Two Centuries of Commodity Futures Premia

(Momentum, Value and Basis)

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Abstract

Using hand-collected data of commodity futures contracts going back to 1877, we replicate in the pre-sample history the well-documented cross-sectional commodity factor premia of momentum, value and basis. All three premia remain significantly positive in the additional 80-plus years of pre-sample data. Compared to a long-only passive basket of commodity futures, a long-only premia portfolio more than doubles its Sharpe in both the early and recent samples, suggesting a more optimal way to obtain portfolio's commodity exposure while maintaining its beneficial inflation hedging property.

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In this paper, we use a novel hand-collected dataset of commodity futures prices back to 1877. Using the novel data, we attempt to answer the question of whether the documented commodity factor premia persist in the previously untested data. This is an increasingly important question as the validity of many discovered factor premia are being critiqued by academics as potential products of data-mining (for example Harvey, Liu, Zhu 2015). As a response, there has been a recent emergence of long-run studies of various cross-sectional factors, for example by Geczy and Samonov review of momentum (2016, 2017). The pre-sample period provides an important opportunity to review these effects for robustness and learn about their more complete distributions.

Using the new data, we test cross-sectional momentum, value (defined as mean reversion), and basis (defined as convenience yield) factor premia observed in the commodity futures and widely discussed in academic work such as Fama (1987), Erb and Harvey (2006), Miffre and Rallis (2007), Gorton, Hayashi and Rouwenhorst (2007), Asness, Moskowitz, Pedersen (2013), and Szymanowska, De Roon, Nijman and Goorbergh (2014), among many others. We create a robust pre-sample validation of the positive association between these characteristics and future returns, adding more than 80 years of evidence to the currently available 50-plus year-long histories.

We find that all three factor premia have positive pre-sample long-short spreads, which argues strongly against the data-mining concerns. We do observe a material deterioration of the size of these premia in the pre-sample, but also observe a lower average commodity future excess returns in general. For example, a portfolio that invests equally in all three long-short premia strategies averages 7.9% per year return in excess of the risk-free rate in the pre-sample period (1870-1959) compared to 14.2% in the recent sample (1959-2017). By comparison, average commodity futures in aggregate have generated an excess return of 3.0% in the pre-1959 vs. 6.8% in the post-1959 period.

In the long-only formulation, the top third of the combined momentum, value, and basis commodity futures basket generates a Sharpe Ratio that is three times that of the equally-weighted average commodity futures return in the pre-sample, and two times of the average in the recent sample, pointing to significant improvement derived from factor tilting commodity exposure. At the same time, the long-only premia-tilted portfolio continues to have a strong positive inflation exposure – which is the desired feature of traditional commodity allocations, diversifying stock-bond portfolios (Erb and Harvey 2006, Blitz and de Groot 2013, Arnott, Chaves, Gunzberg, Hsu, Tsui, 2014). Since passive commodity futures investing at its core still requires continuous rolling of the individual contracts to the same degree required in forming the long-only premia portfolios, it appears more optimal to obtain portfolio's commodity exposure via the long-only premia strategy rather than the typical 'passive' index-type commodity investing.

In addition, the pre-sample reveals several important deviations from recent history. First, the relative size of the long-short spreads of the three factors appears in reverse, with value leading the way, followed by momentum and basis taking the third place. The opposite holds in the post-1959 sample, where basis has the highest spread, followed by momentum and value. Also, consistent with Geczy and Samonov (2016 and 2017), we document new episodes of factor crashes to the magnitudes previously unobserved in recent histories. For example, the basis factor reaches the minimum drawdown of -83% in the early sample, compared to -39% in the recent history. Though the increase in risk can be partially attributed to the decreased sample size in the pre-sample, it is still critical to account for the large potential premia crashes to avoid misestimation of the left-tail risks. These critical deviations from recent history in both returns and risks are an important outcome of long-run studies and point to the danger of over reliance on short data in forming expectations about return and risk properties of factor premia.

The paper proceeds as follows: In Section I we review the case for and the literature behind the growing field of long-run back-testing; in Section II we describe our data collection process and properties; in Section III we present the main results and key properties of momentum, value and basis premia in the pre-sample and full history; Section IV reviews the benefits of replacing long-only commodity exposure with a long-only commodity premia allocation within the context of a traditional stock-bond-commodity portfolio; Section V concludes.

I. The Rise of Long-Run Backtesting

While there exists a well-established (at least a century-old) academic interest in studying the long-run properties of asset class returns like the U.S. Equity and Fixed Income Markets[2], only during the past decade, has there emerged a branch of literature studying the long-run properties of the more dynamic effects like the price momentum, trend and other anomalies (for example Hurst, Ooi, Pedersen (2014) and Geczy and Samonov (2016, 2017)). When we started our work on the "Two Centuries of Price Momentum" paper in late 2007, there were no papers at that time that tried to look behind the traditional back-test starting dates, and since then, we could not have imagined a more positive response and growth of interest in the field of long-run historical research. The insights that come from deep history are informative and critical to consider for both academic and practical reasons.

Perhaps due to the recent over-saturation of new factors, lack of formal models backing most of them, recent unexpected factor outcomes like momentum crashes that were not observed in typically reviewed history, and the resulting skepticism about factor out-of-sample significance, there is a growing interest in extending and studying known factors to the previously untested data, specifically to the pre-sample periods. In addition to providing out-of-sample support or rejection for a given factor hypothesis, the longer timeframes can uncover unique episodes of factor performance, demonstrating outcomes previously unseen in more recent histories. For example, in addition to confirming the long-run significance of price momentum effect in the U.S. stock level data back to 1800, Geczy and Samonov (2016) uncover many previously unseen episodes of momentum crashes and extended drawdowns, helping create a more complete understanding of the distribution of the momentum factor returns in U.S equities.

At first, long-run factor extension literature has focused on the easier to gather, price-only data and the derived effects such as momentum and trend. For example, ABN-Amro (2008) study price momentum in the top 100 UK stocks from 1900 to 2007. Chabot, Ghysels and

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[2] For example: Mitchell (1910), Cowles (1939), Goetzmann, Ibbotson and Peng (2001), Sylla, Wilson and Wright (2006)

Jagannathan (2009) study Victorian England stock price momentum from 1866-1907. Szakmary and Zhou (2015) document industry momentum in the Cowles data from 1900. Goetzmann and Huang (2018) capture price momentum in Imperial Russia stocks from 1865-1914. Geczy and Samonov (2016) extend U.S. stock and sector price momentum back to 1800. Lempérière, Deremble, Seager, Potters and Bouchaud (2014) extend trend back to 1800, and Greyserman and Kaminski (2014) extend trend to 1223. Geczy and Samonov (2017) document multi-asset price momentum in the country equity markets, country government bonds and currency markets, as well as country sectors back to 1800. All above-mentioned studies have observed statistically significant returns to the strategies in the pre-sample while at the same time, to varying degrees, documenting some important deviations from recent histories such as increased frequencies of drawdowns and lower spread returns.

Beyond price-based characteristics, Wahal (2018) looks at profitability factors in the pre-1963 data, and Linnainmaa and Roberts (2016), extend a vast set of U.S. firm level accounting anomalies back to 1918 using the data collected from the Moody's Manuals. Wahal (2016) finds pre-sample support of the profitability factor but not the investment factor. Linnainmaa and Roberts (2016) make a bold claim that both profitability and investment factors are products of data-mining. Baltussen, Swinkels, and van Vliet (2019) extend value, momentum, trend and seasonality factors across asset classes back to 1800.

Levine, Ooi and Richardson (2016) are the first to extend commodity futures data beyond 1959. Using CBOT annual reports, the authors gather data for 10 commodities and use the collected data to study the long-run time-series properties of commodity futures as an asset class, largely confirming in the pre-sample portfolio diversification benefits of commodity allocations, originally observed in Gorton and Rouwenhorst (2006) and Erb and Harvey (2006). Recently, Zaremba, Bianchi, and Mikutowski (2019) study commodity spot price reversals back to 1265, extending results documented by Geczy and Samonov (2017) and Chaves and Viswanathan (2016). Finally, Baltussen, Swinkels, and van Vliet (2019) study commodity premia on 5 commodities back to 1800 using unrolled futures data from GFD – yet unrolled futures returns can be substantially different from the rolled returns, making results more representative of commodity spot results rather than futures per se. For example, their reported commodities momentum factor return is negative, which is a notable feature of commodity spot prices and not the futures (Geczy, Samonov 2017 and Zaremba, Bianchi, and Mikutowski 2019).

In sum, what at first seemed like a small off-shoot exploration of a few anomalies in the deep financial history, has now turned into a small but growing movement on many fronts, jointly facing the important quest of documenting more complete distributions of factor returns and addressing the necessary question of whether the recently overserved premia results of data-mining.

II. Data and Return Formation

This paper is based on the manually collected monthly commodity futures data from Chicago Board of Trade (CBOT) annual reports (1877-1962) and Wall Street Journal Newspaper (1889 – 1964) for Chicago exchange traded commodities.

From the data perspective, our study builds upon and expands Levine, Ooi and Richardson (2016), but we collect data for more commodities and for longer timeframes. Specifically, we cover 15 Chicago commodities instead of the 10 in Levine *et al.* (2016). Also, in addition to CBOT, we collect data from Wall Street Journal (WSJ) month end newspapers for the same 15 commodities, significantly enhancing the quality and coverage of our data. In addition, using WSJ, we manually collect data up to December 1964, instead of 1959 in Levine *et al.* (2016) This enhances data continuity and availability in the early 1960's, where the data from traditional sources is space.

CBOT annual reports start on January 1877 and contain daily prices for Chicago trades commodity futures contracts for all available expirations. We collect only the month-end data for all available commodities and contracts. In total, there are 15 commodities covered in the reports. The earliest data appears for Corn, Oats, Lard, Mess Pork, and Wheat – enough to create a 2 by 2 cross-sectional portfolio spread. By August 1886, Barley, Rye and Short Rib data have begun, bringing the total number of commodities with data to seven. When the month-end price contains the high and the low value instead of the closing price, we take an average for that day. In addition, if the month-end price is missing but earlier in the month the contract had a price, we use the lagged price.

WSJ Commodity Produce section lists commodity futures prices beginning on July 1889. The newspaper contains price data for several contract expirations per commodity. We use the newspaper with the closest date to month-end as possible. If the exact month-end paper does not exist, we start looking back one day at a time until we find data. For feasibility, we focus only on the Chicago traded commodities while WSJ has data for many other non-Chicago commodities, creating a potential area of future research.

We create continuously-rolled near-term and next-available contracts by rolling individual contracts at the month end, before the month of the contract expiration. The near-term contract always invests in the nearest available contract with available return data and the next available invests in the next contract, similar to Levine *et al.* (2016). Data availability is highest for the near-term contract, but remains sufficiently robust for the creation of the second contract. In addition, we create continuously-unrolled (spliced), price-series for the near-term and next-available contracts used in the basis ratio construction. The near-term unrolled contract is traditionally referred to as the spot price in academic literature, while in reality it is a futures-based proxy for the actual spot price.

In total, we have 7158 front-month-contract return data points from CBOT and 4903 from WSJ (shown in table I). To merge the two datasets, we first use CBOT data, and if it is missing, we look to fill it from WSJ. We apply this process to both the rolled near-term and next-available contract returns as well as unrolled levels. Comparing monthly returns between the same commodities from CBOT and WSJ, we observe very large correlations across the two datasets, averaging 87%, giving us confidence that we are merging data for the highly similar commodity contracts with varying data availability across sources. During the overlapping pre-sample period from July 1889 to July 1959, the combined merged dataset has 6117 return observations, compared to 5932 from CBOT alone, generating about a 3% increase in sample size (Table I). Importantly, the increase in the second nearest futures data is 5%, improving our accuracy in calculating the basis effect. See Appendix 1 for the complete list of commodity futures in our sample.

For the post-1959 period, we use a combination of Bloomberg and DataStream data sources to obtain data for 44 commodity futures. We use Bloomberg data first, and then supplement it with DataStream data in the same way that we merged CBOT and WSJ data. We also document data coverage improvement as a result of this merging, as there are some contracts with earlier start dates in DataStream vs. Bloomberg. To preserve consistency of methodologies, between pre-sample and recent data, we convert all Bloomberg / DataStream data to the same raw format as the merged pre-sample data, and apply the same contract rolling process to generate the continuously rolled returns and spliced prices for the near term and next available contracts.

As our CBOT data collection ends on December 1962, and WSJ on December 1964, we have a few years of data overlap with Bloomberg / DataStream set. We document a measurable increase in data coverage when the pre-sample sources are combined with Bloomberg / DataStream during the overlapping years between 1959 and 1964. Specifically, we bring the total number of return data points from 526 in Bloomberg / DataStream alone to 748 in the merged dataset, a 42% increase. There remains a considerable opportunity for future research to supplement the Bloomberg / DataStream data from the WSJ publication in the post-1964 period.

Our final dataset contains 25,595 front contract month-return observations, with about 15.2 commodities on average in the universe over the full sample, and 7.1 in the pre-sample. On October 1877, we have only 3 commodity futures with data, and during the other 6 months we have only 4 commodity futures return data. During these 9 months in the sample, the long-short portfolios are effectively holding 1 commodity long and 1 commodity short. The rest of the sample has 5 or greater number of commodities allowing us to have at least 2 commodities in the Long and Short parts of the spread.

All the commodity futures portfolio returns naturally come out in excess of the risk-free rate. In reporting the stand alone results in section III, we leave out the risk-free rate from all the results, reporting in excess return form. In section IV, where we study results in total portfolio asset allocation context, we add back the risk-free rate to the commodity portfolios to make them comparable to other asset classes.

III. Commodity Futures Factor Premia over the Long-Run

While there exists a long history of commodity focused academic work (for example, Fama and French (1987), Bessenbinder (1992), Bailey and Chan (1993)), as well as a long history of commodity trading in the form of Commodity Trading Advisors, it were the in the 2000's that interest in passive allocations has grown: Greer (2000), Erb and Harvey (2006), and Gorton, Hayashi and Rouwenhorst (2006) permanently expanded the awareness of the general investment professionals of the power of commodities and their premia in the portfolio asset allocation context. Since then, several other influential studies have focused on commodity factors including Miffre and Rallis (2007), Asness, Moskowitz, Pedersen (2013) and Szymanowska, De Roon, Nijman and Goorbergh (2014), Fernandez-Perez, Fuertes and Miffre (2017). Our study focuses of the three of the most known premia, specifically extending momentum, value and basis factors back to 1877.

Our factor portfolios are built monthly throughout the sample and we assign each commodity with an equal weight to one of three groups per factor: High, Medium and Low. To estimate factor returns, we focus on the high minus low spread for each factor and its average across time. We define momentum as the 12-month *(t-12 to t)* return of the rolled near-term contract. We define value as mean reversion, the negative 48-month spot return *(t-60 to t-12).* Finally, we define basis as the rolling 12-month average of the ratio between the near-term and next-available contact prices (So/S1). Our momentum and value definitions follow exactly Levine *et. al* (2016). While our definition of basis is adjusted to take the 12-month rolling average basis instead of the its last value. This alternative definition generates better data coverage in the pre-sample and recent history, perhaps because it tends to smooth out any shorter-term noise and fill in the missing datapoints. We test all three definitions for robustness with alternative definitions and find similar results. In addition, we create combo long-short and combo long-only portfolios that invest equally in the individual premia long-short or long-only portfolios.

Results are summarized in Table II. During the entire sample, momentum long-short portfolio on average generates 1.1% of excess return per month, with 0.9% in the pre-sample and 1.2% after 1959. Value generates 0.9% per month over the entire sample, with 1.0% and 0.9% before and after 1959. Basis takes the third place in the pre-sample with 0.7% return on average, compared to 1.3% in the recent history, and 0.9% per month during the entire period. The combo long-short portfolio delivers a striking 140-year average excess return of 1.0% per month (12.3% per year) with a standard deviation of 3.6% per month (returning 0.8% per month before 1959 and 1.1% after). In the units of Sharpe Ratio the combo's long-short performance deteriorates from 0.36 per month in recent history to 0.22 in the pre-sample. The long-only combo portfolio generates 0.9% per month (10.8% per year) over the full history with a 0.16 monthly Sharpe Ratio compared to equally-weighted commodity universe 0.07 Sharpe ratio and 0.4% monthly return. Unlike the deterioration of the absolute factor returns from recent to early history, on a relative basis, the long-only premia combo portfolio maintains its more than twice Sharpe ratio of the long-only commodity universe in both the pre- and post-1959 history. Our results confirm Blitz and de Groot (2013) and Arnott, Chaves, Gunzberg, Hsu, Tsui (2014), making a strong case for a long-only commodity premia portfolio rather than the typical passive commodity exposure.

In summary, on the one hand, these results strongly suggest that all three of these premia are real effects since they persist in the data that was previously not touched by academic backtests, and hence cannot be a result of data-mining. On the other hand, two out of three premia (momentum and basis), as well as the average commodity futures returns are much lower in the early sample, pointing to a potential over-estimation of the expected size of these premia. Basis experiences the largest deterioration perhaps because of the limiting number of commodities in the early sample, which given the highly idiosyncratic nature of commodities is likely to be a major feature of early data (Daskalaki, Kostakis, Skiadopoulos (2014)).

Looking at the results in Table III, we see generally positive decade-long returns to all three premia, with noticeable degradation of the basis effect in the 1880's and 1910's. Almost surprisingly, all other decades remain positive for all premia and the combo long-short portfolio. The combo long-only portfolio outperforms the universe in 13 out of 14 decades, and it underperforms by only 2% during the earliest decade during the 1880's.

In contrast to decades-long view, the shorter-term drawdowns, shown in Table III, unveil a much more dramatic history than seen in the post-1959 time-frame. For example, all three premia experience drawdowns in the -60 -80% range in the new full history with a combo's maximum drawdown of -41% compared to -11% in the recent history. The universe has a max drawdown of -91% during the late 19th century. In part, this increase in drawdowns is expected because of the lower number of commodities in the long and short parts of the portfolio as well as in the overall universe, resulting in decreased diversification of portfolio's idiosyncratic risk. On other hand, the drawdowns of such magnitude surely point to the practical infeasibility of these strategies in their raw forms, at least in mass application, as well as application of additional leverage, pointing to the limits of arbitrage argument (Acharya, Lochstoer, Ramadorai (2013)).

Correlations, shown in Table IV, between the three premia remain fairly stable between samples, with the highest between basis and momentum (0.27 in the pre-sample and 0.24 in recent history), and lowest between basis and value (-0.18 in the pre-sample and 0.01 in recent history), consistent with literature. We also run monthly time-series regressions of the long-short spreads on the other premia, commodity universe, and two macro-economic factors (NBER expansion Booleans[3] and monthly CPI-changes from Shiller's website[4]), shown in Table V. Over the full sample and pre-sample histories, intercepts of all three premia remain statistically significant. As expected from correlations, momentum has a significant loading on basis, value has a significance negative loading on basis and the universe, and basis has a positive loading on momentum and negative on value. None of the premia load on NBER or CPI changes. The combo long-short portfolio has a slightly negative loading on the universe, and slightly positive

[3] https://www.nber.org/cycles.html
[4] http://www.econ.yale.edu/~shiller/

loading on inflation, with a very significant residual of 0.96 bps per month with a t-statistic of 9.6.

As expected, the commodity universe loads positively on NBER Expansion and CPI changes, consistent with literature (Gorton and Rouwenhorst 2006), and does not have a statistically positive intercept. This points to and supports the observation that commodity exposure in a portfolio consists of exposures to growth and inflation factors without any additional benefits. However, the long-only combo portfolio, not only has the statistically significant growth and inflation loadings, but also all three factor premia loadings, making it a much more attractive candidate in a portfolio setting.

It is important to mention that none of the analysis involves looking at trading costs. Such costs could have been significant enough to eat away a large portion of the profits from these premia. However, the comparison to a long-only passive commodity universe is also done on pre-cost basis, and because the commodity universe still needs to be continuously rebalanced as every futures contract is rolled, the relative benefits of long-only premia portfolios remain meaningful and insightful.

IV. Portfolio Context

Environmental benefits of adding commodity exposure to portfolios consisting of stocks and bonds have been widely discussed (for example, Bodie and Rosansky (1980), Bekaert, Wang and Tille (2010), Gorton and Rouwenhorst (2006, 2015)). In addition, prior literature has explored the asset allocation benefits of introducing factors in general (Ang, Goetzmann, Schaefer (2009), Ilmanen, Kizer (2012), Briand, Nielsen, Stefek (2009)) and commodity futures factors in particular (Blitz and de Groot (2013), Rallis, Miffre and Fuertes (2013)). We build on that literature by comparing stock / bond portfolios with a passive commodity allocation vs. a long-only commodity premia combo portfolio over the long-run. Table VI shows several optimal (highest Sharpe ratio) portfolio allocations to stocks, bonds, commodities, and commodity long-only premia portfolio over sub-periods and overall. The stock, bond and T-bill return data are from Global Financial Data for S&P500 extended index, constant maturity U.S. 10-Year Government bond return, and the U.S. 90 day T-bill. We solve for the optimal weights both on full history as well as pre-sample history only. This is not an attempt to create an out-of-sample rolling implementable strategy, but rather to explore the point of long-only premia commodity portfolio being a more effective way to obtain both the traditional commodity exposures as well as the extra return and diversification from the premia. Because all the commodity futures returns are in excess of the risk-free rate, we add back the monthly T-Bill return to commodity portfolio returns in order to create total return histories comparable to stocks and bonds.

In Table VI, we show that when using stock and bond assets only, the optimal stock weight varies between 35% and 39%, depending on which part of history is used. The optimal stock-bond portfolio realized Sharpe ratio averages 0.13 per month over the entire sample. Adding average commodity universe returns to the optimization, results in a 16% allocation over the full-time frame with 32% allocated to stocks and 52% to bonds. In the pre-1959 history, however, commodities get a much lower, 2% allocation consistent with Levine *et al* (2016). The three-asset-class portfolio has Sharpe ratios ranging from 0.13 in the pre-sample to 0.15 over the full sample, and 0.18 in the recent sample. When the long-only combo premia portfolio is used instead of passive commodities, the pre-sample commodity allocation grows to 16% from 2%, and over the full-history it grows to 30% from 16%. The realized Sharpe ratios are significantly enhanced as well with the introduction of the long-only combo premia allocation, reaching up to 0.29 in recent history. In the pre-sample optimization, the Sharpe ratio of portfolios with long-only combo premia commodities averages 0.16 compared to 0.13 for the stock-bond case alone. These are significant improvements in both pre and recent samples to traditional stock-bond asset allocation.

Finally, in Table VII, we summarize optimal portfolio returns across different states of the stock, bond and commodity markets as well as NBER expansion / recession Boolean and monthly changes in the CPI index. The addition of commodity premia to portfolio mix noticeably improves the stock down state returns. For example, the months with down U.S. equity return average -0.4% for the portfolio with long-only commodity premia instead of -1.2% for stock and bond only. A similar improvement is observed in the down bond months with returns improving from -0.5% to -0.1%. Across inflationary states as categorized by CPI changes, we see that portfolio with long-only commodity premia performs much better in high inflation states averaging 1.0% vs 0.6% for the stock-bond portfolio. Therefore, adding a long-only commodity premia allocation maintains the pro-inflation hedge of passive commodities while improving the average and the down-market returns. The sensitivity to NBER expansions is also slightly improved for the portfolio with the commodity premia allocation, with a slight pro-growth tilt resulting from the commodity allocation. In sum, by adding long-only commodity premia allocation to the portfolio, we see a significant diversification benefit in the down states of all asset classes, while preserving the pro-inflation hedge characteristic of passive commodities.

V. Conclusion

Long-run factor testing has become an important and growing field used to validate and learn about relatively recently discovered factor phenomena. In this paper, we extend commodity futures data and premia of momentum, value and basis back to the inception of commodity futures contracts in 1877. We confirm the positive relation between commodity factor characteristics of momentum, value and basis, and future cross-section of returns. Although long-short returns to momentum and basis deteriorate significantly in the pre-sample data, the long-only three premia portfolio's Sharpe ratio remains more than twice the level of the long-only equally-weighted commodity universe returns. Our results suggest that, combined with its positive inflation hedging property and higher average returns, the long-only premia portfolio is a strong substitute for passive commodity exposure in portfolio asset allocation setting.

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Appendix I: Individual Commodity Future Returns

Commodity	Start Year	End Year	# Months	Ave Return	Ave Vol
Corn_Chicago	1877	2017	1676	5.07%	25%
Oats_Chicago	1877	2017	1690	3.47%	29%
Lard_Chicago	1877	1963	1005	-4.08%	26%
Mess_Pork_Chicago	1877	1922	539	1.35%	32%
Wheat_Chicago	1877	2017	1654	5.06%	26%
Barley_Chicago	1885	1948	178	9.75%	36%
Rye_Chicago	1885	1964	776	-5.85%	30%
Short_Rib_Sides_Chicago	1885	1929	531	7.73%	30%
Flax_Seed_Chicago	1890	1905	164	6.78%	26%
Dry_Salted_Bellies_Chicago	1924	1941	179	1.05%	35%
Cotton_Chicago	1925	2017	1064	4.20%	17%
Soybeans_Chicago	1936	2017	921	8.07%	23%
Soybean_Oil_Chicago	1950	2017	809	8.68%	28%
Soybean_Meal_Chicago	1951	2017	796	11.98%	28%
Loose_Lard_Chicago	1958	1960	23	-17.84%	20%
Cocoa	1960	2017	695	3.89%	25%
Sugar	1961	2017	683	8.03%	34%
Live Cattle	1964	2017	637	3.10%	16%
Orange Juice	1967	2017	610	4.91%	27%
Hard Red Winter Wheat	1970	2017	575	0.84%	26%
Feeder Cattle	1971	2017	553	2.98%	17%
Coffee	1972	2017	544	3.27%	32%
Lean Hogs	1974	2017	527	-5.33%	27%
Platinum	1974	2017	526	11.53%	26%
Silver	1974	2017	527	3.66%	33%
Gold	1975	2017	515	1.14%	19%
Rubber	1975	2017	511	-0.08%	31%
Palladium	1977	2017	481	17.33%	39%
Lumber	1978	2017	478	25.52%	32%
WTI Crude Oil	1983	2017	417	8.24%	33%
Gas Oil	1985	2017	392	11.51%	33%
Heating Oil	1986	2017	380	8.48%	30%
Rough Rice	1986	2017	376	22.56%	34%
Brent Crude Oil	1988	2017	354	12.37%	32%
Copper	1989	2017	348	6.20%	26%
Natural Gas	1990	2017	332	-9.55%	44%
Aluminum	1993	2017	293	-0.80%	19%
Lead	1993	2017	293	12.75%	28%
Nickel	1993	2017	293	8.75%	35%
Tin	1993	2017	293	8.41%	23%
Zinc	1993	2017	293	3.31%	25%
Milk	1996	2017	263	4.73%	27%
Electrolytic Copper	1997	2017	246	8.02%	26%
Appalachian Coal	2001	2016	183	-4.76%	26%
Mustard	2004	2017	167	1.46%	20%
Butter	2005	2017	147	7.52%	25%
Cotton Sead Oil	2005	2017	152	5.74%	23%
RBOB Gasoline	2005	2017	146	5.99%	31%
Newcastle Coal	2009	2017	108	12.81%	27%
Propane	2009	2017	100	9.11%	37%
Cheese	2010	2017	90	6.20%	17%
Malt	2010	2015	62	12.60%	30%

Appendix 2

For robustness, we test alternative definitions of our factors. We test momentum that skips the last month, which is more consistent with literature that includes stock level momentum in which the last month experiences a reversal effect and it typically skipped. The results remain very similar and significant (0.83bps per month for the spread momentum portfolio). However, the reversal effect is applicable only in the stock level universes, and so we choose not to use that definition in the current study. To test the robustness of value, we test the definition used in Asness *et al.* (2013) who use the spot changes from *t-60 to t.* The value effect remains positive and statistically significant (67bps per month). However, this alternative definition causes value's cancelling overlap with the momentum during the *t-12 to t* look back window, hence we use a cleaner definition of reversal (Fama, French (1996), Levine *et. al* (2016)) and skip the last 12 months. Finally, we test a version of basis signal that uses only the last month's basis value and results remain statistically significant (0.48bps per month).

Table I

First panel shows the total number of months with return data for the front-month rolled contract from various data sources. Panel 2 shows average equally-weighted annualized returns for the rolled front-month contracts for various sub-samples and data sources. CBOT corresponds to data from Chicago Board of Trade reports; WSJ corresponds to Wall Street Journal data; Bloomberg + Datastream is a merged set of commodity data using Bloomberg as the primary source, extended with Datastream for commodities that have longer history in Datastream.

	All Dates	*Sub-samples*				*# Of Unique Commodities*
# Of Monthly **Near-Term** Contract Returns	*1877 - 2017*	*1877 - 1889*	*1889 - 1959*	*1959 - 1964*	*1965-2017*	*1877 - 2017*
CBOT (Starts Jan-1877, Ends Dec-1962)	7158	860	5932	366		15
WSJ (Starts Aug-1889, Ends Dec-1964)	4903		4399	504		13
Bloomberg + Datasream (Starts Jul-1959, Ends Dec-2017)	18461			526	17935	44
Merged Final Dataset (Universe)	25595	860	6117	748	17935	52
% Improvement of Multiple Sources	39%		3%	42%		

	All Dates	*Sub-samples*				*# Of Unique Commodities*
# Of Monthly **Second Nearest** Contract Returns	*1877 - 2017*	*1877 - 1889*	*1889 - 1959*	*1959 - 1964*	*1965-2017*	*1877 - 2017*
CBOT (Starts Jan-1877, Ends Dec-1962)	5980	579	5116	285		15
WSJ (Starts Aug-1889, Ends Dec-1964)	3987		3555	432		13
Bloomberg + Datasream (Starts Jul-1959, Ends Dec-2017)	18414			592	17822	44
Merged Final Dataset (Universe)	24459	579	5380	678	17822	52
% Improvement of Multiple Sources	33%		5%	15%		

	All Dates	*Sub-samples*				*Pre-Sample*
Average Annual Excess Returns of Near-Term Contract	*1877 - 2017*	*1877 - 1889*	*1889 - 1959*	*1959 - 1964*	*1965-2017*	*1877-1959*
CBOT (Starts Jan-1877, Ends Dec-1962)	1.9%	-0.7%	4.0%	-5.3%		2.2%
WSJ (Starts Aug-1889, Ends Dec-1964)	4.7%		5.3%	-3.2%		5.3%
Bloomberg + Datasream (Starts Jul-1959, Ends Dec-2017)	7.0%			1.6%	7.6%	
Merged Final Dataset (Universe)	4.2%	-0.7%	4.4%	-2.4%	7.6%	2.5%

Table II

Table shows equally-weighted annualized excess returns of long-short portfolios formed on sorts of the underlying commodity characteristics: momentum, value and basis. Every month during on the sample, we assign each commodity into one of three portfolios: high, medium and low. The long-short portfolio is long the high and short the low groups of commodities. Momentum (MOM) is defined as 12-month excess return of the near-term contract. Value (VAL) is defined as negative spot price change from t-60 to t-12. Basis (BAS) is defined as the 12-month average ratio of the near-term contract's price to the next-available contract's price. Combo long-short and combo long-only invest an equal amount into each of the three long-short or long-only premia portfolios.

1878 - 2017 (All-Dates)

	Return	Stdev	*Sharpe*	*t-stat*
MOM Long-Short	1.1%	5.8%	0.18	**7.5**
VAL Long-Short	0.9%	6.2%	0.15	**6.0**
BAS Long-Short	0.9%	6.0%	0.16	**6.4**
COMBO Long-Short	1.0%	3.6%	0.27	**10.9**
COMBO Long-Only	0.9%	5.3%	0.16	**6.6**
Universe Return	0.4%	4.9%	0.07	**3.1**

1878 - 1959 (Pre-Sample)

	Return	Stdev	*Sharpe*	*t-stat*
MOM Long-Short	0.9%	6.2%	0.15	**4.8**
VAL Long-Short	1.0%	6.8%	0.14	**4.4**
BAS Long-Short	0.7%	6.8%	0.10	**3.0**
COMBO Long-Short	0.8%	3.9%	0.22	**6.8**
COMBO Long-Only	0.7%	6.2%	0.11	**3.3**
Universe Return	0.2%	5.7%	0.04	1.2

1959 - 2017 (Recent-Sample)

	Return	Stdev	*Sharpe*	*t-stat*
MOM Long-Short	1.2%	5.1%	0.24	**6.3**
VAL Long-Short	0.9%	5.3%	0.17	**4.4**
BAS Long-Short	1.3%	4.4%	0.30	**7.8**
COMBO Long-Short	1.1%	3.2%	0.36	**9.4**
COMBO Long-Only	1.2%	3.9%	0.30	**7.8**
Universe Return	0.6%	3.6%	0.16	**4.2**

Table III

Table shows equally-weighted average annualized excess returns and maximum drawdowns by decade of the long-short portfolios based on underlying commodity momentum, value and basis characteristics. Every month in on our sample, we assign each commodity into one of three portfolios: high, medium and low. The long-short portfolio is long the high and short the low groups of commodities. Momentum is defined as 12-month excess return of the near-term contract. Value is defined as negative spot price change from t-60 to t-12. Basis is defined as the ratio of the near-term contract's price to the next-available contract's price. Combo long-short and combo long-only invest an equal amount into each of the three long-short or long-only premia portfolios. Universe is an equally-weighted return of all commodity futures with return data in out sample

Average Annualized Return

Decade	MOM	VAL	BASIS	COMBO L.S.	COMBO L.O.	UNIVERSE
1880's	7%	0%	-19%	-2%	1%	-8%
1890's	11%	12%	0%	9%	-4%	-6%
1900's	10%	6%	6%	10%	-2%	-7%
1910's	21%	6%	6%	13%	18%	10%
1920's	3%	13%	2%	7%	12%	8%
1930's	5%	8%	4%	7%	-6%	-8%
1940's	9%	22%	6%	15%	4%	-4%
1950's	6%	4%	23%	13%	27%	20%
1960's	9%	6%	3%	6%	2%	-2%
1970's	8%	2%	6%	6%	8%	4%
1980's	19%	13%	12%	17%	26%	17%
1990's	12%	14%	28%	19%	13%	3%
2000's	19%	9%	18%	16%	11%	3%
2010's	19%	6%	25%	17%	22%	12%
As of 2017	9%	10%	12%	11%	8%	3%
All dates	11%	9%	9%	11%	9%	3%

Max Drawdown

Decade	MOM	VAL	BASIS	COMBO L.S.	COMBO L.O.	UNIVERSE
1880's	-26%	0%	-60%	-24%	-20%	-37%
1890's	-36%	-56%	-83%	-41%	-64%	-70%
1900's	-59%	-62%	-67%	-28%	-76%	-88%
1910's	-22%	-66%	-47%	-12%	-57%	-81%
1920's	-35%	-28%	-70%	-19%	-46%	-59%
1930's	-40%	-40%	-64%	-26%	-70%	-74%
1940's	-56%	-52%	-66%	-35%	-87%	-91%
1950's	-56%	-38%	-19%	-12%	-55%	-83%
1960's	-22%	-25%	-39%	-17%	-35%	-29%
1970's	-33%	-54%	-37%	-23%	-25%	-31%
1980's	-30%	-44%	-31%	-14%	-17%	-23%
1990's	-42%	-21%	-18%	-13%	-15%	-25%
2000's	-17%	-23%	-22%	-11%	-17%	-22%
2010's	-20%	-47%	-12%	-13%	-34%	-41%
As of 2017	-20%	-27%	-28%	-13%	-34%	-41%
All dates	-59%	-66%	-83%	-41%	-87%	-91%

Table IV

Table shows correlations of equally-weighted average annualized excess returns of the long-short portfolios based on underlying commodity momentum, value and basis characteristics. Every month in on our sample, we assign each commodity into one of three portfolios: high, medium and low. The long-short portfolio is long the high and short the low groups of commodities. Momentum is defined as 12-month excess return of the near-term contract. Value is defined as negative spot price change from t-60 to t-12. Basis is defined as the ratio of the near-term contract's price to the next-available contract's price. Combo long-short and combo long-only invest an equal amount into each of the three long-short or long-only premia portfolios. Universe is an equally-weighted return of all commodity futures with return data in out sample

Correlations						
1878 - 2017	MOM	VAL	BAS	COMBO L.S.	COMBO L.O.	UNIVERSE
MOM	1					
VAL	4%	1				
BAS	26%	-13%	1			
COMBO L.S.	69%	25%	55%	1		
COMBO L.O.	32%	8%	26%	44%	1	
UNIVERSE	-1%	-4%	0%	-4%	85%	1
1878 - 1959	MOM	VAL	BAS	COMBO L.S.	COMBO L.O.	UNIVERSE
MOM	1					
VAL	1%	1				
BAS	27%	-18%	1			
COMBO L.S.	68%	21%	53%	1		
COMBO L.O.	29%	11%	26%	43%	1	
UNIVERSE	-4%	3%	4%	-3%	86%	1
1960 - 2017	MOM	VAL	BAS	COMBO L.S.	COMBO L.O.	UNIVERSE
MOM	1					
VAL	12%	1				
BAS	23%	1%	1			
COMBO L.S.	72%	37%	59%	1		
COMBO L.O.	40%	-1%	23%	46%	1	
UNIVERSE	7%	-24%	-15%	-7%	81%	1

Table V

Table shows results of regressions of monthly returns of long-short portfolios based on underlying commodity momentum, value and basis characteristics, universe and combo long-short and long-only portfolios on monthly returns of momentum, value, basis, universe, NBER expansion Booleans and CPI changes. Significant t-statistics are highlighted in bold.

		Regressions							
1878 - 2017		MOM	VAL	BAS	UNIVERSE	NBER (Expansion)	CPI	Intercept	Rsq.
MOM	*coeff.*		0.07	0.26	-0.01	0.00	0.06	0.76%	7%
	t-stat		**3.1**	**11.1**	-0.3	-0.1	0.4	**4.8**	
VAL	*coeff.*	0.08		-0.15	-0.06	0.00	0.20	0.95%	2%
	t-stat	**3.1**		**-5.9**	-1.9	-0.3	1.3	**4.3**	
BAS	*coeff.*	0.27	-0.14		-0.02	0.00	0.28	0.76%	9%
	t-stat	**11.1**	**-5.9**		-0.7	-0.5	1.9	**4.7**	
UNIVERSE	*coeff.*	-0.01	-0.04	-0.01		0.00	1.32	-0.01%	8%
	t-stat	-0.3	-1.9	**-0.7**		**2.8**	**11.0**	-0.1	
COMBO Long-Short	*coeff.*				-0.03	0.00	0.20	0.96%	0%
	t-stat				-1.6	-0.6	**2.2**	**9.6**	
COMBO Long-Only	*coeff.*	0.15	0.14	0.17		0.00	1.28	0.03%	17%
	t-stat	**6.8**	**7.3**	**8.1**		**2.1**	**10.4**	0.2	

		Regressions							
1878 - 1959		MOM	VAL	BAS	UNIVERSE	NBER (Expansion)	CPI	Intercept	Rsq.
MOM	*coeff.*		0.05	0.25	-0.06	0.00	0.07	0.70%	8%
	t-stat		1.8	**8.9**	-1.7	0.4	0.4	**3.5**	
VAL	*coeff.*	0.06		-0.19	0.04	0.00	0.06	0.94%	4%
	t-stat	1.8		**-5.9**	1.0	0.4	0.4	**4.3**	
BAS	*coeff.*	0.30	-0.19		0.06	0.00	0.15	0.58%	11%
	t-stat	**8.9**	**-5.9**		1.5	-1.1	0.9	**2.7**	
UNIVERSE	*coeff.*	-0.05	0.03	0.04		0.00	1.29	-0.05%	10%
	t-stat	-1.7	1.0	1.5		**2.3**	**9.0**	-0.3	
COMBO Long-Short	*coeff.*				0.00	0.00	0.11	0.83%	0%
	t-stat				0.2	-0.3	1.0	**6.5**	
COMBO Long-Only	*coeff.*	0.10	0.22	0.23		0.00	1.25	-0.05%	21%
	t-stat	**3.3**	**8.3**	**8.7**		1.9	**8.7**	-0.3	

Table VI

Table shows total returns and risk profiles of asset allocation optimizations for different portfolio mixes consisting of U.S. Equity Index and U.S. Government Bond Index, with additions of either passive commodities (long-only equally-weighted commodity futures total returns) or combo long-only premia portfolio that invests equally in the top third portfolios of momentum, value and basis. Optimal weights, for the highest Sharpe ratio portfolio, are shown for both the full sample and for the pre-1959 sample only.

Asset Allocation	1878 - 2017			1878 - 1959 (Pre-Sample)			1960 - 2017			Optimal Weights			
	Ann. Ret	Stdev	*Sharpe*	Ann. Ret	Stdev	*Sharpe*	Ann. Ret	Stdev	*Sharpe*	Stocks	Bonds	Commodities	ComboL.O.
Tbills	0.3%	0.2%	0.00	0.2%	0.1%	0.00	0.4%	0.3%	0.00				
U.S. Stocks	0.9%	4.8%	0.12	0.3%	1.1%	0.07	0.6%	2.2%	0.08				
U.S. Gov Bonds	0.4%	1.7%	0.07	0.8%	5.2%	0.12	0.9%	4.2%	0.12				
Commodities	0.7%	5.0%	0.08	0.4%	5.7%	0.04	1.0%	3.6%	0.16				
COMBO Long-Only	1.1%	5.3%	0.16	0.8%	6.1%	0.11	1.5%	3.9%	0.30				
Stock_Bond Opt Full	0.6%	2.2%	0.13	0.5%	2.2%	0.13	0.7%	2.2%	0.14	39%	61%		
Stock_Bond_Comm Opt Full	0.6%	2.1%	0.15	0.5%	2.2%	0.13	0.7%	1.9%	0.18	32%	52%	16%	
Stock_Bond_Combo Opt Full	0.7%	2.2%	0.20	0.6%	2.4%	0.15	0.9%	1.8%	0.29	19%	51%		30%
Stock_Bond Opt Pre_1960	0.6%	2.1%	0.13	0.5%	2.0%	0.13	0.7%	2.2%	0.13	35%	65%		
Stock_Bond_Comm Opt Pre_1960	0.6%	2.1%	0.14	0.5%	2.0%	0.13	0.7%	2.1%	0.14	34%	64%	2%	
Stock_Bond_Combo Opt Pre_1960	0.6%	1.8%	0.18	0.5%	1.8%	0.16	0.8%	1.8%	0.22	21%	64%		16%

Table VII

Table shows average returns of Full Sample Optimized portfolios during UP and DOWN states of U.S. Equity, U.S. Government Bond, Commodity Futures, NBER Recession Boolean and monthly CPI changes. Stock_Bond portfolio invests in U.S. Equity Index and U.S. Government Bond Index. Stock_Bond_Comm_Opt adds passive Commodity Futures allocation. Stock_Bond_Combo replaces passive commodities with Long-Only Premia Combo Commodity portfolio.

Average Monthly Returns In Different Environments				
1877 - 2017		Stock_Bond Opt Full	Stock_Bond_Comm Opt Full	Stock_Bond_Combo Opt Full
U.S. Equity return (1877-2017)	UP (Positive)	1.7%	1.6%	1.4%
	DOWN (Negative)	-1.2%	-1.0%	-0.4%
	UP - DOWN	2.9%	2.6%	1.8%
	t-stat	**33.1**	**25.1**	**16.8**
U.S. Gov. Bonds return (1877-2017)	UP (Positive)	1.2%	1.1%	1.2%
	DOWN (Negative)	-0.5%	-0.3%	-0.1%
	UP - DOWN	1.7%	1.4%	1.2%
	t-stat	**16.3**	**13.5**	**11.2**
Commodity return (1877-2017)	UP (Positive)	0.8%	1.3%	1.7%
	DOWN (Negative)	0.3%	-0.3%	-0.6%
	UP - DOWN	0.6%	1.6%	2.4%
	t-stat	**5.1**	**16.9**	**24.2**
NBER (1877-2017)	UP (Expansion)	0.7%	0.7%	0.8%
	DOWN (Recession)	0.3%	0.2%	0.3%
	UP - DOWN	0.4%	0.5%	0.5%
	t-stat	**2.8**	**4.2**	**4.0**
CPI (1877-2017)	UP (Positive)	0.6%	0.7%	1.0%
	DOWN (Negative)	0.5%	0.4%	0.4%
	UP - DOWN	0.1%	0.3%	0.6%
	t-stat	0.5	**3.3**	**5.4**

Graph I

Graph shows equally-weighted annualized excess returns of long-short portfolios formed on sorts of the underlying commodity characteristics: momentum, value and basis, as well as the equally weighted return of all commodities, and the combo long-only, which is the average of the long only (top third) momentum, value, basis portfolios. Every month during on the sample, we assign each commodity into one of three portfolios: high, medium and low. The long-short portfolio is long the high and short the low groups of commodities. Momentum (MOM) is defined as 12-month excess return of the near-term contract. Value (VAL) is defined as negative spot price change from t-60 to t-12. Basis (BAS) is defined as the 12-month average ratio of the near-term contract's price to the next-available contract's price. Combo long-short and combo long-only invest an equal amount into each of the three long-short or long-only premia portfolios.