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RESEARCH DIGEST ARTICLES

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"FORECASTING CRUDE OIL AND REFINED PRODUCTS VOLATILITIES AND CORRELATIONS: NEW EVIDENCE FROM FRACTIONALLY-INTEGRATED MULTIVARIATE GARCH MODELS"

AS SUMMARIZED BY PROFESSOR ANA-MARIA FUERTES, Ph.D., CASS BUSINESS SCHOOL, CITY, UNIVERSITY OF LONDON, U.K.

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Fear of Hazards in Commodity Markets

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This paper examines the predictive content of active attention to hazards or "hazard fear" which is proxied by changes in the volume of internet search queries (or active attention) by 149 weather, disease, geopolitical or economic terms. A long-short portfolio strategy that sorts the cross-section of commodity futures by a hazard fear signal -- inferred from the co-movement of past excess returns with the active attention -- is able to capture an economically and statistically significant premium. A time-series analysis suggests that this hazard fear premium partially reflects compensation for known risks such as those formalized as hedging pressure, momentum, illiquidity and skewness factors, but is not subsumed by them. Exposure to hazard-fear is strongly priced in the cross-section of individual commodity futures and commodity portfolios over and above known risk factors. The hazard fear premium is significantly greater in periods of higher financial investor pessimism which reveals a channel for the transmission of sentiment to commodity futures markets.

Introduction

Commodity hazard fear is broadly defined as the economic agents' apprehension or anxiety about potential weather, agricultural disease, geopolitical and economic threats that may shift the commodity supply or demand curves. Building on economic psychology, the empirical investigation conducted by the authors builds on the assumption that economic agents' fear about threats induces them actively to search for information (Lemieux and Peterson, 2011). This active information demand is referred to as "attention" in the recent asset pricing literature (Da *et al.*, 2011, 2015; Han *et al.*, 2017a, 2017b; Vozlyublennaia, 2014). The authors hypothesize that fear of rare and extreme events contains predictive content for commodity futures returns and influences the pricing of commodity futures contracts over and beyond the fundamental backwardation and contango cycle. Fear of hazards induces expectations of a sharp rise/decline in spot prices. These expectations, in turn, can influence the hedging decisions of commodity market participants and the compensation demanded by speculators to absorb changes in net hedging. For instance, when there is fear about a threat inducing a dramatic drop in supply and thus, when the spot price is expected to sharply rise, speculators may demand a higher premium for taking short positions (than in the absence of such fear) which implies higher current futures prices; thus, the

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decrease in the futures price as maturity approaches is the overall premium captured by short speculators which incorporates a fundamental and a hazard-fear component.

Economic agents' fear can arise from many reasons. In our paper, building on the aforementioned literature on the pricing content of "attention" we are agnostic as to whether the internet searches by the hazard terms are induced by news releases about impending hazards or simply by a phenomenon akin to the "representativeness" heuristic – for instance, a coffee producer may be anxious about extreme weather pre-harvest because her crops were thus adversely affected in the past or because she is mindful of extreme weather phenomena that had dramatically shifted inward the supply of other commodities.

The paper provides three contributions to the literature. Using the internet search volume by 149 commodity hazard-related keywords as a proxy for hazard-fear, the authors adapt the framework of Da *et al*. (2015) to obtain a commodity-specific hazard fear characteristic (hereafter CFEAR) that reflects the co-movement between the commodity futures returns and the hazard-fear. Second, they construct a CFEAR-sorted portfolio of commodities to formally assess the out-of-sample predictive content of the CFEAR characteristic for commodity futures returns (the fear premium) and deploy time-series spanning tests to examine whether the fear premium is subsumed by well-known commodity risk factors. Third, the paper contributes to the commodity pricing literature by providing cross-sectional tests for commodity portfolios (sorted on characteristics and sectors) and individual commodities to investigate whether the CFEAR factor captures priced risk over and above known commodity risk factors.

Relevance of the Research Question

The analysis conducted in this paper fills a void in the futures markets literature by investigating whether fear of (and attention to) hazards conveys expectations about subsequent futures prices. By demonstrating that a long-short portfolio strategy based on a fear signal is able to capture a significant premium and that this premium is not subsumed by fundamental premia such as term structure, hedging pressure or momentum (inter alia) the paper provides novel evidence that hazard fear can also influence commodity futures prices over and above the fundamentals. Filling a void in the literature, the authors show that "animal spirits" (paraphrasing the British economist John Maynard Keynes) in the form of adverse moods or pessimism (i.e., sentiment) in the broad financial markets, as proxied by VIX levels, can be channeled into commodity futures markets by exacerbating the hazard fear.

Data, CFEAR Signal and Portfolio Construction

Inspired by the extant literature that uses Google search volume as a proxy for investor attention (or information demand) in financial markets, this paper introduces a commodity hazard-fear characteristic that is constructed from internet search volume data from *Google Trends* using an array of 149 hazards as query terms. The Google searches are sampled at a weekly frequency (as daily searches are likely to be noisier) with each observation capturing the search queries from Monday 00:00:00 to Sunday 23:59:59. Thus, the portfolio rebalancing is carried out at the start of each Monday to exploit the previous-week searches. As in Da *et al*. (2015), the measure of interest is the weekly log change in the Google search volume or attention to hazard *j* defined as $\Delta S_{j,t} \equiv \log(s_{j,t}/s_{j,t-1})$, $j = 1, \ldots, J$, so that sharp increases in the attention to hazards can be taken to signal a surge in hazard-specific fear. Following Da *et al*. (2015), in order to make the attention series comparable across the $j = 1, \ldots, 149$ keywords we standardize each as $\Delta S^*_{j,t} \equiv \Delta S_{j,t}/\sigma^{\Delta S}_{j,t}$ where $\sigma^{\Delta S}_{j,t}$ is the standard deviation of the series $\Delta S_{j,t}$ using data from week 1 to *t*. As in Da *et al*. (2015), we run backward-looking regressions to measure the strength of the historical contemporaneous relationship between searches and commodity futures returns:

$$r_{i,t-l} = \alpha + \beta^{CFEAR}_{i,j,t-l} \cdot \Delta S^*_{j,t-l} + \varepsilon_{t-l}, \quad l = 0, \ldots, L-1 \tag{1}$$

for each of the $j = 1, \ldots, 149$ keywords in the sample. We estimate Equation (1) by OLS and, for commodity i we construct the CFEAR characteristic as follows:

$$CFEAR_{i,t} \equiv \sum_{j=1}^{J} \hat{\beta}^{CFEAR}_{i,j,t-l} \tag{2}$$

by aggregating the corresponding sensitivity measures for the $J = 149$ keywords. The long-short CFEAR portfolio takes long positions on the commodities with the most negative ($CFEAR_{i,t} < 0$) signal, and short positions on those with the most positive ($CFEAR_{i,t} > 0$) signal. To avoid a look-ahead bias, the analysis is conducted out-of-sample; namely, the buy or sell decisions at each week *t* hinge on past data.

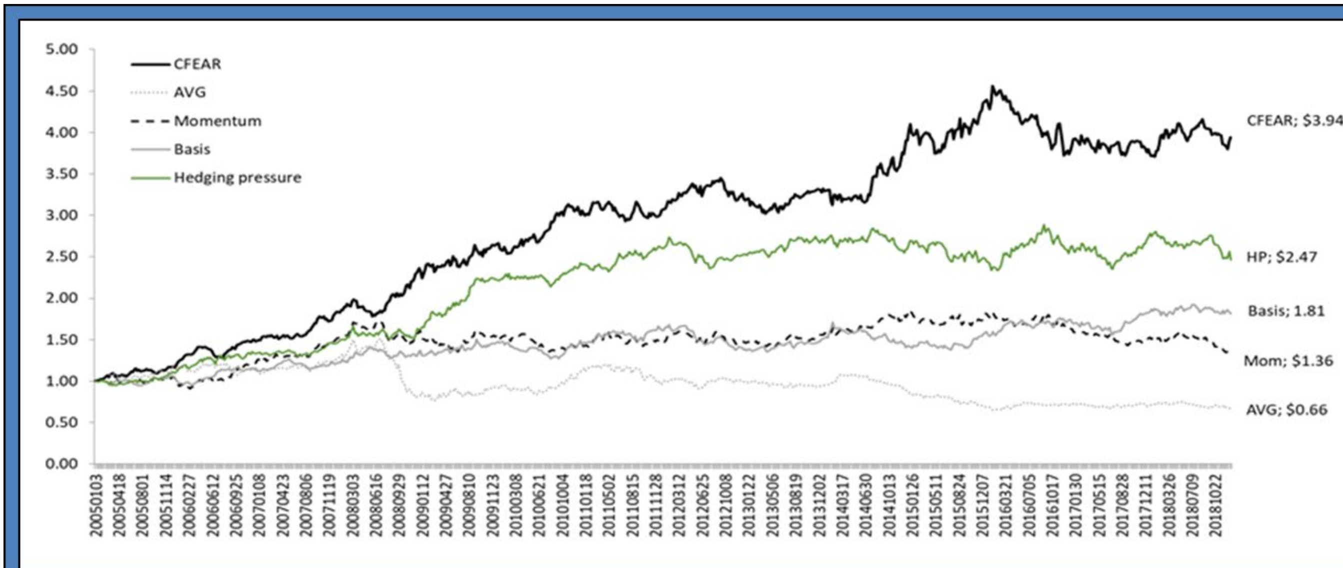
The authors deploy the long-short portfolios on a cross-section of 28 commodity futures contracts comprising 17 agricultural (4 cereal grains, 4 oilseeds, 4 meats, 5 miscellaneous other softs), 6 energy, and 5 metals (1 base, 4 precious). The observation period is from January 1, 2004 (as dictated by the availability of weekly *Google Trends* search data) until December 31, 2018.

Results

The fully-collateralized long-short CFEAR portfolio captures an economically and statistically significant premium of 9.28% p.a. ($t = 3.35$) which stands well relative to traditional premia as shown in Figure 1 on the next page. In addition, the CFEAR portfolio has an appealing risk profile, that materializes in a Sharpe ratio of 0.9012 versus 0.3387 (term structure portfolio), 0.5926 (hedging pressure) and 0.1296 (momentum). Further, the CFEAR portfolio presents relatively favorable tail (crash) risk characteristics as borne out, for instance, by a 99% VaR and maximum drawdown of 0.0341 and -0.1881, respectively, while the corresponding risk measures for aforementioned long-short traditional portfolios lie in the ranges [0.0356, 0.0421] and [-0.2872, -0.1828], respectively.

Figure 1 shows the evolution of $1 invested in the long-only equally weighted portfolio of the 28 commodities (AVG), and the long-short basis, momentum, hedging pressure and CFEAR portfolios.

Figure 1
Future Value of $1 Invested in Commodity Portfolios



Examining the excess returns of the long versus short legs of the portfolio reveals that the CFEAR premium is mostly driven by the short positions. This finding is consistent with the inherent asymmetry of inventories which can be built up to dampen commodity price falls but their natural zero lower bound makes them likely to be perceived by agents as an ineffective lever to stifle upswings in commodity prices.

Next the authors estimate time-series regressions of the returns of the long-short CFEAR portfolio on the term structure, hedging pressure and momentum factors – and other factors suggested in the literature such as basis-momentum, convexity, illiquidity and skewness inter alia (Gu *et al*., 2019; Boons and Prado, 2019; Fernandez-Perez *et al*., 2018; Szymanowska *et al*., 2014). The results reveal exposure to some of these factors but the regression intercept (or alpha) remains economically and statistically significant. Therefore compensation for exposure to fundamentals risks does not tell the whole story.

Cross-sectional asset pricing tests deployed both for individual commodities and commodity portfolios as test assets reveal that exposure to the CFEAR factor is consistently priced, and that the CFEAR factor is able to improve the explanatory power (reduce the pricing error) of extant commodity pricing models.

The mean excess return and alpha of the CFEAR portfolio are found to be greater when VIX levels are high; i.e., when risk-aversion is high or when sentiment is adverse. A rationale is that speculators may demand a higher premium in high VIX periods because their risk-bearing ability has been then impaired (due either to funding liquidity constraints or to their reluctance to take risks in bad times) or because their investment decisions are contaminated by adverse sentiment (pessimism). Given that risk aversion and sentiment are likely to co-vary over time, it is challenging to tell the two explanations apart. However, an identical analysis conducted for the fundamental term structure, hedging pressure and momentum premia reveals that they are, in sharp contrast, unrelated to the VIX; this suggests that broad financial market sentiment can be channeled into commodity futures pricing through hazard fear. The intuition is that when investors are out of their comfort zone because of turmoil in financial markets, as signaled by a high VIX, they are more vulnerable to emotions such as (hazard) fear.

A battery of robustness tests are not able to challenge the above findings. These tests include alternative portfolio formation approaches (e.g., monthly rebalanced), and CFEAR signal extraction methods. Among the latter, the authors measure the CFEAR signal in a manner that controls for the impact of media coverage defined, as in Fang and Peress (2009) and others, as the number of news articles published about each commodity per week to proxy for its overall media exposure (or information supply).

Seeking to rule out concerns that the finding of a significant hazard-fear premia in commodity futures markets is an artefact of the methodology employed, the authors carry out an intuitive "placebo" test (focusing on the 123 keywords in the weather and crop disease categories) that consists of deploying the same long-short portfolio strategy for 4 cross-sections of commodity, equity, currency and fixed income futures contracts, respectively. The fear premium remains sizeable and statistically significant in commodity futures markets at 8.17% p.a. (t=3.06) but is merely 1.83% p.a. (t=1.62) in equity index futures markets, 0.19% p.a. (t=0.25) in fixed income futures markets and 1.16% p.a. (t=1.50) in currency futures markets. This suggests that the CFEAR premium in commodity futures is unlikely to be spurious.

Conclusions

Does the human emotion known as fear influence commodities futures pricing? This paper addresses this question by focusing on weather, agricultural pests, geopolitical or economic threats to the commodity supply or demand. Fear is proxied by surges in the active search for information or attention.

A long-short CFEAR portfolio is able to earn a sizeable premium in commodity futures markets. Using time-series spanning tests, it is shown that this premium cannot be fully rationalized as compensation for exposure to known risk factors. Through asset pricing tests the paper further demonstrates that exposure to hazard-fear is a key determinant of the cross-sectional variation in the excess returns of both individual commodities and commodity portfolios beyond known fundamental pricing factors. The results are robust to trading costs and to alternative CFEAR signal measurement and portfolio construction methods. The CFEAR premium magnifies in periods of pessimism as proxied by the VIX revealing a channel for overall financial investor sentiment to transmit into commodity futures markets. A key takeaway is that fear about potential hazards contains predictive information about commodity futures prices.

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Keywords

Commodity supply, commodity demand, hazards, fear, attention, search activity, sentiment, long-short portfolios.

Investable Commodity Premia in China

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This paper discusses how investable Chinese commodity risk premia might be, amid the recent acceleration of the market opening process in China. The findings suggest that strategies based on conventional contract rolling and portfolio weighting schemes are not investable due to limited capacity induced by policy-induced liquidity dynamics. It is further shown that the capacity can be substantially increased by dynamic rolling and strategic portfolio weights, and that style integration can notably enhance the investor's opportunity set. The investable premia documented survive execution delay, stop-loss, seasonality, sub-periods, illiquidity and transaction cost tests, and provide portfolio diversification benefits. Finally, the analysis reveals that investable commodity premia in China exhibit a strong ability to predict global real economic growth.

Introduction

The investment management industry has embraced the rising opportunities in China as a result of the government's recent effort to internationalize its financial markets. As of 2020, many of the world's largest hedge funds – BlackRock, Bridgewater Associates, Invesco, Man Group, UBS and Winton Capital inter alia – have established subsidiaries in China.

Meanwhile, as one of the most popular investment styles in recent decades, a growing number of studies have confirmed the profitability of momentum and trend-following strategies in Chinese commodity futures markets (Li *et al*., 2017; Ham *et al*., 2019). Fan and Zhang (2020) conduct a study that confirms the existence of carry and momentum premia in these markets after controlling for an exhaustive list of long-short factors that have been documented in the U.S. market. However, the extant literature has largely neglected the effects of retail-dominance, barriers-to-entry, time-varying margins and strict position limits.

This paper investigates how investable various risk premia are in Chinese commodity futures markets. These premia include the momentum, carry and recently proposed basis-momentum factors that have been documented in the U.S. futures markets. Using a wide range of portfolio construction methods, the authors assess how investable these factors are in Chinese futures markets from three angles: capacity, enhancement, and implementation. The specific research questions addressed by this study in the context of the above styles in commodity futures markets are as follows: (1) Are those risk premia

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investable? (2) How can investment in those premia be effectively increased? (3) Do such premia have predictive implications for the global economy?

Why the Paper's Research Questions are Important

The literature on commodity factor investing has gained popularity because of its implications to the investment management industry. While the literature to date focused on developed futures markets in the U.S., U.K., and Japan, the emerging commodity market in China offers a natural laboratory to conduct experiments on existing factors. Despite its importance to global commodity trading and increased attention from investors, the Chinese commodity futures market is still poorly understood due to the unique institutional settings. Largely deviating from the real-world setting, naïve assumptions imposed by existing studies cast doubt on the validity and practicality of previously documented results. To fill the gap, this paper explores investing in risk premia by examining the investment capacity, implementation challenges and the implications for the global economy. The findings are of imminent interest to global institutional investors. This study also contributes to the growing debate on the replicability of risk factors (Harvey *et al*., 2016; Hou *et al*., 2018).

Data Description

Data for 44 commodities covering grains, oilseeds, industrials, metals and energy sectors, traded on the Dalian (DCE), Shanghai (SHFE) and Zhengzhou (ZCE) exchanges, respectively, are obtained from Datastream International. The cross-section of the raw dataset spans 4,500 individual contracts and maturities from 1993 to 2018. Thinly traded products are dynamically excluded. As macroeconomic variables, the authors employ inflation and industrial production data from China, the U.S. and world, the Keqiang, Kilian and Baltic Dry indices, and the Chinese versions of the Economic Policy Uncertainty (EPU) Index, the Geopolitical Risk (GPR) Index, the term spread and the TED spread. As financial variables, the authors consider broad stock, bond and currency indices for China, U.S., and Europe.

Methodology

The authors investigate how investable factors such as carry are (Koijen *et al*., 2018), as well as momentum (Miffre and Rallis, 2007) and basis-momentum (Boons and Prado, 2019), in Chinese commodity futures markets. To measure the threshold capacity (Vangelisti, 2006), the authors compute the position ceilings set by regulators for each commodity covered in the sample. Accordingly, they estimate the maximum investment capacity of carry, momentum and basis-momentum factors using the conventional rolling method and equal portfolio weights. The conventional roll holds the m^{th} (where m = 1, 2, 3, 4) nearest contracts until the last trading day of the month prior to expiration of the front contract.

In an effort to improve capacity, two alternative roll-over methods are employed: the Gradual roll expands the rollover process evenly over the last five trading days (de Groot *et al*., 2014), and the Dynamic roll changes positions whenever the open interest of the holding contract is surpassed by another contract for three consecutive days (Asness *et al*., 2013). In addition to equal weights, four strategic portfolio weighting techniques are exploited including rank (Koijen *et al*., 2018), strength (Fan *et al*., 2020), volatility (Moskowitz *et al*., 2012) and trade weights. Each long-short portfolio consists of the entire cross-section and is rebalanced monthly. For risk adjustments, the authors employ commodity market factors (Bakshi, *et al.*, 2019), common risk factors (Fan *et al.*, 2020), as well as a geopolitical risk measure (Caldara and Iacoviello, 2019; GPR) and Chinese economic policy uncertainty measure constructed à la Baker, Bloom and Davies (2016; EPU).

Key Results

Momentum, carry and basis-momentum premia are robust under conventional contract rolling and equal portfolio weights, but are not investable due to limited capacity (approx. one million Chinese Renminbi (RMB) or U.S. $142,000). However, dynamic rolling and strategic portfolio weights significantly boost the capacity of the above strategies to billions of RMB, without compromising the statistical or economic significance of the risk premia.

Second, the observed investable risk premia can be enhanced through a simple style integration framework (Fernandez-Perez *et al.*, 2019), while maintaining a high level of investment capacity. These integrated strategies report an average annualized Sharpe ratio of 0.81 and a median capacity of 932 million RMB. However, only the combination of momentum and basis-momentum under rank, strength and trade weights can deliver "alpha" when the standalone risk premia are used as benchmarks.

Third, the investable risk premia are robust to several implementation concerns, such as execution delay, stop-loss and liquidity considerations. A 10% stop-loss improves the risk-return profile for the carry strategy but not for momentum and basis-momentum. Moreover, a correlation analysis reveals that investable premia in Chinese commodity futures can provide diversification benefits for both Chinese and international risk exposures on traditional assets.

Fourth, the paper finds no evidence of a significant relationship between investable commodity premia in China and macroeconomic, liquidity, volatility and economic policy/geopolitical risks. However, investable carry premia persistently predict real global economic activity for up to one year ahead. This highlights the important role that Chinese commodity markets play in the global economy. Lastly, the robustness of investable premia is reassured in seasonality and sub-period tests and the premia remain when subjected to transaction costs.

Conclusion

This article examines investing in commodity risk premia in China. Conventional momentum, carry and basis-momentum premia are not investable given the minuscule capacity on the front end of the commodity futures curve. To harvest the premia, dynamic contract rolling and strategic portfolio weights play an indispensable role. Such investable premia survive a variety of implementation tests and can convey important information about the future growth of the global economy. Moreover, the paper shows that style integration can be a very useful tool to enhance the investable risk premia. Overall, the paper highlights the importance of taking into consideration how investable and replicable factor risk premia are across asset classes and regions.

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Keywords

China, commodity futures, momentum, carry, capacity.

The Price of Shelter – Downside Risk Reduction with Precious Metals

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This article examines the potential to reduce downside risk by adding precious metals to a portfolio consisting of traditional assets. It shows that gold, silver and platinum contribute to downside risk reduction at short horizons, but diversification into silver and platinum may result in increased long horizon portfolio risk. The price of sheltering an equity portfolio from downside risk using precious metals is a relative reduction in portfolio risk-adjusted returns. The key message is that gold is an effective but costly hedge against negative portfolio returns while silver and platinum provide only short-run relief against downside risk.

Introduction

Fearing losses from declines in asset prices, investors may allocate a proportion of their wealth to alternative assets, in the hope of limiting portfolio exposures during bear markets. In the context of traditional assets, especially equity portfolios, gold is frequently proposed as a hedge (due to its low correlation with them) and safe-haven (negative correlation during downturns); see e.g. Bredin *et al*. (2015), Baur and Lucey (2010), and Baur and McDermott (2010). The allure of gold as an investment asset also relates to its potential as a hedge against inflation (Conlon *et al*., 2018b; Gorton and Rouwenhorst, 2006) and as a currency safe-haven (Reboredo, 2013). Little is known, however, about the price an investor must pay to diversify a traditional portfolio using gold. The authors investigate the latter question and measure the downside risk protection offered not only by gold but also silver and platinum.

To quantify hedge and safe-haven properties, the authors gauge the extent to which S&P 500 downside risk at various investment horizons can be reduced by allocating a proportion of total capital to precious metals. Downside risk, the maximum expected loss for a portfolio over a given horizon, is measured through the Cornish-Fisher expansion. To measure the costs of hedging, the authors estimate the change in risk-adjusted returns (Sharpe ratio) resulting from the allocation to precious metals.

The paper contributes to the literature in several ways. This is among the first papers to examine the downside risk reduction properties of silver and platinum. The analysis provides an accurate assessment

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of portfolio downside risk by incorporating higher-order distributional moments. A central theme of the paper is the importance of the investor's horizon in estimating downside risk benefits of precious metals. Finally, the paper investigates the tradeoff between downside risk benefits from diversifying the S&P 500 portfolio with precious metals and expected portfolio returns, which are eroded by the costs of hedging.

Relevance of the Research Question

Aversion to acute losses may motivate investors to seek a risk premium for bearing downside risk (Bali *et al*., 2009) and can impact their optimal allocation strategy (Jarrow and Zhao, 2006). This dislike for extreme negative outcomes may lead investors to seek out asset classes which provide diversification benefits during downturns. Gold has long been considered a store of value, a unit of exchange and an investment asset. The late 2000s global financial crisis renewed gold's role as an investment asset.

This paper aims to provide a new perspective on precious metals as a safe-haven asset. By investigating the performance of silver and platinum as downside risk diversifiers, the paper assesses alternatives to gold. As well documented in the literature, important financial characteristic such as risk and correlation are heavily dependent upon the horizon at which they are estimated (Conlon *et al*., 2018a). This, in turn, impacts the hedging effectiveness which can be achieved at different horizons, especially for gold (Bredin *et al*., 2015). This paper seeks to identify the specific range of horizons at which precious metals act to reduce downside risk for equity investors. Finally, while diversification has been proclaimed as the only "free lunch" in finance, we determine whether this holds for investment into precious metals. Can equity investors reduce their downside risk exposures in a costless manner using any of gold, silver or platinum?

Data and Downside Risk Estimation

The paper gathers daily data on gold and silver (London Bullion Market Association) and platinum (London Platinum Free Market) in addition to closing prices on the S&P 500 index from 1980 through 2014. All data is obtained from Thomson Reuters Datastream. Logarithmic returns are calculated at a daily level and aggregated for longer horizons of up to 60 days. Downside risk is estimated as follows:

$$MVaR_p(1-\alpha,\tau) = \mu - \sigma\hat{Z}(\alpha,S,K),$$

where $MVaR_p$ denotes the modified four-moment value-at-risk (VaR) of the portfolio, α is the quantile of interest set to 99% in this study. $\hat{Z}(\alpha,S,K)$ is the quantile obtained through the Cornish-Fisher expansion, with S and K the skewness and excess kurtosis of the distribution of returns, respectively.

Relative risk reduction is estimated using the proportion of equity portfolio VaR that remains after diversifying with precious metals and is given by:

$$RR_{VaR} = \frac{MVaR_p(1-\alpha,\tau)}{MVaR_e(1-\alpha,\tau)},$$

where $MVaR_e$ is the modified VaR associated with an equities-only portfolio and $MVaR_p$ is the modified VaR of the diversified portfolio. The price of shelter is estimated with the relative Sharpe ratio (RSR) as:

$$RSR = \frac{SR_P}{SR_e},$$

that measures the Sharpe ratio of an equity portfolio diversified with precious metals relative to the Sharpe ratio of the equities-only portfolio. Accordingly, an $RSR < 1$ implies that diversification with precious metals is costly as borne out by a reduction in risk-adjusted returns.

Results

The main empirical findings are highlighted in Table 1 for a 10% allocation to precious metals. Concentrating on a 1-day interval, the analysis reveals that gold, silver, and platinum each provide downside risk reduction benefits. Silver provides the strongest short-run benefits, with a 10% allocation resulting in a 20% reduction in downside risk. This reduction comes with a cost, however, with a reduction in the Sharpe ratio of 0.77 relative to holding a portfolio containing only the S&P 500. The implication is that using silver, an investor must sacrifice 23% of the risk-adjusted returns associated with investing in the S&P 500 in order to secure a 20% reduction in downside risk.

Table 1
Downside Risk Reduction (RR) and Relative Sharpe Ratio (RSR) for a Portfolio with a 10% Allocation to Precious Metals over the Period, 1980-2014

	Gold		Silver		Platinum	
Horizon	**RR**	**RSR**	**RR**	**RSR**	**RR**	**RSR**
1	0.85	0.91	0.80	0.77	0.86	0.98
5	0.87	0.90	0.88	0.74	0.89	0.96
10	0.89	0.89	0.91	0.73	0.91	0.96
30	0.91	0.88	0.97	0.71	1.00	0.95
60	0.91	0.89	0.99	0.71	1.03	0.94

Gold provides a somewhat smaller downside risk-reduction at a 1-day horizon, by about 15%, but the price paid is lower than for silver, with a Sharpe ratio equal to 0.91 times that of the equity-only portfolio. The results suggest that at increasing horizons, the risk reduction potential of the three precious metals decrease. Specifically, while a 10% allocation to gold removes 15% of downside risk at a 1-day horizon, at a 60-day horizon the reduction is only 9%. Considering the cost of hedging downside risk with gold, the relative Sharpe ratio decreases by a modest amount from 0.91 to 0.89 as the investment horizon increases from 1 day to 60 days.

The long-horizon risk reduction available to an investor employing silver or platinum to hedge equity portfolio downside risk is much weaker. While both reduce risk at a 1-day horizon, any benefits are largely expunged at a 60-day horizon. In fact, for platinum, an investor with a horizon of 60 days will experience an increase in downside risk. The cost of including either silver or platinum in the portfolio is substantial, particularly at long horizons. For the longest horizon examined, an investor with a 10% allocation to gold only reduces downside risk by 1% but surrenders 29% of the equity-only risk adjusted returns. The analogous results for platinum suggest an increase in downside risk and a decrease in Sharpe ratio.

The paper considers alternative proportional allocations and shows that they provide analogous findings. Time variation in risk-reduction benefits is notable, with the cost of diversification proving especially high during the 1980s, perhaps relating to an increased interest in gold as an investment asset during this period of high inflationary pressures. Furthermore, precious metal-specific exchange-traded funds and futures contracts are shown to provide an interesting and viable diversification alternative to physical metals. The risk reduction benefits found in the paper are attributed to the variance and kurtosis characteristics of precious metals.

Conclusions

This paper examines the downside risk reduction benefits of investing in precious metals. The empirical findings indicate that gold provides the most consistent risk reduction benefits across all horizons, but that investors must surrender a proportion of their risk-adjusted returns to obtain these benefits. The investment case for silver and platinum is weaker, with limited long-horizon risk reduction and higher costs, as borne out by lower risk-adjusted portfolio returns. While previous research has advocated gold as a costless way to reduce risk, the finding of a reduced Sharpe ratio highlights that investors may have to forego performance to diversify away downside risk. Further research is warranted to identify the downside risk benefits of precious metals across an optimized portfolio containing a larger investment opportunity set.

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Keywords

Precious metals, gold, downside risk, risk-adjusted returns.

Futures Trading and the Excess Co-movement of Commodity Prices

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The authors empirically reinvestigate the issue of the excess co-movement of commodity prices initially raised in Pindyck and Rotemberg (1990). Excess co-movement appears when commodity prices remain correlated even after adjusting for the impact of fundamentals. The authors use recent developments in large approximate factor models to consider a richer information set and adequately model these fundamentals. They consider a set of eight unrelated commodities along with 184 real and nominal macroeconomic variables, from developed and emerging economies, from which nine factors are extracted over the 1993–2013 period. Their estimates provide evidence of time-varying excess co-movement which is particularly high after 2007. They further show that speculative intensity is a driver of the estimated excess co-movement, as speculative trading is both correlated across the commodity futures markets and correlated with the futures prices. Their results can be taken as direct evidence of the significant impact of financialization on commodity-price correlations.

Introduction

This paper revisits the issue of the excess co-movement of commodity prices in the context of a growing financial influence in commodity markets for the past two decades. Pindyck and Rotemberg (1990) (PR hereafter) define excess co-movement as commodity prices remaining correlated after adjusting for common macroeconomic variables representing aggregate demand and supply.

In this context, one major issue is the selection of the common macroeconomic variables to filter commodity returns. A first contribution of the paper is to use the large factor approximate modelling approach of Stock and Watson (2002a, 2002b) to extract significant indicators from a set of 184 macroeconomic variables of developed and emerging countries. The authors find that commodity returns are explained by the first extracted factor, that is highly correlated with the real variables of emerging countries, and by the second factor, that is correlated with the nominal variables. These findings highlight the role played by these emerging countries in shaping commodity prices in the recent years. The authors further investigate the behavior of excess co-movement through time.

A second contribution of the paper is to study the empirical relationship between excess co-movement and speculative activity in commodity futures markets. Using data from the U.S. Commodity Futures Trading Commission (CFTC), the authors find empirical evidence that an indicator of speculative trading is able to explain this excess co-movement. These results give support to Barberis and Shleifer (2003)'s contention that investors view commodities as a single "commodity style" asset and lends indirect support

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to the theoretical model of Basak and Pavlova (2016) which predicts that the correlation between commodity returns can be explained by the positions of institutional investors.

Filtering Commodity Returns with Macro Variables

The analysis is based on monthly observations from February 1993 to November 2013 for a sample of 8 commodities[1] which are representative of the main commodity classes. Arguably, according to their negligible supply and demand cross-elasticities, these commodities should be unrelated. Instead, as a first step, the authors find 15 positive and significant correlations between their commodity returns.

To explain the correlations, the authors put together a comprehensive set of 184 real and nominal macroeconomic variables for developed countries (Australia, Canada, France, Germany, Japan, the U.K., and the U.S.; 118 variables in total) and emerging countries (China, Brazil, Korea, Taiwan, Mexico inter alia; 66 variables). The real variables are country-specific measures of aggregate economic activity (e.g., industrial production index, manufacturing orders, and capacity utilization) and the nominal variables are country-specific monetary aggregates, stock indices, interest rates, price indices, and exchange rates.

The static large factor model of Stock and Watson (2002a) is used to extract key common information from the comprehensive set of macro variables. Each variable is split into a component driven by a small set of common factors and an idiosyncratic component. The factors obtained by the principal components method are ordered according to their explanatory power from largest to smallest. The authors focus on the first 9 factors that explain around 37% of the total variation in the original set of 184 macroeconomic variables. As in Stock and Watson (2002b) and Ludvigson and Ng (2009), the authors consider all possible groupings of these factors to select per commodity the regression specification for returns, which minimizes the Bayesian Information Criterion. Finally, the Seemingly Unrelated Regression (SUR) approach is used to jointly estimate the 8 commodity regressions selected.

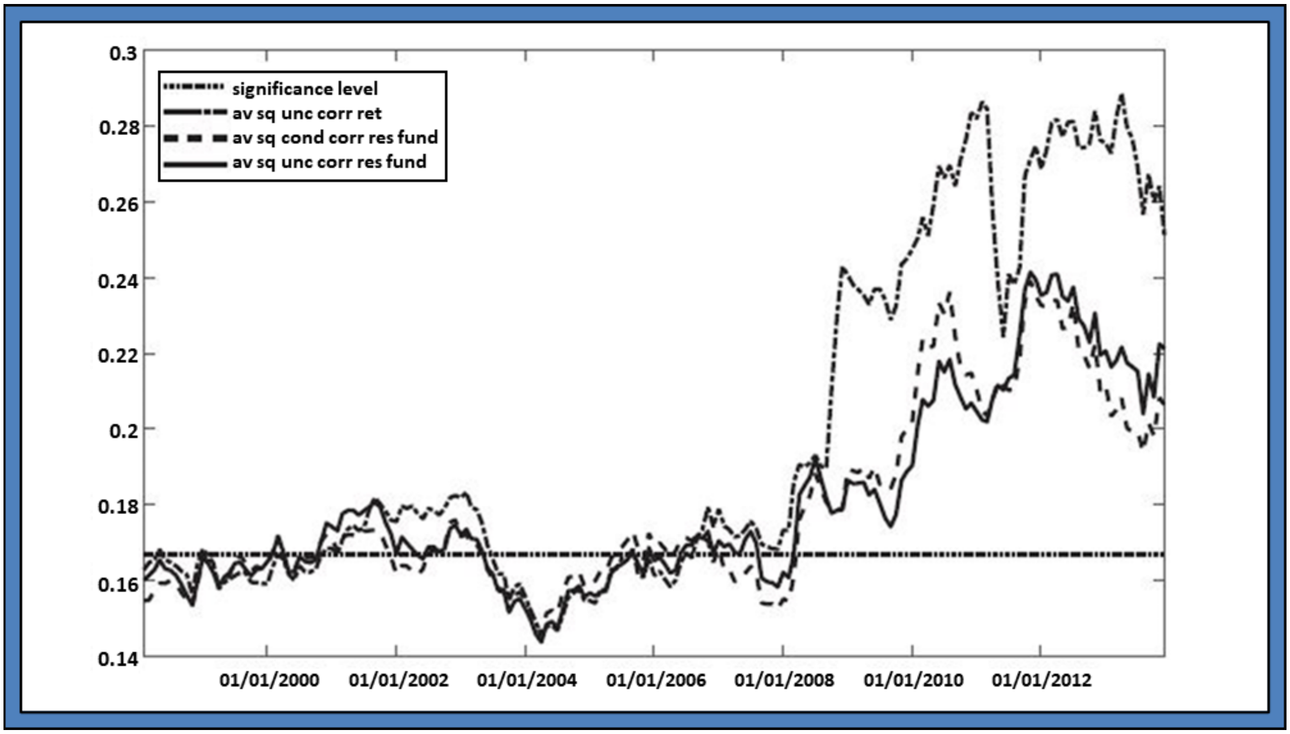
In spite of the large set of macro variables considered, the extracted factors explain only a small part of the variation in the commodity returns, except to a certain extent for copper and crude oil. The most significant factors are the first and second one. The first factor is mostly correlated with real variables from emerging countries. Its correlation with some commodity returns shows the role played by emerging countries in shaping commodity prices in recent years. The second factor is mostly correlated with nominal variables which reaffirms earlier contentions (Barsky and Kilian, 2002; Frankel and Rose, 2010) about the relationship between interest rates and commodity price movements.

Excess Co-movement of Commodity Returns

Next the authors examine the filtered commodity returns (i.e., the residuals from the SUR regressions) and observe that filtering out the common macroeconomic effects reduces only marginally the number of significant cross-correlations. At the 5% significance level, 10 out of 15 correlations are still significant, which is interpreted as evidence of excess co-movement. The authors compute a global, unbiased and time-varying indicator of excess commodity co-movement by deploying the Forbes and Rigobon (2002) unbiased estimator to compute each residual correlation recursively through 30-month rolling windows.

The indicator thus computed as the mean of the squared unbiased correlation for all commodities gives an overall picture of the pattern of excess co-movement, as shown in Figure 1.

Figure 1
Mean Excess Squared Correlation for Commodity Raw/Filtered Returns



Notes: (i) "av sq unc corr ret" is the average squared unconditional correlation for the original (or raw) returns. (ii) "av sq cond corr res fund" is the average squared correlation of filtered returns. (iii) "av sq unc corr res fund" is the average squared correlation corrected for heteroscedasticity-robust filtered returns. Significance level is the minimum value above which a squared correlation is significant at 5% level.

The excess co-movement indicator is significant at the 5% level only half of the time in the period under consideration. We thus conclude that the excess co-movement in commodity prices cannot be viewed as a general feature of commodity markets; it is instead a time-dependent phenomenon. As revealed by Figure 1, the excess co-movement provides is mostly significant during periods of financial crisis: from mid-2000 to early 2003, and from 2008 onwards. In their "convective risk flows" model, Cheng *et al.* (2015) show that financial traders (speculators) cut their net long positions in response to market distress. A coordinated drop in the long positions of financial traders may thus help explain excess co-movement. Alternatively, excess co-movement may also reflect a "flight-to-quality" phenomenon, where investors decide to partly leave the stock market and invest heavily in commodities to diversify their positions. Moreover, the period starting in 2000 also corresponds to the growing financialization of commodity futures markets, as surveyed in Cheng and Xiong (2014). As such, the excess co-movement might be induced by speculative activity in commodity futures markets, a conjecture that the authors investigate empirically in the final section of the paper.

Commodity Returns and Speculative Intensity

The Commodity Futures Trading Commission (CFTC) publishes the weekly aggregate positions of "commercial" and "non-commercial" traders in the Commitment of Traders (CoT) report released each Tuesday. The authors use these long/short futures positions data to compute the Han (2008) index of speculative activity for the eight commodities in the sample. This index is equal to the number of long non-commercial contracts minus the number of short non-commercial contracts, scaled by the total open interest in futures markets for the commodity of interest; as such this is a directional index of speculative activity in the futures market. These indices are adjusted for the effect of the business cycle.

The empirical evidence from regressions estimated by the GMM method (to control for endogeneity in the speculative indices) suggest a positive and significant impact of the Han index on the respective commodity returns for 5 commodities (wheat, soybeans, raw sugar, cotton, live cattle). Negative cross effects between crude oil return and the Han speculative index are found, for instance, in cotton. The empirical evidence suggests that the speculative indices simultaneously impact most commodity returns which provides an explanation to rationalize the strong excess co-movement in the recent decade.

Conclusions

This paper brings new insights on the issue of the excess co-movement of commodity prices. It utilizes large approximate factor models to extract the key common information contained in a large set of macroeconomic variables. The extracted factors can only explain a small part of the excess co-movement. The paper documents a time-varying overall co-movement which has notably magnified post-2008 and provides evidence to suggest that it relates to speculative futures trading activity.

Endnote

1 Wheat, copper, silver, soybeans, raw sugar, cotton, crude oil, live cattle.

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Keywords

Commodity excess co-movement, factor model, futures trading, speculative trading.

Forecasting Crude Oil and Refined Products Volatilities and Correlations: New Evidence from Fractionally-Integrated Multivariate GARCH Models

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This paper advocates the use of long-memory multivariate GARCH models to forecast spot return volatilities and correlations for crude oil and related products. The findings show from a risk management perspective that the multivariate models incorporating long-memory features outperform the short-memory counterparts in providing the most accurate Value-at-Risk measures. The paper provides useful insights to non-commercial oil traders and other energy markets agents engaged in hedging and risk management operations.

Introduction

There is a consensus in the empirical literature on the effectiveness of multivariate GARCH (MGARCH) models to forecast volatilities and correlations of crude oil and refined products returns. However, all the MGARCH model specifications used in the literature so far implicitly impose a short-memory decay rate on volatilities and correlations. This is problematic since they have been shown to display a strong degree of persistence, i.e., the impact of shocks to them decays very slowly. Several univariate long-memory models, including the fractionally integrated autoregressive (ARFIMA) model and the fractionally integrated GARCH (FIGARCH) model, have been successfully used to forecast the volatilities of crude oil and refined products returns (Block *et al*., 2015; Tong *et al*., 2013; Chang *et al*., 2010; Borenstein *et al*., 1997) but, to the best of our knowledge, no attempt has yet been made to demonstrate the advantage of incorporating the long-memory feature in multivariate models.

In practice, failure to account for this very slow decay rate in the volatility and correlation processes implies misspecification of the true data generating processes which, in turn, can potentially lead to: (i) biased conclusions about the response of refined products volatility to crude oil price shocks, (ii) inaccurate volatility forecasts and (iii) flawed risk management practices.

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This paper fills a gap in the literature by assessing whether, as regards the out-of-sample prediction of volatilities and co-movements between crude oil and refined products returns, the use of multivariate long-memory GARCH models with long-memory leads to gains in statistical accuracy as well as benefits from a risk management perspective.

The paper models the volatilities and correlations of crude oil returns (West Texas Intermediate-Cushing) and two refined products return series, conventional gasoline (New York Harbor) and heating oil (New York Harbor), by means of different MGARCH models, including the fractionally integrated dynamic conditional correlation (DCC) model. The models are rigorously compared in-sample and from an out-of-sample forecasting perspective to assess whether long-memory specifications with dynamic correlations and asymmetries outperform their short memory counterparts. The models' attractiveness in terms of risk management is assessed by forecasting the Value at Risk.

Relevance of the Research Question

Crude oil prices are central to global economic activity. Crude oil is of limited direct usage as a fuel. It is the range of products yielded by refining crude oil which are consumed either directly (e.g., gasoline and diesel for motor vehicles) or indirectly (e.g., fuel oil to generate electricity, or naphtha as petrochemical feedstock). Because of the need to transform crude oil into refined products, the interaction between upstream producers and downstream consumers is not direct. Prices for refined products can be linked back to those of crude oil through the netback mechanism. Refined product prices should theoretically be linked to the cost of acquiring crude oil (of various qualities and provenances), transporting it (via pipelines or tankers, often from abroad) to the transformation point, storing it, refining it, storing the refined products and distributing these products to a myriad of consumption points, which may be located abroad as well. Such calculations might be feasible if all the relevant information were publicly available and easily accessible. As this is not usually the case, researchers investigate the linkages empirically using models estimated with data for the most commonly traded crude oils and refined products.

The subject of the paper is important because return volatilities and correlations of crude oil and refined products are key inputs to macroeconomic models, option pricing models, investment portfolio construction, and hedging and risk management practices inter alia. These practices are of particular significance to the refining industry, which forms the nexus between crude oil production and final consumption and which is exposed to risks from the supply and demand sides of the marketplace.

Data and Models

The paper estimates 48 different MGARCH models using daily spot price returns on crude oil (CO), conventional gasoline (CG) and heating oil (HO) from 1 June 1993 to 1 June 2018 from the Energy Information Administration (EIA) of the U.S. Department of Energy. The daily return is calculated as the difference in the logarithmic closing price.

Examining the data, it is observed that the average daily returns are very small compared to the sample standard deviations. The returns display some evidence of skewness and excess kurtosis (deviation from normality). More importantly for the present purposes, the correlogram and the Ljung–Box Q statistic for serial correlation of the squared returns suggests a very strong degree of persistence in all volatility series, consistently with a long-memory decay rate. The latter is confirmed by estimating semi-parametrically for each series the long-memory parameter *d* using the local Whittle estimator of Robinson (1995) with bandwidth m = 100 and no trimming. To account for serial correlation in the data, we fit a VAR(p) model to the returns finding that a VAR(1) parameterization suffices to account for the conditional mean dynamics of the series. There is no evidence of spillover effects between the means series.

Results

In-sample results show strong evidence of GARCH-type dynamics, long-range dependence and leverage effects in the individual volatilities. In terms of the multivariate structure, the data strongly support the hypothesis of dynamic conditional correlations.

The most important finding of the paper is that the use of multivariate GARCH models with a *long-memory* significantly improves the out-of-sample forecasting accuracy of volatilities and correlations from the viewpoint of statistical loss functions and economic loss functions.

Using a fixed rolling window scheme, the authors assess the 1-, 5- and 20-day ahead out-of-sample forecasting accuracy of the models using different statistical approaches and criteria (Laurent *et al*., 2012; Hansen, 2005). Since the processes under study (volatilities) are unobservable/latent, the authors consider various matrix loss functions which are robust to the choice of the volatility proxy. Then they evaluate the models' forecasting performance in an economically meaningful way by using the model forecasts as inputs to obtain Value-at-Risk predictions.

The results suggest that models with a long-memory decay rate surpass the short-memory counterparts from a statistical as well as an economic perspective and their use can significantly improve the assessment of oil market risk. The sensitivity of the results to the sample period under study is examined by considering, in addition to the full sample, three sub-samples. The findings indicate that it is particularly important to incorporate long-memory in the multivariate models when the period to be forecasted is a turbulent (as opposed to tranquil) one. Finally, it is also shown that accounting for long-memory in the modeling tools is particularly important when the forecasting horizon is as lengthy as 21 days ahead.

Conclusions

This paper advances research on the modeling of crude oil markets and the markets of refined products by comparing the return volatility and correlation forecasts obtained from multivariate long-memory GARCH models with those obtained from the simpler short-memory models that have been used thus far in the energy markets literature. The results endorse the former and are particularly important for agents including refiners and oil trading companies who have risk exposures to both the crude and refined sides of the market. Risk managers in such companies may consider the long-memory models advocated in this paper to improve their Value-at-Risk forecasts and risk management practices.

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Keywords

Crude oil and refined products correlations, volatility forecasting, multivariate GARCH with long memory, Superior Predictive Ability test, Value-at-Risk.

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