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Cointegration and causal linkages in fertilizer markets across different regimes

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HIGHLIGHTS

- Fertilizers markets are closely linked to each other during low and high regimes; and, particularly during high regime (after crisis).
- All significant linkages are only unidirectional.
- Causality effects have emerged during high regime (after crisis).
- Impulse responses are higher after crisis.

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ABSTRACT

Cointegration and causal linkages among five different fertilizer markets are investigated during low and high market regimes. The database includes prices of rock phosphate (RP), triple super phosphate (TSP), diammonium phosphate (DAP), urea, and potassium chloride (PC). It is found that fertilizer markets are closely linked to each other during low and high regimes; and, particularly during high regime (after 2007 international financial crisis). In addition, there is no evidence of bidirectional linear relationship between markets during low and high regime time periods. Furthermore, all significant linkages are only unidirectional. Moreover, some causality effects have emerged during high regime. Finally, the effect of an impulse during high regime time period persists longer and is stronger than the effect of an impulse during low regime time period (before 2007 international financial crisis).

1. Introduction

Studying cointegration and causal relationships are useful to understand respectively long term and short term linkages across time series. Therefore, a large body of works in econophysics focused on cointegration and causality issues with relation to exchange markets [1,2], crude oil and gold market markets [3–5], shipping markets [6], real estate markets [7], credit risk markets [8,9], carbon and energy markets [10], economic systems modeling [11–17], and stock markets [18–32]. Evidence of causal relationships between series was found in all of these previous works [1–32]. As a result, many of economic and financial time series evolve as a cointegrated system with close interrelations. Besides, other works based and fractal and cross-correlation analysis examined the relationship between weather and financial markets [33–35], carbon and energy markets [36,37], and between international stock exchanges [38].

In recent years, studying fertilizer markets is receiving a growing interest [39–42]. Indeed, fertilizers are key factors in improving agricultural productivity [43,44]. Furthermore, they help improving private input sector growth, increasing smallholder incomes, diminishing poverty, and improving food security [45]. For instance, the authors in [39] performed an analysis of rock phosphate production costs and found that its price volatility is likely to have more impact on food prices

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than rising rock phosphate production costs. More recently, price and volatility transmission between natural gas, ammonia, and corn markets was investigated in [40]. It was concluded that there is evidence of connection between fertilizer and corn markets and low connection between prices and volatility between these markets and natural gas. Additionally, empirical results revealed existence of a positive relation between corn and ammonia prices in the short run, and that both prices react to deviations from the long-run parity. Finally, the empirical results showed that conditional volatility of ammonia prices positively affects conditional volatility in the corn market and vice versa. In an interesting study, the authors examined global trade dynamics affecting fertilizers and their raw materials and factors that influence fertilizer prices [41]. They found that volatility of commodities considerably increased and robustly affected fertilizer purchases for crop production. Besides, the validity of investing capital in fertilizer-mining companies was examined in [42]. The obtained results showed that stocks belonging to fertilizer-mining companies reached good returns over the 1995–2012; but, the highest returns were reached during January 2004–December 2007 time period. In addition, the empirical results showed that these stocks are suitable for portfolio hedging. More recently, asymmetry, leverage, and persistence of shocks on price volatility of five fertilizers were investigated in [46] before and after 2007 international financial crisis. The empirical results showed that after international financial crisis, statistical characteristics of each type of fertilizer price have been changed, volatilities have increased, and responses to chocks are more pronounced.

The main purpose of this work is to investigate relationships between five fertilizer markets; including rock phosphate (RP), triple super phosphate (TSP), diammonium phosphate (DAP), urea, and potassium chloride (PC). Indeed, understanding relationships between these markets is essential to producers, investors, and policy makers for better decision making. In our study, we examine cointegration and causal linkages between fertilizers separately during periods of low and high movements in market prices to better understand co-movements. These two periods coincide with pre-2007 and post-2007 international financial crisis. In this regard, econophysics literature dealing with the study of financial and economic time series in periods of crisis is enriched [1,4,6–8,46–50]. Indeed, in these studies, it was found that patterns of markets are deeply affected by international financial crises. Thus, we seek to understand to which extent such difficult periods could affect fertilizer markets co-movements to enrich literature on cointegration and causality issues.

In order to investigate long and short run relationships between different fertilizers markets, Johansen [51] and Johansen and Juselius [52] cointegration approach based on the vector error correction model (VECM), and Granger causality test [53] are employed. Indeed, they are common techniques used in econophysics [1–32] to study dynamic linkages and help determining whether series are substitutable or interchangeable. The tests are conducted separately during low and high regimes in market prices; for instance, before and after 2007 international financial crisis.

In sum, the contributions of our work follow. First, we examine linkages and causal relationships between five major fertilizer markets. In fact, this is the first paper to focus on this issue, to the best of our knowledge. Indeed, investigating such issues is important to understand joint dynamics of fertilizer markets and their causal relationships for better control of costs, portfolio management and hedging, improvement of food security, increasing economic growth and reduction of poverty; especially for developing and low-income countries. Second, both econophysics literature dealing with cointegration and causality issues [1–32] and fertilizer markets related literature [39–45] are enriched. Third, the effect of recent and major international financial crisis on causal relationships between fertilizer markets is studied. This is important for producers, governments, and investors for better decision-making and risk management.

The rest of the paper is organized as follows. In Section 2, cointegration and Granger causality tests are presented. Section 3 provides empirical results. Finally, Section 4 concludes.

2. Methods

2.1. Vector error correction model and cointegration test

The Johansen [51] and Johansen and Juselius [52] cointegration approach is useful to understand the long-term equilibrium relation between a number of variables under study. It is based on the vector error correction model (VECM) which is given by:

$$\Delta Y_t = A_0 + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + \Pi Y_{t-p} + \varepsilon_t \tag{1}$$

where Y_t is a k-vector of non-stationary variables, Δ is the difference operator, A_0 is a k-vector of intercepts, ε is a k-vector of Gaussian errors, and Γ is a coefficient matrix representing short term dynamics, and Π is a matrix whose rank determines the number of distinct cointegrating vectors that exist among the variables in Y_t. The matrices Γ and Π are computed as follows:

$$\Gamma = -\sum_{i=1}^{p} A_i \tag{2}$$

$$\Pi = -\sum_{i=1}^{p} A_i - I_i. \tag{3}$$