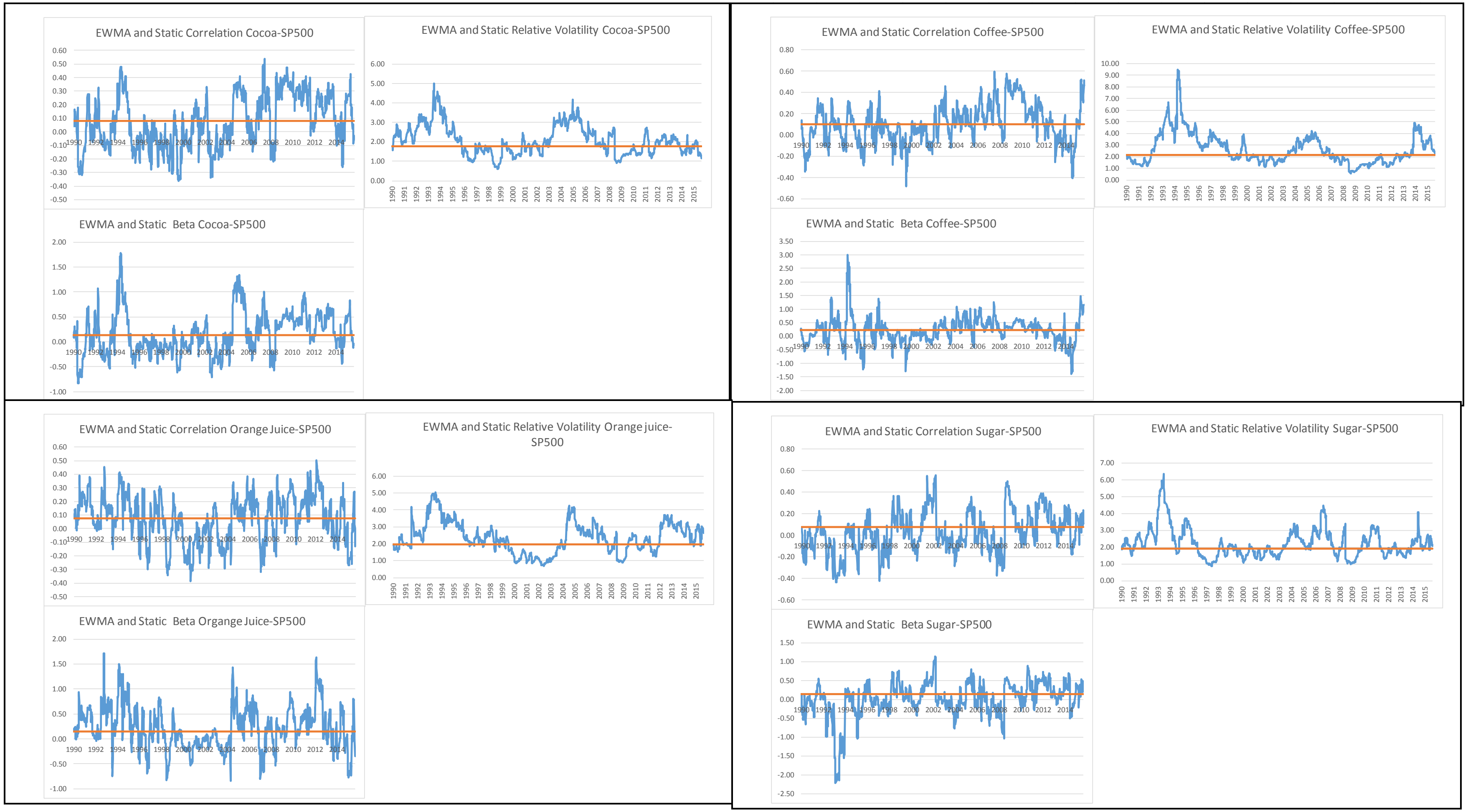

Exhibit 13. Each panel show the static correlation, beta, and relative volatility (straight line) for each commodity together with exponential weighted estimations (using a lambda of 0.94) of these measures for a given commodity. The whole dataset is used for estimation. Continuous front futures contracts from CME are concatenated using Stevenson continuous database in Quandl. A calendar weighted method are used during roll-overs of contracts.

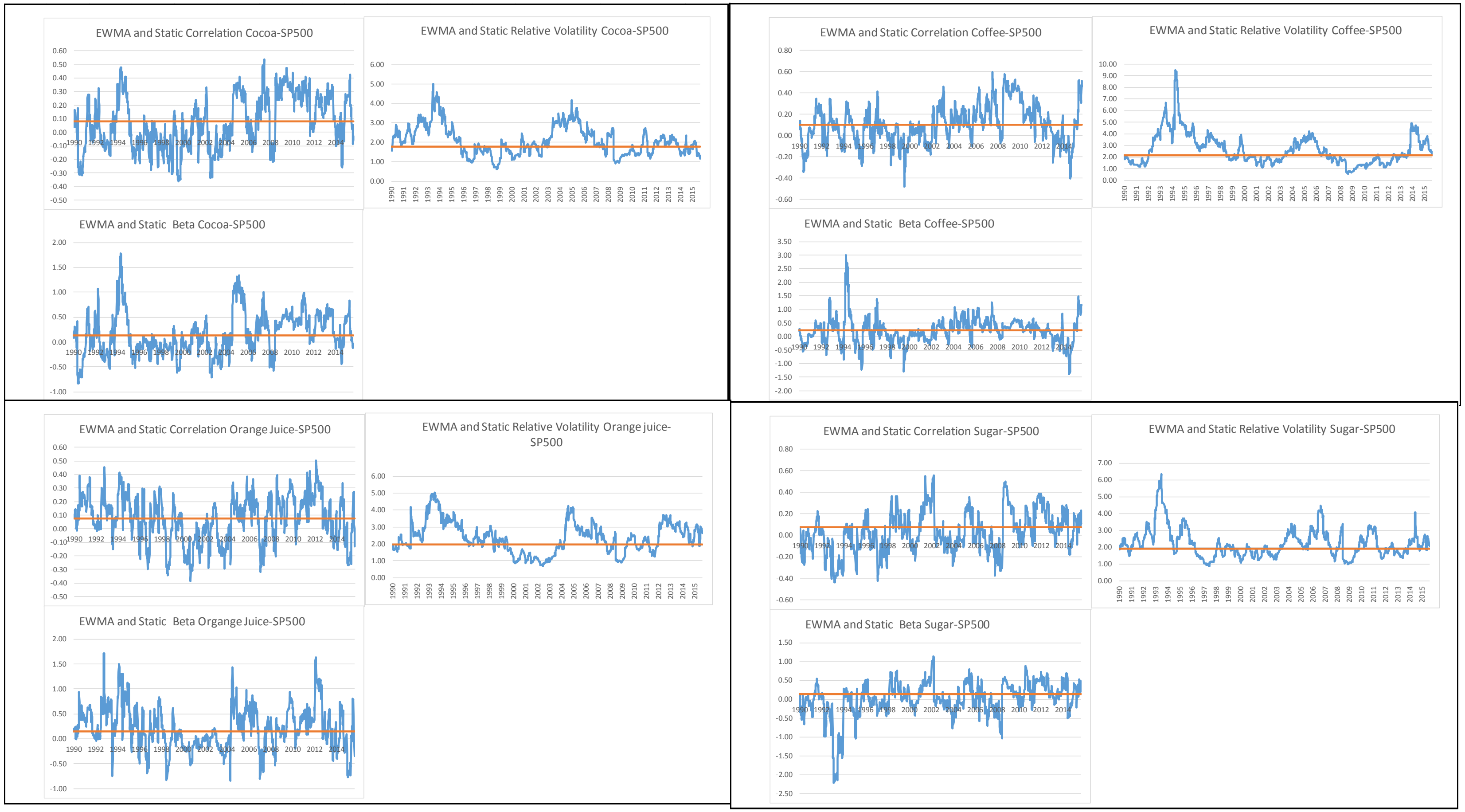

Exhibit 14. Each panel show the static correlation, beta, and relative volatility (straight line) for each commodity together with exponential weighted estimations (using a lambda of 0.94) of these measures for a given commodity. The whole dataset is used for estimation. Continuous front futures contracts from CME are concatenated using Stevenson continuous database in Quandl. A calendar weighted method are used during roll-overs of contracts.

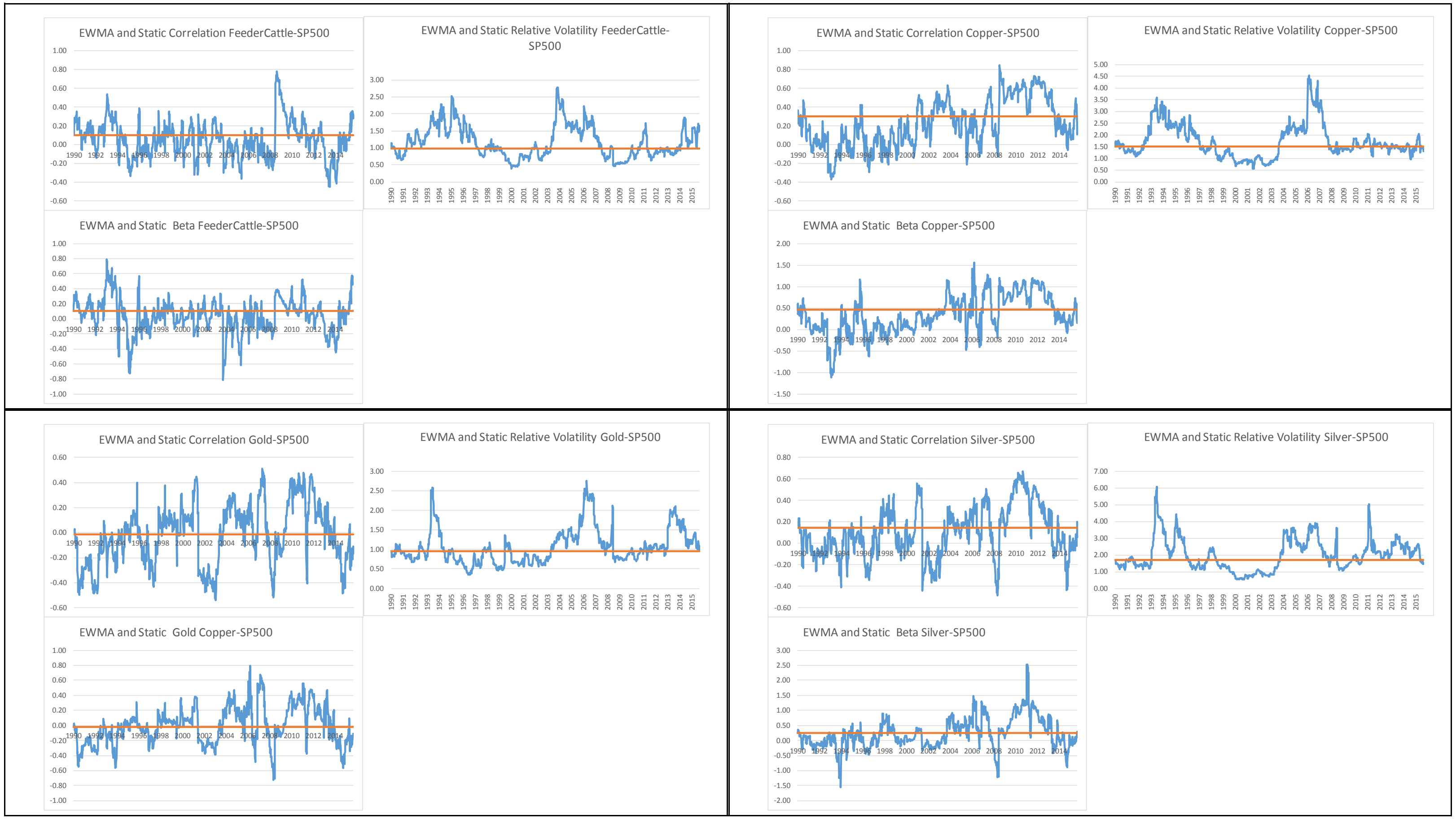

Exhibit 15. Each panel show the static correlation, beta, and relative volatility (straight line) for each commodity together with exponential weighted estimations (using a lambda of 0.94) of these measures for a given commodity. The whole dataset is used for estimation. Continuous front futures contracts from CME are concatenated using Stevenson continuous database in Quandl. A calendar weighted method are used during roll-overs of contracts.