Energy Economics 40 (2013) 832–844

Contents lists available at ScienceDirect

Energy Economics

journal homepage: www.elsevier.com/locate/eneco

On the short- and long-run efficiency of energy and precious metal markets

Mohamed El Hedi Arouri [a,b], Shawkat Hammoudeh [c,*], Amine Lahiani [d,e], Duc Khuong Nguyen [f]

[a] University of Auvergne, France
[b] EDHEC Business School, France
[c] LeBow College of Business, Drexel University, United States
[d] LEO, University of Orléans, France
[e] ESC Rennes Business School, France
[f] IPAG Lab, IPAG Business School, France

ARTICLE INFO

Article history:
Received 22 November 2012
Received in revised form 1 October 2013
Accepted 5 October 2013
Available online 18 October 2013

JEL classification:
C3
C5
G1

Keywords:
Market efficiency
Precious metals
Energy markets
Linear and nonlinear ECM models

ABSTRACT

This article contributes to the related literature by empirically investigating the efficiency of nine energy and precious metal markets over the last decades, employing several pronounced models. We test for both short- and the long-run efficiency using, in addition to linear cointegration models, nonlinear cointegration and error-correction models (ECMs) which allow the efficiency intensity to change per regime. Our findings can be summarized as follows: *i*) futures prices are found to be cointegrated with spot prices, but they do not constitute unbiased predictors of future spot prices; *ii*) the hypothesis of risk neutrality is rejected; *iii*) the short-run efficiency hypothesis is rejected, suggesting that using past futures price returns improves the modeling and forecasting of future spot prices; and *iv*) the nonlinear modeling suggests the presence of two distinct regimes wherein the first regime the efficiency hypothesis is supported, whereas in the second it is rejected. The empirical findings have important implications for producers, hedgers, speculators and policymakers.

1. Introduction

International financial markets have known a succession of serious crises since 1987 (e.g., the 1997–1998 Asian crisis, the 2001 dot com recession, the 2001 Argentina economic crisis and the 2007–2010 global financial crisis), which are commonly characterized by high volatility and contagion effects (Forbes and Rigobon, 2002; Lee et al., 2007; Markwat et al., 2009). Recent studies also suggest lower diversification benefits from equity investments due to the increased correlations between equity markets around the world, particularly during times of high and extreme volatility (Chan-Lau et al., 2004; Diamandis, 2009). These stylized facts have undeniably encouraged investors to consider alternative investment instruments as a hedge against increasing risk and uncertainty in equity markets. Energy products (mainly oil, oil-related and natural gas contracts) and precious metals (mainly gold, palladium, platinum and silver) have emerged as natural desirable asset classes for international portfolio diversification because of their different volatile returns and low correlations with stocks (Arouri and Nguyen, 2010; Conover et al., 2010; Daskalaki and Skiadopoulos, 2011; Hammoudeh et al., 2013). The flight-to-quality phenomenon equally occurs when financial instability increases and deepens in the stock markets or when the price of oil exhibits long swings. Indeed, most investors, for fear of losses, allocate their investments to precious metals which are viewed as safe-haven and refuge assets during widespread market panics. On the other hand, the sharp increase in the level and volatility of commodity prices over the last decade, owing to increased commodity demand from emerging countries and growing financialization of commodity markets (derivative trading and financial investor activity), has given rise to considerable interest in the factors driving commodity prices (Domanski and Heath, 2007; Dwyer et al., 2011). That is, commodity markets have also become somewhat more like financial markets. Choi and Hammoudeh (2010) also find that similar to those of the S&P 500 equity market index, the dynamics of five strategic commodities including crude oil and precious metals is governed by two volatility regimes. These commodity prices are also found to be affected by macroeconomic variables and subject to herding behavior. Likewise, Creti et al. (2013) examine the links between price returns for 25 commodities and the S&P 500 index over the period 2001–2011 and

* Corresponding author. Tel.: +1 610-949-0133; fax: +1 25-895-6975.
E-mail addresses: mohamed.arouri@udamail.fr (M.E.H. Arouri), hammousm@drexel.edu (S. Hammoudeh), amine.lahiani@univ-orleans.fr (A. Lahiani), duc.nguyen@ipag.fr (D.K. Nguyen).

0140-9883/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.eneco.2013.10.004

show that the conditional correlations between commodity and stock markets change over time and are highly volatile. These authors also note that the 2007–2008 financial crisis strengthens the links between these markets as well as underlines the financialization of commodity markets particularly as indicated by evidence of speculation for oil, coffee and cocoa markets. This has led to considerable interest in commodity markets as evidenced by the extent to which they have reflected the 'fundamental' determinants of demand and supply versus the growing financialization of these markets. All are more likely to be influenced by demand, supply and expectations about future business cycles. The observed increases in price speculations and the high degree of elastic substitution among energy products and between precious metal contracts in both consumption and production all call for a careful investigation of their price dynamics.

The energy and precious metal futures contracts allow hedgers to secure the prices of their expected purchase or sale of energy products and precious metals at a specified delivery date in the future. The prices of futures contracts thus convey information about expectations of market participants concerning the spot prices at the maturity date. Such information is crucial for agents not fully hedged as well as for agents planning for future production or use of precious metals and energy products. The importance of futures prices thus arises in particular with their ability to forecast spot prices at specified future dates as they provide economic agents with means of managing the risks related to the trading of energy products or precious metals in the spot markets. While all risk management tools share a common interest, i.e., minimizing the risk against an unfavorable evolution of future spot prices, their use is conditional on some market conditions among which informational efficiency is most important. Having its root in the well-known efficient market theory of financial economics, informational efficiency refers to the degree to which market prices reflect accurately and instantaneously all the relevant information about the true underlying value of financial securities. In this schema of things, the informational efficiency matters in two main ways. First, if a particular market is inefficient, investors may build up various trading strategies that lead to earn abnormal returns. Note however that these abnormal returns can only be made in the short-run when the opportunity arises, but should be arbitraged away in the long run when all investors do the same. Second, if all relevant information is incorporated in financial securities' prices as soon as they appear, new capital will go to the most productive investments. These features thus highlight the necessity of research on the efficiency of asset markets.

The efficient market hypothesis (EMH), formally developed by Fama (1965, 1970), has been tested for a variety of asset classes including commodities. As far as the energy and precious metal markets are concerned, this hypothesis implies that futures prices constitute the best unbiased forecasts of future spot prices plus or minus a time-varying risk premium, and thus speculators cannot earn abnormal profits. On the other hand, futures prices are unbiased forecasts of future spot prices if one or more speculators are risk-neutral. Therefore, the question of whether or not commodity prices behave according to the market efficiency hypothesis matters because efficiency enables one to know if speculative returns could be earned. To date, several empirical studies have addressed this issue for commodity markets (Aggarwal and Sundararaghavan, 1987; Alvarez-Ramirez et al., 2010; Arouri et al., 2010; Booth and Kaen, 1979; Ortiz-Cruz et al., 2012; Solt and Swanson, 1981; Tabak and Cajueiro, 2007), but their focus is mainly on the stochastic properties of successive spot and/or futures price changes of gold, silver and crude oil.

Comparing to previous studies, this article tests the hypotheses of informational efficiency and risk neutrality for energy and precious metals markets over the short- and the long-run, using both linear and nonlinear techniques among which the exponential smooth transition error-correction model (ESTECM) is of particular interest. Indeed, a market may experience some inefficiency in the short-run but it remains globally efficient in the long-run. These different patterns of the price behavior have obviously important but also very different implications for market operators. Moreover, because of transaction costs, information asymmetry and investors' heterogeneous expectations, markets can be inefficient during a certain regime. As a result, the use of nonlinear models is of particular interest for capturing short-run changes in the efficiency intensity over different regimes. Under the efficient and risk neutrality hypotheses, the futures price will be an optimal forecast of the future spot price at the contract termination. Furthermore, the efficiency hypothesis also states that asset prices fully and instantaneously reflect all available information so that no traders can consistently earn abnormal profits by speculating in the futures prices. Our paper also contributes to the literature by testing this hypothesis. Thus, we propose an integrated approach to empirically test the market efficiency and risk-neutrality hypotheses in the presence of nonlinearity at both the short- and long-run levels for petroleum (WTI, gasoline, heating oil, and propane), natural gas and precious metals markets (gold, silver, palladium, and platinum). We particularly examine the dynamic relationships between the spot and futures prices of these markets, most of which have not been researched well in the market efficiency literature.

The remainder of this article is organized as follows. Section 2 briefly reviews the related literature. The empirical framework is introduced in Section 3. Section 4 describes the data used and reports the obtained results. Section 5 discusses and concludes the main implications of the empirical results.

2. Literature review

As noted earlier, the previous literature has been mostly concerned with testing the efficiency hypothesis of spot and/or futures markets for crude oil, gold, and silver. For oil and oil-related product markets, this literature begins with Green and Mork (1991) who examine whether the official prices of crude-oil contracts are efficient in the sense of Fama (1970), i.e., whether the price of a futures contract on crude oil is an efficient predictor of the *ex-post* spot price at the time of merchandise delivery, if all the relevant information was available at the time when the contract was set up. Using the generalized method of moments (GMM) to make inferences about the predictability of monthly prices on Mideast Light (including Arabian Light, Iraq-Basrah Light, and Kirkut) and African Light/North Sea crude oils, Green and Mork (1991) reject the weak-form efficiency for the whole sample period 1978–1985 because the futures-spot price differentials can be predicted by their own past values. They however show evidence of efficiency improvement over time as the forecastability of the futures-spot price differentials is lower during the more recent subperiod 1981–1985 than during the subperiod 1978–1981. More recently, Switzer and El-Khoury (2007) test the efficiency of the NYMEX (New York Mercantile Exchange) light sweet crude oil futures contract market during the recent period of extreme volatility, and find that the prices of crude oil futures contracts are cointegrated with the spot prices. Maslyuk and Smyth (2008) examine the efficiency of crude oil markets by analyzing the weekly spot and futures prices for both West Texas Intermediate (WTI) and Brent crude oil prices over the period from January 1991 through December 2004. They employ Lagrange Multiplier unit root tests allowing for one and two structural breaks, and show that each of the oil price series follows a random walk, i.e., the crude oil markets under consideration are weak-form efficient. Differently, Shambora and Rossiter (2007) find evidence against the validity of the EMH for the NYMEX crude oil futures contracts. Their results from an artificial neural network (ANN) model and several technical trading rules show significant predictability in the futures market for oil. There is also evidence to support the hypothesis of evolving efficiency through time (Alvarez-Ramirez et al., 2008, 2010; Arouri et al., 2010; Elder and Serletis, 2008; Ortiz-Cruz et al., 2012; Tabak and Cajueiro, 2007). Tabak and Cajueiro (2007) investigate the time-varying degrees of long-range dependence in the Brent and WTI