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Time-varying efficiency in food and energy markets: Evidence and implications

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ABSTRACT

This paper analyses weak-form efficiency in daily spot and futures prices in the food and energy markets, given the simultaneous volatilities characterising prices in both markets. To determine the structural breaks and efficiency changes over time, we use the time-varying rolling Hurst exponent and threshold vector error correction models. Our main findings indicate that all of the studied commodities exhibit long-term efficiency and short-term inefficiencies that can be explained by global economic conditions: the 2008 global financial crisis, financialisation of commodities markets, and fluctuations in crude oil prices. Time-varying optimal weights minimising the portfolio risk show different patterns between food and crude oil. In terms of hedging effectiveness, food futures are better than crude oil futures. Therefore, optimal portfolios risk hedging requires an adequate rebalancing between spot and futures prices depending on markets conditions and the type of commodities considered. Investigation of the semi-strong efficiency form of these markets through the consideration of intra-day prices could constitute a future extension of the present work.

1. Introduction

With the volatility in food prices in recent years, more attention has been paid to futures contracts, which are considered the most important means for price discovery and risk management (Chang et al., 2011; Chang and Lee, 2015; Ruan et al., 2016). Given the sustained, growing divergence between futures and spot prices in food markets (wheat, corn, and soybean) during 2005–2011 (Aulerich et al., 2011), the efficiency of futures has become controversial. Movements in food prices have been both simultaneous and in similar directions to those in energy markets (Jebabli et al., 2014), rendering investigations of the interactions between these two markets more interesting (Bouri et al., 2017). The links between these two markets have been explained in the literature according to three main channels: the use of oil for agricultural production, the biofuel channel, and macroeconomic factors (Algieri, 2014; Chiu et al., 2016; Koirala et al., 2015; López Cabrera and Schulz, 2016; Olson et al., 2014; Reboredo, 2012; Wei and Chen, 2016).

In this paper, we aim to investigate the efficiency of food and energy

markets in terms of the relationships between their spot and futures prices based on the fact that efficient markets are characterised by the simultaneous incorporation of new information into their spot and futures markets (Zhong et al., 2004). We also aim to determine which of these markets allows for better futures hedging.

Interest in this issue has been increasing, specifically since the introduction of passively and actively managed exchange traded funds (ETFs).¹ In fact, one of the most important decisions for investors is deciding on their management strategies based on past information; this importance has pushed investors to focus on market efficiency by considering the possible short-term deviations in spot and futures prices (Ruan et al., 2016). A review of the extant literature debating the superiority of active versus passive management strategies² in terms of increases in market efficiency reveals that the theories on this subject are conflicting. In fact, studies addressing the impact of active and passive management strategies can be categorised into two groups: the first group argues that active management enhances market efficiency (Grossman and Stiglitz, 1980), while the second emphasises the

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¹ The Investment Company Institute Fact Book (2014) indicates that the total number of passively and actively managed ETFs had increased to 1332 and that total net assets were 1.675 trillion USD by the end of 2013.

² Active management consists of beating the market, typically symbolised by a type of index, while passive management is based on constructing a portfolio in a manner that mimics a market index.

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underperformance of active management in terms of achieving market efficiency (Busse et al., 2010; Fama and French, 2010; Wermers, 2000), supporting the idea that passive strategies are better than active ones (Andriosopoulos and Nomikos, 2014).

In recent years, spot and futures commodity markets have been considered alternative investment instruments for hedging against risk in equity markets due to the lower diversification benefits from equity investments during financial crises and the growing financialisation of commodity markets (Sensoy et al., 2015).

To restrain or reduce the risk of unfavourable price changes, hedging through trading futures contracts has been considered one solution (Chang et al., 2011). Information on hedging is required by investors to decide on appropriate positions in the futures markets, allowing them to compensate for the risk from their corresponding holdings in the spot market (Fan et al., 2016). Although particular attention has been paid to hedging through commodity futures in recent years, papers in the empirical literature focusing on commodities' risk-hedging in a time-varying framework are scarce (Mellios et al., 2016).

Our paper contributes to the literature by studying the time-varying efficiency of food markets (corn and soybean) compared to energy markets and investigating the impact on hedging through futures in an inter-temporal context. We opt for the time-varying rolling Hurst exponent and threshold cointegration methods, which allow us to consider structural breaks and capture the nonlinearity in the adjustment of the deviations towards long-term equilibrium. To elucidate the usefulness of the futures markets as a tool for risk management, we focus on estimating optimal hedge ratios and evaluating the effectiveness of hedging based on a multivariate dynamic conditional correlation generalised autoregressive heteroskedasticity (DCC-GARCH) model. To the best of our knowledge, this study is the first investigating the link between the efficiency of these markets and hedging in a time-varying context.

The remainder of this paper is as follows. Section 2 presents a literature review of the main studies addressing market efficiency and hedging. Sections 3 and 4 describe our proposed methodology and a pertinent preliminary data analysis, respectively. Section 5 is devoted to a discussion of our empirical findings. Finally, Section 6 summarises our conclusions and discusses their policy implications.

2. Literature review

According to the weak form of the efficient market hypothesis (Fama, 1970), futures prices cannot be predicted on the basis of past spot prices. Two main financial theories focusing on the relationship between spot and futures prices can explain the results of the investigation of market efficiency. The first theory corresponds to the non-arbitrage theory, or the theory of storage (Kaldor, 1939), according to which the difference between spot and futures prices is explained by the cost of carrying (i.e., the sum of the cost of storage and the interest rate) and convenience yield. The second is the asset pricing theory, according to which the price of a futures contract is influenced by the expected future spot price, conditional on the information set. Based on these theoretical models of the spot-futures relationship, spot and futures prices are expected to be linked.

Furthermore, only a few of the available studies have addressed the time-varying efficiency in detecting the changing degree of market efficiency over time and the existence of potential structural breaks (Khediri and Charfeddine, 2015). Moreover, recent studies indicate that the market is not perpetually in equilibrium (Lo, 2005, 2004).

Based on the previous literature, although market efficiency has been studied thoroughly, investigations into the efficiency hypothesis for commodity markets have not yet been sufficiently developed and have been a long-standing agenda in financial economics (Go and Lau, 2017; Hosseinzadeh et al., 2016).

In previous studies, particular attention has been paid to weak-form efficiency in energy markets, in which energy price movements substantially affect the performance of most economic sectors at different

levels and through various channels (Lescaroux and Mignon, 2008). Most recent studies focusing on energy market efficiency have emphasised the presence of time-varying efficiency using different methods (see, e.g., Arouri et al., 2013; Chang and Lee, 2015; Chen et al., 2014; Jawadi et al., 2017; Khediri and Charfeddine, 2015; Mensi et al., 2014; Ortiz-Cruz et al., 2012; Sensoy and Hacıhasanoğlu, 2014; Zhang, 2013; Zhang et al., 2014).

Based on linear cointegration, non-linear cointegration, and error correction models (ECMs), Arouri et al. (2013) tested the short- and long-term efficiencies of nine energy and precious metal markets. Their findings rejected the short-term efficiency hypothesis and identified two distinct regimes: the efficiency hypothesis was supported in the first regime and rejected in the second.

Chen et al. (2014) also utilised cointegration models and Granger causality tests. Their results indicated the presence of one structural breakpoint (July 2004) in the long-term relationship between spot and futures oil prices and emphasised the effects of structural breaks on the efficiency of oil markets.

Cointegration techniques were also used in a recent study by Chang and Lee (2015), which focused on oil spot and futures prices from January 1986 to February 2014. They highlighted the evidence of a long-term cointegration relationship between these prices.

Ortiz-Cruz et al. (2012) applied entropy analysis to daily West Texas Intermediate (WTI) crude oil prices from January 1986 to March 2011. Their results indicated that, apart from the two episodes of inefficiency connected to the US recessions in the early 1990s and late 2000s, the market is efficient, and they emphasised the impact of market deregulation on the improvement in this efficiency.

Sensoy and Hacıhasanoğlu (2014) applied a rolling-window approach (covering the period from 1990 to 2013) and estimated the time-varying generalised Hurst exponents of several daily energy futures contracts with different months to maturity. They found that time variation in the efficiency of the energy futures can be severe due to several factors, including financial crises, supply shocks, and regulations.

Mensi et al. (2014) considered different models for the investigation of time-varying weak-form efficiency and the presence of structural breaks for two worldwide crude oil benchmarks. Their findings revealed that the Hurst exponent outperforms the Shannon entropy method for describing crude oil dynamics. Their main findings also indicated that turbulent events are responsible for the inefficiency of crude oil markets.

In addition to cointegration models, the Hurst exponent, and Shannon entropy, other methods have been considered in recent studies.

Zhang (2013) applied a generalised spectral test method and the rolling-window approach to daily data on four major crude oil markets and found that crude oil markets are weak-form efficient in the long term, with some inefficiencies in the short run during certain extreme events.³

Zhang et al. (2014) used the time-varying general auto-regression-threshold GARCH (GAR(1)-TGARCH(1,1)) model to test the weak-form efficiency of crude oil spot markets. Their findings showed that efficiency is time-variant, and they underscored the significant effects of the 2008 financial crisis on the efficiency of oil markets.

Using detrended fluctuation analysis (DFA) and variance ratio (VR) tests, Khediri and Charfeddine (2015) applied a rolling sample approach to investigate the time-varying efficiency of energy market. Their main findings indicated the presence of time-varying weak-form efficiency, depending on the prevailing economic and political conditions.

Resorting to parametric and non-parametric econometric tests, Jawadi et al. (2017) investigated the efficiency of four commodity markets (oil, gas, electricity, and coal) using daily closing prices in 1997–2016. Their findings indicated that these commodities are short-run inefficient and confirmed their long-term efficiency.

Nevertheless, the literature has paid little attention to food market

³ The effects of extreme events on short-term market efficiency were discussed in detail in Wang and Wu (2012).

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