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Variance risk in commodity markets[☆]

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ABSTRACT

We analyze the variance risk of commodity markets. We construct synthetic variance swaps and find significantly negative realized variance swap payoffs in most markets. We find evidence of commonalities among the realized payoffs of commodity variance swaps. We also document comovements between the realized payoffs of commodity, equity and bond variance swaps. Similar results hold for expected variance swap payoffs. Furthermore, we show that both realized and expected commodity variance swap payoffs are distinct from the realized and expected commodity futures returns, indicating that variance risk is unspanned by commodity futures.

1. Introduction

Over the past few years, several commodity-related volatility instruments, such as oil and gold VIX, have been introduced. The proliferation of these products raises several questions. Chief among them include: how large is the compensation required by investors to bear variance risk in commodity markets? Are there commonalities among realized commodity variance swap payoffs? How do these payoffs relate to those of the bond and equity markets? What is the relationship between the return on a commodity futures and the variance swap payoff on the same commodity? These are some of the questions we seek to answer in this paper.

We analyze variance risk in 21 commodity markets. On average, we document significantly negative realized variance swap payoffs in most commodity markets. We find that the variance swap payoffs of commodity markets are related to those of the S&P 500 index. However, the commodity variance swaps offer additional payoffs beyond what an investor with a passive exposure to the equity index variance swap payoff would earn. We document that the realized commodity variance swap payoffs are generally unrelated to commodity futures returns. An implication of this result is that commodity variance risk is not spanned by commodity futures. Similar results arise for the expected variance swap payoffs, i.e. the variance risk premia.

Our paper adds to the research of Coval and Shumway (2001), Bakshi and Kapadia (2003a, 2003b), Carr and Wu (2009), Driessen et al. (2009), Trolle and Schwartz (2010), Wang et al. (2011) and Choi et al. (2016), who study variance risk in a range of markets. Bakshi and Kapadia (2003a, 2003b) use a delta-hedging approach and find significant payoffs in individual equity options. Carr and Wu (2009) and Driessen et al. (2009) construct synthetic variance swaps and find little evidence of significant variance swap payoffs in individual equities. The conflicting evidence reported in extant studies may be due to their fairly short sample periods and different methodologies, which make the results difficult to compare.

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Our study also complements the contributions of Gorton et al. (2013), Daskalaki et al. (2014) and Szymanowska et al. (2014), among others, on commodity futures returns. We focus on the compensation that investors require for bearing variance (rather than futures return) risk in commodity markets. We show that commodity variance swap payoffs are largely unrelated to commodity futures returns, suggesting that variance risk cannot be hedged by trading in the corresponding commodity futures market.

Our results are relevant for risk management in commodity markets. The existence of economically important variance swap payoffs in commodity markets challenges the common practice of relying on implied variance to obtain unbiased forecasts of future variance. To obtain a more accurate prediction of future variance, one must specifically account for the role of the variance risk premium (Prokopczuk and Wese Simen, 2014; Kourtis et al., 2016). Failure to do so would result in biased forecasts and suboptimal risk management decisions.

This paper proceeds as follows. In Section 2 we introduce our methodology and describe the data set employed. In Section 3 we present and discuss our empirical results. Finally, Section 4 concludes.

2. Methodology and data

2.1. Data

We obtain our futures and option data from the Commodity Research Bureau (CRB). Table A.1 of the online appendix introduces the 21 commodities included in our sample. These commodity markets cover a variety of sectors, including energy and wood commodities. Overall, our dataset spans the period from January 1984 to July 2011. However, the exact starting date varies from one market to another depending on data availability. Table A.2 of the online appendix specifies the starting date of the option data for each commodity market. The data set contains information on the strike price, maturity and settlement price of individual commodity derivatives.

The last column of Table A.1 reports the average annual trading volume and open interest of individual commodity options for the period from 2008 to 2011. This information is obtained directly from the corresponding exchange.[1] We notice a lot of variation in trading activity across commodity sectors. The energy and grain sectors appear to be the most liquid groups. Relatedly, we find some heterogeneity within sectors. The energy sector illustrates this point. We can see that the average yearly trading volume in crude oil is more than 33 millions. In contrast, the comparable statistic for the heating oil options is merely 810,740.

To mitigate the effect of micro-structure related issues such as infrequent trading and stale prices, we only retain options with time-to-maturity of at least 12 days. We further discard options with prices lower than five times the minimum tick size reported in Table A.1. Given that our data set comprises American options and that our estimation approach requires European option prices, we convert the American option prices into European prices by following the standard approach of Barone-Adesi and Whaley (1987).

Our empirical analysis focuses on variance swaps with a maturity of 60 days. This decision is motivated by the observation that, with the exception of energy markets, no other commodity exhibits a monthly expiration schedule (see Table A.1). Therefore, we retain only OTM options on the two nearest maturity futures contracts. For energy commodities, we retain OTM options on the second and third nearest futures contracts. The reason for selecting the second and third nearby futures contracts is that energy commodities have a monthly expiration schedule. Table A.2 of the online appendix provides an overview of the final data set of option prices. The last two columns report the average number of OTM call and put options per trading day. Across all commodities, there are on average 17 and 14 OTM call and put options with different strike prices per day, respectively. These numbers compare well with other studies such as those of Carr and Wu (2009) and Taylor et al. (2010).

2.2. Methodology

Empirical studies on variance risk are usually anchored around one of the following three estimation approaches: parametric, semi-parametric or model-free. The parametric approach consists of specifying a data-generating process for the underlying. In this framework, variance risk is usually analyzed by exploiting information from the underlying asset and options prices. This approach is not only computationally intensive but also subject to specification errors since it depends on the modelling choice. Broadie et al. (2007) empirically examine the impact of model misspecification.

Bakshi and Kapadia (2003a) propose a semi-parametric framework based on the profitability of delta-hedged puts and calls. This approach builds on the insights of financial theory, which posits that option prices are affected by changes in implied volatility and the underlying's price. Since delta-neutral positions are insensitive to small movements of the underlying's price, their profitability may shed light on the compensation investors require for bearing volatility risk. Though intuitive, this approach is still vulnerable to the criticism that it relies on a specific hedging model.

The more recent model-free approach builds on variance swaps defined as swap contracts in which the floating leg corresponds to the realized variance of the underlying over a predetermined period. The idea is to study the realized variance swap payoffs, defined as the differences between the realized variance and the risk-neutral expectation of variance. No-arbitrage arguments imply that the variance swap rate, which is known at inception, must be equal to the risk-neutral expectation of variance over the life of the swap. The realized payoff to a variance swap contract (with a notional of 1) can be computed at expiration as follows:

$$VSP_{t+\tau} = RV_{t\to t+\tau} - SV_{t\to t+\tau} \tag{1}$$

$$VSP_{t+\tau} \equiv RV_{t\to t+\tau} - \mathbb{E}_t^{\mathbb{Q}}(V_{t\to t+\tau}) \tag{2}$$

where $VSP_{t+\tau}$ is the annualized variance swap payoff computed at $t+\tau$. τ indicates the time-to-maturity, expressed in months, of the variance swap at inception. $RV_{t\to t+\tau}$ denotes the annualized realized variance computed using all return data for the period starting at t and ending at $t+\tau$. SV_t is the annualized variance swap rate at time t, which is equal to the risk-neutral expectation of variance $\mathbb{E}_t^{\mathbb{Q}}(V_{t\to t+\tau})$ for the period starting at t and ending at $t+\tau$.

Realized Variance. We use the following estimator to compute the annualized realized variance:

$$RV_{t\to t+\tau} = \frac{12}{\tau}\sum_{i=t}^{t+\tau-1}\left(\log\frac{F_{i+1}}{F_i}\right)^2 \tag{3}$$

where F_i denotes the price of the futures contract observed at time i. It is worth pointing out that futures contracts have a finite life. Thus, if one directly implements the formula above, the returns

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[1] Ideally, one should report the average annual open interest and trading volume for the full sample period. Alas, the CRB does not provide such information. Fortunately, the exchanges recently started reporting volume and open interest data. We use the information for the period 2008–2011 as an indication of trading activity in commodity markets. This is the longest period over which this information is publicly available across all exchanges. Section 3.3.6 addresses the concerns related to the tradability of these instruments.