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A multiplicative seasonal component in commodity derivative pricing

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Abstract

In this paper, we focus on a seasonal jump-diffusion model to price commodity derivatives. We propose a novel approach to estimate the functions of the risk-neutral processes directly from data in the market, even when a closed-form solution for the model is not known. Then, this new approach is applied to price some natural gas derivative contracts traded at New York Mercantile Exchange (NYMEX). Moreover, we use nonparametric estimation techniques in order to avoid arbitrary restrictions on the model. After applying this approach, we find that a jump-diffusion model allowing for seasonality outperforms a standard jump-diffusion model to price natural gas futures. Furthermore, we also show that there are considerable differences in the option prices and the risk premium when we consider seasonality or not. These results have important implications for practitioners in the market. *JEL classification*: G13, G17.

Keywords: commodity futures options, jump-diffusion stochastic processes, seasonality, risk-neutral measure, numerical differentiation, nonparametric estimation, risk premium.

1. Introduction

In the 1990s, and especially the 2000s, commodity derivatives have become an important component of many investors portfolios. In particular, pension funds and other portfolio managers have considered commodities as an independent asset class that, when combined with traditional stock and bond portfolios, can improve the risk-return performance. Most practitioners use simple models, such as the models which are the basis for the Black-Scholes option pricing formula, to analyze commodity prices and price commodity derivatives. Nevertheless, these models are extremely limited and do not answer questions related to the effects of speculation, see [28].

When pricing commodity derivatives, the special features of these markets should be considered. In the literature, the commodity price is usually assumed to follow a mean-reverting diffusion process, because of the dynamics of the supply and demand, see [14] and [31]. However, nowadays, the commodity prices suffer from abrupt changes and empirical studies find significant evidence about the presence of jumps in commodity processes, see [10] and [32]. Then, this fact has also been considered in the commodity pricing literature, see, among others, [20], [36], [21], [23]. Lastly, there are numerous studies, e.g. [12] and [3], which have documented that commodity prices show a seasonal behaviour. Therefore, this property has been taken into account in several models in the literature. Lucia and Schwartz [24], Cartea and Figueroa [7] and Li et al. [25] considered the seasonality in electricity markets, García et al. [13] in the natural gas markets, Kyriakou et al. [23] in petroleum commodities and Back et al. [3] in the soybean, corn, heating oil and natural gas markets. Recently, Arismendi et al. [2] analyze the importance of the seasonal behaviour in the volatility to price commodity options.

In the commodity pricing literature, the functions of the stochastic processes and the market prices of risk are usually assumed as simple parametric functions, for pure tractability and simplicity. Moreover, the whole functions are usually chosen to provide an affine model which has a known closed-form solution. However, there is not any empirical evidence either consensus about affine models are the best models to price commodity futures. Furthermore, the market prices of risk are not observed in the markets. Hence, if we consider other more realistic functions for the stochastic variables or the market prices of risk or even a nonparametric approach then, the model would not be affine anymore, a closed-form solution could not be obtained and the estimation of the market prices of risk would not be possible. This problem was solved by [17] but for a jump-diffusion model without seasonality. Then, we contribute to the literature by filling this gap for a seasonal jump-diffusion model.

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