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Detecting positive feedback in multivariate time series: The case of metal prices and US inflation

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Abstract

The objective of this paper is to examine causality and feedback relationships between primary commodity prices and US inflation. To this end, the bivariate noisy Mackey–Glass process recently developed by Kyrtsou and Labys [Evidence for chaotic dependence between US inflation and commodity prices, J. Macroecon. 28(1) (2006) 256–266] has been applied to assess this relationship. Results obtained support evidence in favour of causality, which can help to identify the influences of speculative price behaviour on inflation.

Keywords: Positive feedback; Multivariate time series; Noisy chaos; Noisy Mackey–Glass process; Economic time series

1. Introduction

Recent empirical investigation of the source of shocks in economic systems has led to the conclusion that such shocks can arise from fluctuations in financial markets. Nevertheless, economic instability can also stem from volatility in primary commodity markets. Commodity markets feature trading in derivatives such as futures and options contracts and thus possess a dimension similar to that of foreign exchange and stock markets. Techniques employed include hedging and speculation: hedgers, for example, can sell contracts for commodities they have produced in order to insure themselves against the risk of a price decline; speculators can take opposite positions with the hope of making profits from a price change in an expected direction.

Underlying this view of market fundamentals is the assumption that traders have rational expectations and thus incorporate available information concerning these fundamentals into their decisions. However, heterogeneity of market participants with boundly rational expectations, receiving manipulated endogenous information as well as the presence of noise quite often cause price behaviour to deviate from being efficient, instead being complex, chaotic. Recent studies of Hommes and Manzan [1], Boswijk et al. [2], Hommes [3], LeBaron [4,5] survey empirical work on agent-based modelling and shed more light on the impact of agents' heterogeneity into market prices and general economic behaviour.

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The complex nature of commodity prices has been studied in the recent work of Kyrtsou et al. [6]. In a different framework, Westerhoff and Reitz [7] and He and Westerhoff [8] use heterogeneous agent-based models to characterise commodity price fluctuations. In this paper, we are interested in detecting inherent causality and feedbacks in the linkages between inflation and primary commodity prices with the use of the bivariate Mackey–Glass model, recently presented in Kyrtsou and Labys [9]. Quantifying and then qualifying the presence of feedback can help both practitioners and researchers to understand the mechanism of shock transmission from the financial sector to macroeconomy and vice versa.

The remainder of the paper is organised as follows. In Section 2 we briefly discuss the model and present the empirical results, while Section 3 concludes.

2. The model and results

The bivariate noisy Mackey–Glass model is based on the discrete version of the deterministic Mackey–Glass process [10]. The Mackey–Glass process is a high-dimensional system that can present quite interesting properties with a small variation of its parameters. As Kyrtsou and Terraza [11] have demonstrated, the addition of noise (white and heteroskedastic) to the deterministic version of Mackey–Glass model enriches the obtained dynamics and produces characteristic structures of real financial and economic data.

In more details, the model is presented below:

$$X_t = \alpha_{11}\frac{X_{t-\tau_1}}{1+X_{t-\tau_1}^{c_1}} - \delta_{11}X_{t-1} + \alpha_{12}\frac{Y_{t-\tau_2}}{1+Y_{t-\tau_2}^{c_2}} - \delta_{12}Y_{t-1} + \varepsilon_t, \quad \varepsilon_t \sim \mathrm{N}(0,1), \tag{1}$$

$$Y_t = \alpha_{21}\frac{X_{t-\tau_1}}{1+X_{t-\tau_1}^{c_1}} - \delta_{21}X_{t-1} + \alpha_{22}\frac{Y_{t-\tau_2}}{1+Y_{t-\tau_2}^{c_2}} - \delta_{22}Y_{t-1} + u_t, \quad u_t \sim \mathrm{N}(0,1),$$

where α and δ are parameters to be estimated. τ is the delay and c a constant. The best delays are chosen on the basis of likelihood ratio tests. Different values for τ and c can change dramatically the dynamic behaviour of the process. The multivariate transformation of the model does not modify its dynamic properties in a univariate context. The non-linear trading strategy in the mean equation of the model permits the creation of positive and negative feedback dynamics. When the sum of α and $(-)\delta$ is positive, we expect to observe positive feedback behaviour. On the contrary, when the sum is negative (under certain conditions) the traders adopt negative feedback behaviour.[1] If the condition of significant Mackey–Glass terms is satisfied then we can proceed with the identification of the type of the detected feedback.

We provide a test of the bivariate noisy Mackey-Glass model by examining feedback relationships between metal prices and US inflation. We employ the growth rates of cpi[2] and mpp, the metal price series[3] to conduct these tests. Both series contain 511 monthly observations from 01/1960 to 07/2002 and are not seasonally adjusted. The estimation results are reported in Table 1.

As one can see, the first sum $\alpha_{12}-\delta_{12} = 37.8267-(-37.7233) = 75.55$ is strongly positive. This means that there is a significant positive non-linear feedback relationship between cpi and the metal price series. The second sum $\alpha_{21}-\delta_{21} = 0.17502-0.1073 = 0.06772$ is also positive but not so high as the previous; metal prices can be said to positively cause cpi. The different intensity of the observed feedbacks reveals the underlying force of fundamentals to influence financial series in the US market. Moreover, the significance of the second sum confirms the key role of a specific commodity series to create destabilising forces in the US inflation series.

3. Conclusions

The relation between commodity prices and inflation is twofold. Since commodity prices ultimately enter the consumer price index, rising prices for a commodity will cause consumer prices and hence inflation to

[1]For more details about the meaning of these coefficients and the determination of the nature of feedback, see Kyrtsou [12,13].

[2]The Consumer Price Index is the BLS CPI–all urban consumers CUUROOOOAA0 index.

[3]The metals price index is BLS producer price index component WPU10, restricted to metals and metal products. All data can be obtained from the International Monetary Fund, International Financial Statistics, Washington, DC (http://www.imf.org).

Table 1
Estimation results for the bivariate noisy Mackey–Glass model*

Coefficients	Values
α_{11}	0.28062* (7.6125)
δ_{11}	0.5495* (14.290)
α_{12}	37.8267* (1.9799)
δ_{12}	−37.7233* (−1.9759)
α_{21}	0.17502* (2.1388)
δ_{21}	0.1073* (1.9669)
α_{22}	−91.2328* (−2.1511)
δ_{22}	91.8040* (2.1661)

*Within parentheses, t-statistic is reported. An asterisk indicates significance at 5%. We used $\tau_1 = 3$, $\tau_2 = 1$, and $c_1 = c_2 = 2$.

increase. Inflation represents a condition in which full supply capacity is reached, and so further increases in commodity demand will cause commodity prices to increase, because commodity suppliers have to pay higher wages, higher interest payments, etc. So in this sense inflation also causes commodity price increases. The identification of this positive feedback relationship is the main contribution of the paper. With the use of the bivariate noisy Mackey–Glass model, we concretised the type of non-linearity and hence arrived at results that can help researchers to understand the rules of a complicated game between macroeconomic and financial fundamentals.

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