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Asymmetric and persistent responses in price volatility of fertilizers through stable and unstable periods

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HIGHLIGHTS

- Asymmetry, leverage, and persistence of shocks on price volatility of five fertilizers are investigated.
- Results are compared before and after 2007 international financial crisis.
- 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.

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ABSTRACT

Fertilizers are important to improve agricultural productivity growth. The purpose of this study is to investigate asymmetry, leverage, and persistence of shocks on price volatility of five fertilizers using EGARCH model during stable and unstable time periods, corresponding to before and after 2007 international financial crisis, respectively. Using price data of rock phosphate, triple super phosphate, diammonium phosphate (DAP), urea, and potassium chloride, it is found that fertilizers price volatilities display an apparent asymmetric response to shocks which have much pronounced and permanent effect during unstable period than in during stable period. Such effects should be taken into account whenever volatility modeling of fertilizers is considered, particularly during periods of volatile price.

1. Introduction

As an indicator of uncertainty, volatility modeling is essential to understand dynamics of time series and has major implications for investment decisions since it is important in risk evaluation and management. In this regard, a large volume of econophysics literature has emerged on modeling, explaining and forecasting volatility. For instance, such studies include examining the asymmetric reactions of stock returns volatility to domestic and international information [1], contagion effect between Taiwan and US stocks under asymmetry [2], contagion effect between the US and Chinese stock markets [3], volatility clustering in high-frequency price changes in stock and exchange markets [4,5], risk in portfolio and financial market [6–8], relationship between internet and volatility [9,10], inflation targeting [11], causality in stock market networks [12], persistence in stock market volatility [13], correlations between stocks [14], and volatility breaks and asymmetry in financial assets [15–18]. Certainly, previous works focused on stock and exchange markets [1–18]. Besides, other works have focused on long memory and forecasting in volatility of gold market [19,20], volatility prediction and transmission in crude oil prices [21–23], natural gas prices [24], and Carbon emission trading market [25]. However, no attention has been given to fertilizers, to the best of our knowledge.

Indeed, recent works on fertilizer markets focused on analysis of phosphate rock production costs [26], investigation of price and volatility transmission between natural gas, fertilizer (ammonia), and corn markets [27], analysis of global trade

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dynamics affecting fertilizers and their raw materials and factors that influence fertilizer prices [28], and study of the validity of investing capital in fertilizer-mining companies [29]. For instance, it was found that phosphate rock price volatility is likely to have more impact on food prices than rising phosphate rock production costs [26]. The authors in Ref. [27] found significant relationship between fertilizer and corn markets and low association between prices and volatility between these markets and natural gas. In addition, they found a positive link between corn and ammonia prices in the short run, and that both prices react to deviations from the long-run parity. Moreover, it was found that lagged conditional volatility of ammonia prices have positive effect on conditional volatility in the corn market and vice versa. Besides, the authors in Ref. [28] concluded that volatility of commodities significantly augmented and strongly influenced fertilizer purchases for crop production. Finally, it was found that stocks of fertilizer-mining companies yielded good returns over the 1995–2012 time period and extremely high ones from January 2004 to December 2007. In addition, the authors concluded that these stocks are attractive in terms of portfolio hedging.

As discussed above, most recent works examined several aspects of fertilizer markets, including analysis of production costs [30], investigation of price and volatility transmission [31], modeling global trade dynamics [32], and investment in fertilizer-mining companies [33]. However, to the best of our knowledge, studying asymmetric and persistent responses in price volatility of fertilizers has not received attention. Indeed, such topics deserve investigation to better understand dynamics of fertilizer markets. In fact, these markets are of main concern of producers, governments, farmers, and investors; for instance, for better management of production costs, food security, and profits.

Motivated by these points, the purpose of this paper is to investigate asymmetry, leverage, and persistence of shocks on price volatility in five fertilizers, namely rock phosphate, triple super phosphate, diammonium phosphate (DAP), urea, and potassium chloride. Since most of fertilizers are produced from phosphate rock, the latter is also considered in our study. This work focuses on fertilizer markets because of reasons cited previously and also because fertilizers are important factors to improve agricultural productivity, especially in sub-Saharan African countries [30,31]. In addition, fertilizers help improving private input sector growth, increasing smallholder incomes, diminishing poverty, and improving food security [32]. Unfortunately, in recent years there has been a remarkable increase of price volatility in international food markets and also in the developing world, particularly in sub-Saharan Africa [33]. Besides, fertilizer prices, returns and volatilities have considerably increased since summer 2007. Therefore, it seems to be interesting to examine price volatility of fertilizers in order to understand their dynamics and responses to external shocks, particularly, before and after 2007 international financial crisis.

The contributions of our work follow. First, volatility dynamics in five major fertilizer markets is investigated. Second, particular attention is given to estimation of asymmetric responses and short-term persistence across markets. Third, the study is conducted before and after 2007 international financial crisis to shed light on its effect on asymmetric responses and short-term persistence of each fertilizer market. Fourth, our work is the first to investigate these issues to enrich academic literature on fertilizer markets.

In this study, exponential autoregressive conditional heteroscedasticity (EGARCH) process [34] is chosen to model fertilizer price volatility during stable period (before 2007 international crisis) and unstable time period (after 2007 international crisis). In the EGARCH framework, log-volatility is expressed as a linear combination of its past values and past values of the positive and negative parts of the innovations (shocks). Therefore, unlike traditional GARCH process [35], EGARCH model allows capturing asymmetry effect on volatility and does not impose any positivity restrictions on the volatility estimated coefficients.

In sum, our analysis contributes to econophysics literature in the following ways. First, econophysics literature dealing with volatility modeling and analysis in finance [1–18] and in energy, Carbon emission, and gold markets [19–25] is enriched by studying asymmetric responses, leverage and persistence of shocks in volatility of five major fertilizer markets. Second, the study investigates the effect of a recent international financial crisis on the dynamics of these markets. Consequently, econophysics literature dealing with effect of international financial crisis on financial and economic time series in times of political or economic instability [36–39] is also enriched.

The remainder of our paper is structured as follows. Section 2 briefly presents EGARCH process. Section 3 provides the empirical results. Finally, Section 4 concludes.

2. EGARCH process

Let the price return of a fertilizer at time t be defined as $r_t = \log(p_t) - \log(p_{t-1})$, where p is the price of fertilizer. In addition, let assume that price return r_t behavior follows an ARMA(m, n)-EGARCH(p, q) process (for example, ARMA is autoregressive moving average), where ARMA(m, n) and EGARCH(p, q) are, respectively, the mean and variance equation. They are, respectively, given by [34]

$$r_t = c + \sum_{i=1}^{m} \phi_i r_{t-i} + \varepsilon_t + \sum_{j=1}^{n} \psi_j \varepsilon_{t-j} \tag{1}$$

$$\log\left(\sigma_t^2\right) = \kappa + \sum_{i=1}^{p} \gamma_i \log\left(\sigma_{t-i}^2\right) + \sum_{j=1}^{q} \alpha_j \left[\frac{\left|\varepsilon_{t-j}\right|}{\sigma_{t-j}} - E\left\{ \frac{\left|\varepsilon_{t-j}\right|}{\sigma_{t-j}} \right\} \right] + \sum_{j=1}^{q} \xi_j \left(\frac{\varepsilon_{t-j}}{\sigma_{t-j}} \right) \tag{2}$$