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NONLINEAR FEATURES OF COMOVEMENTS BETWEEN COMMODITY PRICES AND INFLATION

Dr. Catherine Kyrtsou

Department of Economics
University of Macedonia
Egnatia str., 156,
54006, Thessaloniki, GREECE
(Corresponding Author's e-mail: ckyrtsou@uom.gr)

Abstract

This paper attempts to investigate further the nonlinear feedback relationship found in Kyrtsou and Labys (2006) between US inflation (BLS CPI) and primary commodity price index (the BLS PPI component for all primary commodity series). Our goal is to disaggregate the above index to the individual commodity level for a group of raw materials prices, including crude oil. Assuming the hypothesis that a non-linear feedback relationship exists between US inflation and the commodity price index, we examine if individual primary commodity prices also nonlinearly causes inflation and vice-versa. We also improve upon our previous research by employing a new test for non-linear feedback causality recently developed by Hristu-Varsakelis and Kyrtsou (2006). Our results suggest the presence of non-linear interdependences between inflation and the various commodity price series, and particularly bi-directionality in the case of crude oil.

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1.Introduction

This paper attempts to investigate further the nonlinear feedback relationship found in Kyrtsou and Labys (2006) between US inflation (BLS CPI) and the primary commodity price index (the BLS PPI component for all primary commodity series). Our goal is to disaggregate the above index to the individual commodity level for a group of raw materials prices, including crude oil. Assuming the hypothesis that a non-linear feedback relationship exists between US inflation and commodity price index, we examine if individual primary commodity prices also nonlinearly cause inflation and vice-versa. We also improve upon our previous research by employing a new test for non-linear feedback causality recently developed by Hristu-Varsakelis and Kyrtsou (2006). This paper consists of the following parts: 2. Background, 3. Hristu-Varsakelis and Kyrtsou Nonlinear Granger Causality Test, 4. Data Description and Empirical Results, and 5. Conclusions.

2. Background

Why are primary commodity prices so volatile and why does this volatility affect inflation? For agricultural commodities whose demand is relatively constant (price-inelastic), fluctuations in production resulting from weather variations cause fluctuations in prices. For mineral and energy commodities where supply is relatively fixed (capacity is price inelastic in the short term), fluctuations in international business cycles tend to destabilize commodity demand and hence prices. In the case of the crude oil market, policies designed to decrease or increase production or to allocate market shares can also induce price disturbances. For markets where futures exchanges also exist, excessive speculation (relative to actual production) can amplify any price swings already started. Underlying this view of "market fundamentals" is the assumption that traders have "rational expectations" and thus incorporate available information concerning these "fundamentals" in their decisions. However, random information or noise often distorts such price formation, and price behavior will deviate from efficiency, often being cyclic or even chaotic.

The volatility of commodity prices can affect the economy and inflation as well as vice-versa. Commodity producers and consumers, whether they are individuals or vast multinational organizations, suffer from price fluctuations. For example, sudden high crude oil prices can cause consumers to reduce purchases and to reallocate their budgets. Transportation becomes restrictive with gasoline prices rising and supplements added to normal passenger fares and freight rates. Elderly persons on fixed incomes can no longer afford normal heating bills. Manufacturers not capable of rapid energy substitution face costly disruptions in order to avoid final product price increases.

When the latter occurs, we have the beginnings of inflation. A strong case has been made for the relations between commodity prices and inflation by Bosworth and Lawrence (1982), Beckerman and Jenkinson (1986), Cooper and Lawrence (1975), and Moore (1988). An important extension of this work by Boughton and Branson (1988), Durand and Blondal (1988), and Mahdavi and Zhou (1997) is determining whether commodity prices constitute leading indicators of inflation. Since then the study of this relationship has received more critical attention. See, for example, Hua (1998) Kyrtsou and Labys (2006,2007), and Malliaris (2005). Inflation can be caused by consumer's, producer's and investor's expectations of the future. "In an overheated economy, increased futures trading activity on the part of speculators can amplify already rising commodity prices." (Labys, 2000). In this case, if speculators expect demand for a good to rise, the price for that good will lead the increase in demand thus leading to higher consumer prices. In the other direction, for example, if there is an increase in commodity production due to speculation and that production exceeds commodity demand, there will be a surplus causing exports to rise and imports to fall.

Because a rise in inflation will lower profits for many producers, they may reduce the work force, thus increasing the level of unemployment. This rise in unemployment will reduce disposable income, reduce commodity demand and thus cause a surplus if there is not a reduction in commodity production. Cristini (1999), for example, shows an influence of commodity prices on employment in OECD countries. The combination of lower wages, higher unemployment and an increased CPI will amplify a recessionary cycle: decreased commodity demand in addition to overall demand, fall in industrial activity, further decline in disposable income, increased decline in elastic goods demand, inventory surplus, increased exports coupled with decreased imports, worsened trade imbalance, etc.

Turning to econometric analysis, Labys and Maizels (1993) focused on causality and feedback effects between commodity prices and macroeconomic variables by employing Granger-causality tests to compare the results of a large number of studies dealing with macroeconomic and commodity market interactions. They did find a direct relationship between commodity prices and industrial production. When commodity prices rise, especially at an accelerated rate, consumers and often the government react strongly. Today, high prices are causing some consumers to cut back on expenditures and are thus off-setting producer's expected profit. Simultaneously, the Federal Reserve is looking to adjust interest rates, to cool down the economy and to temper inflation. Labys and Maizels conclude that the highest degree of causality exists between "international primary commodity prices and national prices, selected macroeconomic indicators including industrial production, and monetary variables in the major OECD countries than was previously believed" (Labys and Maizels, 1993). The implications of their findings, as suggested, rest in incorporating commodity price fluctuations in determining practical and effective stabilization policies.

Borensztein and Reinhart (1994), Chu and Morrison (1984), Bosworth and Lawrence (1982), Darby (1982), Fama and French (1988), Grilli and Yang (1980), and Moore (1988) also report on some relations between business cycles and metals prices. More specifically, fluctuations in global industrial production and financial variables have been shown to influence the industrial demand for metals, and given the short term price inelasticity of metal supplies, the resulting demand fluctuations tend to influence the related metal prices. The influence of the financial variables may come less directly in the forming of expectations of agents who deal in the demand, supply and stocking of metals. As evidence for such phenomena, Kyrtsou and Labys (2007) particularly have found a relation between primary metals prices and inflation.

A final linkage comes from the extent to which the US economy relies on the imports of primary commodities such as crude oil to sustain its own production, consumption and services. There is no doubt of the importance of crude oil prices as an influence on inflation, since these prices influence just about all sectors of a national economy. A considerable effort has been made to demonstrate this interaction. See, for example, studies by Darby (1982), Ferderer (1996), Labys (2000) and Mork et al (1990).

3. Hristu-Varsakelis and Kyrtsou Nonlinear Granger Causality Test (2006)[1]

This test is constructed on the basis of a special type of non-linear structure, known as the *bivariate noisy Mackey-Glass model* (Kyrtsou and Labys, 2006, 2007). The model is given below:

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

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

where X and Y are a pair of related time series variables, the α_{ij}, and δ_{ij} are parameters to be estimated, τ_i are delays, and c_i are constants. The best model (1) is that allowing the maximum Log Likehood value and minimum Schwarz information criterion. Erroneous conclusions about the pair of parameters c_i and τ_i used for estimating model (1) can lead to misleading interpretations of the underlying dynamics causing non-linear comovements. As mentioned in Kyrtsou and Labys (2006, 2007), Kyrtsou and Vorlow (2007), Kyrtsou and Malliaris (2007), the principle advantage of (1) over simple VAR alternatives is that the non-linear Mackey-

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[1] The non-linear causality test was implemented in Matlab. The code is available from the authors upon request. The asymmetric version of the test can be found in Hristu-Varsakelis and Kyrtsou (2007).

Glass (hereafter M-G) terms are able to capture more complex dependent dynamics in a time series. The identification of significant M-G terms in a pair of series reveals the non-linear feedback law between *X* and *Y* and elucidate qualitative features of this law.

The Hristu-Varsakelis and Kyrtsou causality test aims to capture whether past samples of a variable *Y* have a significant non-linear effect (of the type $\frac{Y_{t-\tau_2}}{1+Y_{t-\tau_2}^{c_2}}$) on the current value of another variable *X*. Algorithmically, the test is similar to the linear Granger causality test, except that the two models fitted to the series are M-G processes. Test procedure begins by estimating the parameters of a M-G model that best fits the given series, using ordinary least squares. To test reverse causality (i.e. *from Y to X)*, a second M-G model is estimated, under the constraint $\alpha_{12}=0$. The latter equation represents our *null hypothesis*. Let $\hat{\varepsilon}_t, \hat{\theta}_t$ be the residuals produced by the unconstrained and constrained best-fit M-G models, respectively. We compute and compare the sums of squared residuals $S_c = \sum_{t=1}^{N} \hat{\theta}_t$ and $S_u = \sum_{t=1}^{N} \hat{\varepsilon}_t$. Let $n_{free}=4$ be the number of free parameters in our M-G model and $n_{restr}=1$ be the number of parameters set to zero when estimating the constrained model. If the test statistic $S_F = \frac{(S_c - S_u)/n_{restr}}{S_u/(N-n_{free}-1)} \sim F_{n_{restr}, N-n_{free}-1}$ is greater than a specified value, then we reject the null hypothesis that *Y* causes *X*. The p-value for the test is finally computed from $p = 1 - F^{cdf}_{n_{restr}, N-n_{free}-1}(S_F, n_{restr}, N-n_{free}-1)$, where $F^{cdf}_{a,b}$ is the cumulative distribution function for the $F_{a,b}$ distribution.

It is worth noting that the Hristu-Varsakelis and Kyrtsou test is implemented in order to filter specific non-linear structures, such as the M-G framework providing useful information on the particularity of feedback between economic time series. The presence of non-linear feedback can be the precursor of instability and inherent unpredictably. The non-proportionality in the response of one variable to a shock on a second or even an entire set of variables mirrors profound characteristic of the overall economic system where this machanism is observed. Evidence for the applicability of conclusions from the use of the M-G model in financial market analysis can be found in Kyrtsou and Terraza (2003), Kyrtsou et al. (2004), Kyrtsou (2005), and Kyrtsou and Serletis (2006).

4. Data Description and Empirical Results

The consumer price index appears from the US Bureau of Labor Statistics. The price data are monthly price series for a set of individual primary commodities, namely aluminium, copper, gold, lead, nickel, crude oil (petrol), platinum, silver, tin, tungsten, and zinc. Raw materials or metal and energy prices were selected rather than agricultural prices because the former prices have a more profound impact on manufacturing activities and hence inflation. These prices are drawn from the UNCTAD *Commodity Price Bulletin*. Definitions and sources of each price series appear in Appendix A. Following the rationale of Kyrtsou and Labys (2006), these series are compared to the BLS (Bureau of Labor Statistics) CPI – all urban consumers (CUUROOOOAA0) index. The sample period for all series extends from 01/1970 to 12/2004. Data are not seasonally adjusted as the aim to preserve possibly intrinsic structures. First differences of the logarithms of price series are employed to obtain returns series: dlcpi for CPI, dlalum for aluminium, dlcop for copper, dlgold for gold, dllead for lead, dlnic for nickel, dlpetr for crude oil, dl plat for platinum, dlsilv for silver, dltin for tin, dltun for tungsten ore and dlzin for zinc. A description of the behavior of the returns series can be found in Figures 1a and b.

The results of the Hristu-Varsakelis and Kyrtsou test are reported in Table 1 containing also respective lags for the bivariate M-G model.

Table 1: Test for non-linear causality*

X,Y	Relation	F statistic	Probability**	Lags for M-G
dlcpi, dlalum	dlcpi→dlalum dlalum→dlcpi	2.3105 *4.0832*	0.1293 *0.044*	$\tau_1=4$, $\tau_2=1$, $c_1=c_2=2$
dlcpi, dlcop	dlcpi→dlcop dlcop→dlcpi	2.4196 *3.0322*	0.1206 *0.0824*	$\tau_1=\tau_2=1$, $c_1=c_2=2$
dlcpi, dlgold	dlcpi→dlgold dlgold→dlcpi	0.2014 *5.5578*	0.6538 *0.0189*	$\tau_1=5$, $\tau_2=4$, $c_1=c_2=2$
dlcpi, dllead	dlcpi→dllead dllead→dlcpi	*3.1487* *6.1904*	*0.0767* *0.0132*	$\tau_1=\tau_2=3$, $c_1=c_2=2$
dlcpi, dlnic	dlcpi→dlnic dlnic→dlcpi	1.1729 *2.9228*	0.2794 *0.0881*	$\tau_1=\tau_2=4$, $c_1=c_2=2$
dlcpi, dlpetr	dlcpi→dlpetr dlpetr→dlcpi	*4.8246* *5.9844*	*0.0286* *0.0149*	$\tau_1=5$, $\tau_2=2$, $c_1=c_2=2$
dlcpi, dlplat	dlcpi→dlplat dlplat→dlcpi	0.3798 *5.7661*	0.5381 *0.0168*	$\tau_1=\tau_2=4$, $c_1=c_2=2$
dlcpi, dlsilv	dlcpi→dlsilv dlcop→dlcpi	1.7160 *5.3213*	0.1909 *0.0216*	$\tau_1=4$, $\tau_2=3$, $c_1=c_2=2$
dlcpi, dltin	dlcpi→dltin dltin→dlcpi	0.9756 *2.6912*	0.3239 *0.0917*	$\tau_1=2$, $\tau_2=8$, $c_1=c_2=2$
dlcpi, dltun	dlcpi→dltun dltun→dlcpi	0.4161 *3.7991*	0.5193 *0.0520*	$\tau_1=\tau_2=7$, $c_1=c_2=2$
dlcpi, dlzin	dlcpi→dlzin dlzin→dlcpi	0.0013 *5.6552*	0.9712 *0.0179*	$\tau_1=4$, $\tau_2=3$, $c_1=c_2=2$

* In model (1) where X we use the dlcpi series while at the place of Y the primary commodity returns series is considered each time.
** If prob<0.05 (0.10), then at 5%(10%) we accept the H_α that A does cause B. Values in italics indicate statistical significance.

This table clearly shows the impact of the individual commodity series on inflation. Probabilities vary close to zero with a few exceptions; for example we have the cases of copper (prob=0.0824), nickel (prob=0.0881) and tin (prob=0.0917). Nevertheless, bi-directional causality or otherwise non-linear feedback is only archived for lead and crude oil, with crude oil (prob=0.0149) the dominant influence. In comparison with the empirical findings of Kyrtsou and Labys (2006) the test for non-linear causality brings new insights on the determination of the relationship between US inflation and commodity price series. It comes out that the major part of the bi-directional comovement is largely driven by crude oil. Hence, our analysis seems to confirm, that among the selected commodity prices, crude oil prices appear to be a very important determining factor of fluctuations in US inflation. Our work also confirms what was discovered in the mentioned works of Darby (1982), Ferderer (1996), Labys (2000), and Mork et al (1990).

5. Conclusions

In the present paper we have tried to disaggregate the bi-directional causal relationship between US inflation and primary commodity price index, based on the study of Kyrtsou and Labys (2006), to analyse a number of individual commodity price series, in this case metals and energy prices. The application of the recent test of Hristu-Varsakelis and Kyrtsou (2006) reveals an interdependence between the various price series. Unidirectional non-linear causality is detected for all series except lead and crude oil. For those two commodities, an additional bi-directional non-linear structure is identified. The results concerning crude oil are particularly interesting. They confirm the more general studies of commodity prices and inflation, and particularly of the influence of crude oil prices made by Darby (1982), Ferderer (1996), and Mork et al (1990). Also confirmed is the lack of a relation between gold prices and inflation, as discovered by Mahdevi and Zhou (1997).

The implications of these results are several. First, US policy makers have continued to neglect the impact of crude oil prices on inflation, and have relied excessively on monetary policy to resolve the problem. Second, the extremely high oil prices we are currently viewing should be considered with caution. Third the asymmetry of the impact of US inflation on commodity prices (in the sense that it affects only a few of them) could elucidate phases of economic process that aid commodity price stabilization. And fourth, employing asymmetric versions of non-linear causality tests could help policy makers to refine their understanding of commodity price fluctuations in upturns differently from downturns.

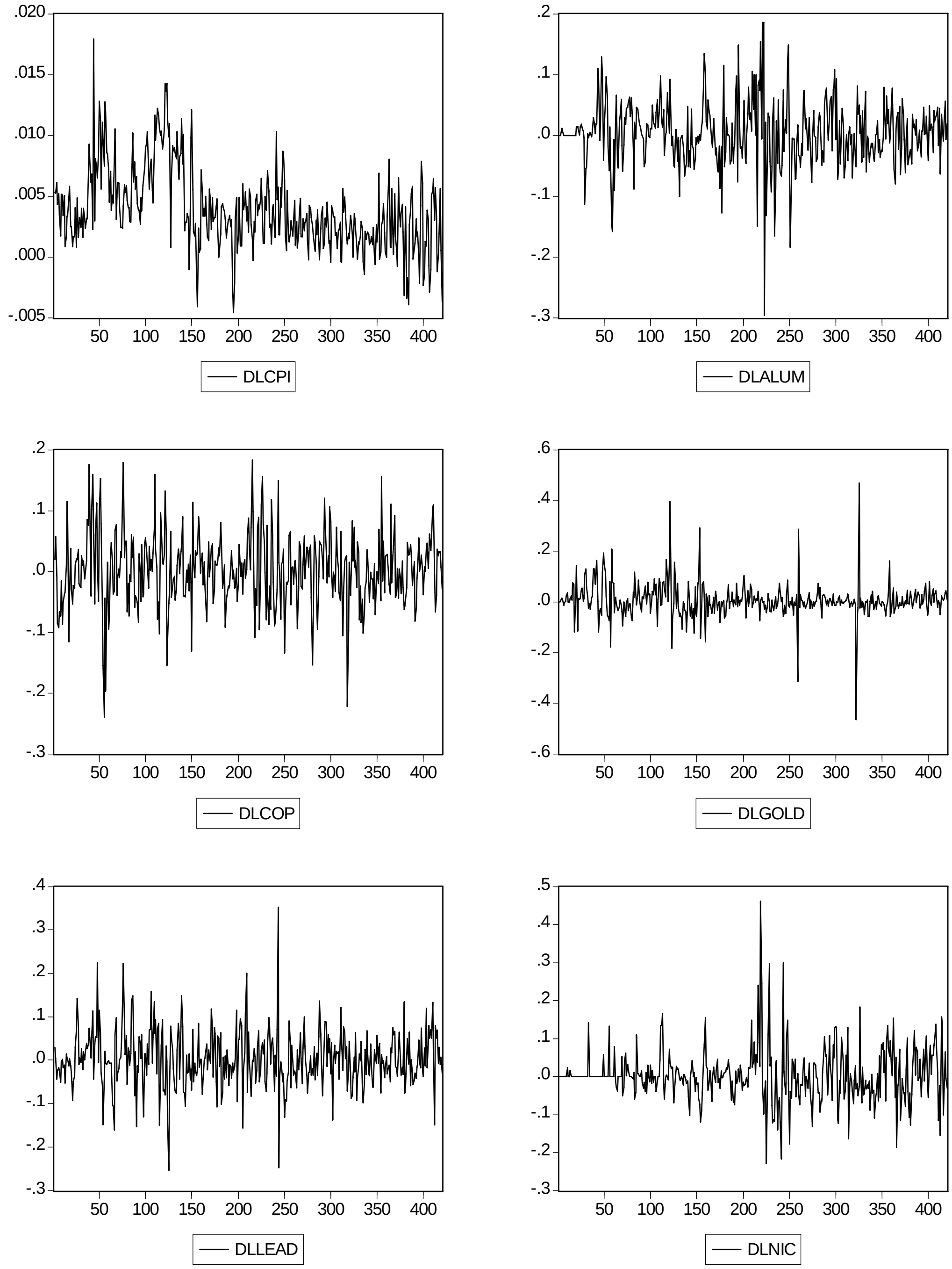

Figure 1a: US Inflation and commodity price returns series

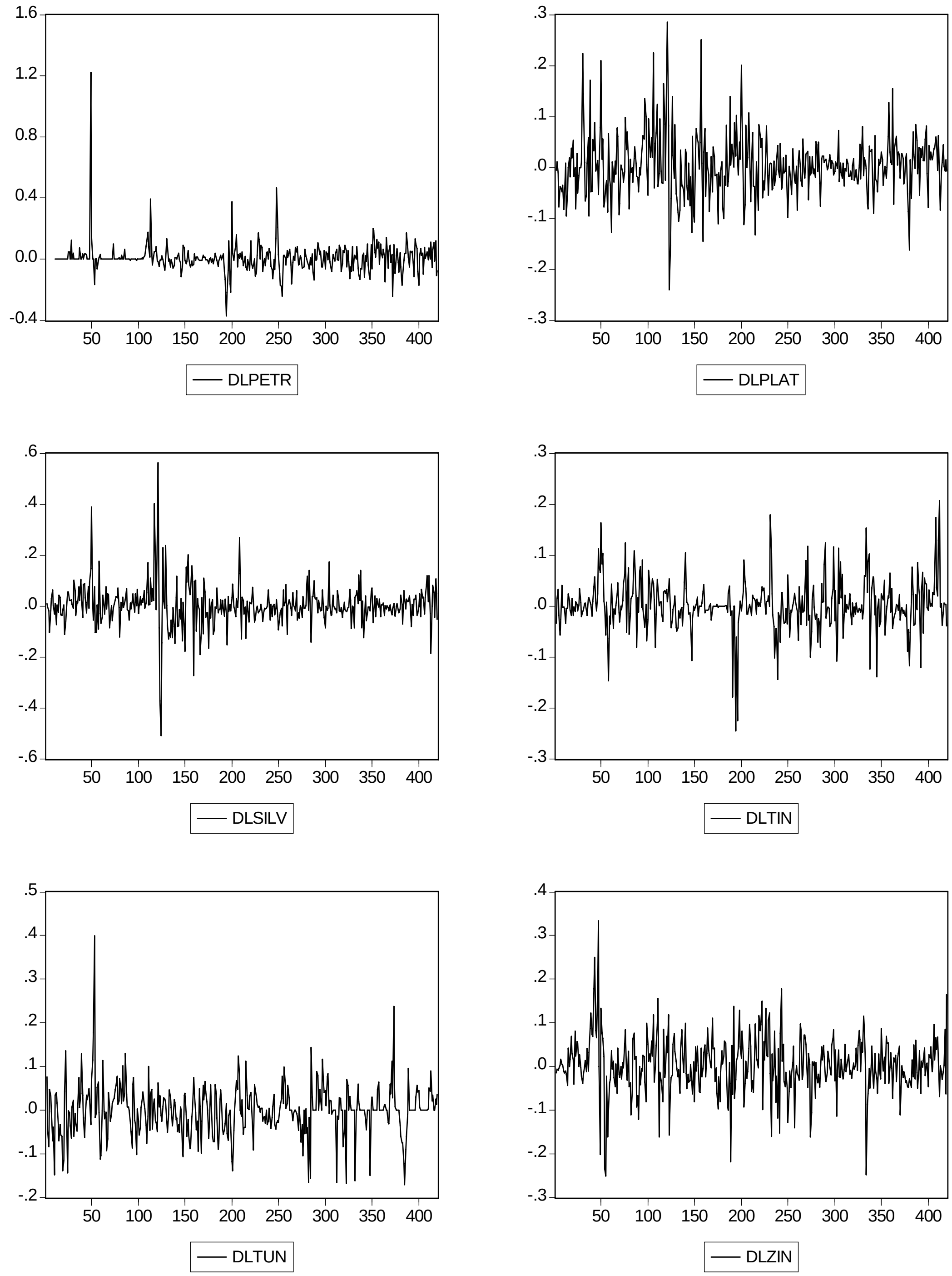

Figure 1b: Commodity price returns series

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Appendix A:
DEFINITION OF PRICE SERIES

Aluminium: London Metal Exchange, high grade, cash. From February 1970 to December 1978: virgin ingot, 99.5% purity, c.i.f. Europe, Prior to January 1970: virgin ingot, spot London (*Metal Bulletin*, London).

Copper: London Metal Exchange, electrolytic wire bars, high grade, cash (*Metal Bulletin*, London).

Gold: United Kingdom, 99.5% fine, London afternoon fixing, average of daily prices (*Metal Bulletin,* London)**.**

Lead: London Metal Exchange settlement and cash seller's price in warehouse excluding duty, range main United Kingdom ports, Purity 99.97% Pb (*Lead and Zinc Statistics,* International Lead and Zinc Study Group, London).

Crude Oil: Average of Dubai, United Kingdom Brent and Alaska N. Slope crude prices, reflecting relatively equal consumption of medium, light and heavy crude worldwide. Dubai Fateh 32 API, spot, f.o.b. Dubai; United Kingdom, Brent Bland 38 API, spot f.o.b. United Kingdom ports; United States, Alaskan N. Slope 27 API, spot, f.o.b. U.S. Gulf of Mexico ports.

Platinum: Monthly average of the London Fix PM, London Platinum and Palladium Market, $US/troy ounce. (Kitco.com).

Silver: Handy & Harman, 99.5% grade refined, average daily quotations, New York (*Metal Bulletin,* London).

Tin: Ex-works price Kuala Lumpur market (ITC reference price since 4 July 1972). Tin trade was suspended from 24 October 1985 to end of January 1986 (*Metal Week,* New York).

Tungsten: Wolfram, c.i.f. European ports concentrates, basis minimum 65% WO_3 (*Metal Bulletin,* London).

Zinc: London Metal Exchange, settlement and cash seller's price in warehouses excluding duty, range main United Kingdom ports; Virgin zinc, high grade (*Lead and Zinc Statistics,* International Lead and Zinc Study Group, London).