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The cyclical behavior of monthly NYMEX energy prices

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Abstract

This paper systematically investigates the basic stylized facts of energy price movements using monthly data for the period that energy has been traded on organized exchanges and the methodology suggested by Kydland and Prescott (Kydland, F.E., Prescott, E.C., 1990. Business cycles: real facts and a monetary myth. Fed. Reserve Bank Minneapolis Q. Rev. Spring, 3–18). The results indicate that energy prices are in general procyclical, in contrast to the accepted fact that energy prices are countercyclical and leading the cycle. © 1998 Elsevier Science B.V.

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1. Introduction

The cyclical behavior of energy prices is important and has been the subject of a large number of studies, exemplified by Hamilton (1983). These studies have, almost without exception, concentrated on the apparently adverse business-cycle effects of oil price shocks. For example, Hamilton (1983) working on pre-1972 data and based on vector autoregression (VAR) analysis, concluded that energy prices are countercyclical and lead the cycle. However, as Mork (1988, p. 74) put it '... his study pertained to a period in which all the large oil price movements were upward,

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and thus it left unanswered the question whether the correlation persists in periods of price decline'. In fact, as shown by Mork (1988), there is an asymmetry in the responses in that the correlation between oil price decreases and gross national product (GNP) growth is significantly different than the correlation between oil price increases and GNP growth, with the former being perhaps zero.

The objective of this paper is to examine the cyclical behavior of energy prices using monthly data for crude oil, heating oil, unleaded gasoline and natural gas for the period that each of these commodities has been traded on organized exchanges. In doing so, we follow Lucas (1977) and define the growth and cycle components of a variable as its smoothed trend and the deviation of the smoothed trend from the actual values of the variable, respectively. Moreover, we define energy cycle regularities as the dynamic comovements of the cyclical components of energy prices and the cycle. In particular, the type of business cycle regularities that we consider are autocorrelations and dynamic cross-correlations between the cyclical components of energy prices, on the one hand, and the cycle, on the other. The robustness of the results to alternative measures of the cycle is also investigated.

The paper is organized as follows. Sec. 2 briefly discusses the Hodrick–Prescott (HP) filtering procedure for decomposing time series into long-run and business cycle components. Sec. 3 discusses the data and presents HP empirical correlations of energy prices with US output, prices and the unemployment rate. Sec. 4 summarizes and concludes the paper.

2. Methodology

For a description of the stylized facts, we follow the current practice of detrending the data with the Hodrick–Prescott (HP) filter — see Prescott (1986). For the logarithm of a time series X_t, for $t = 1, 2, \ldots, T$, this procedure defines the trend or growth component, denoted τ_t, for $t = 1, 2, \ldots, T$, as the solution to the following optimization problem

$$\min_{\tau_t} \sum_{t=1}^{T} (X_t - \tau_t)^2 + \lambda \sum_{t=2}^{T-1} [(\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1})]^2$$

so that $X_t - \tau_t$ is the HP filtered series. For $\lambda = 0$ the growth component is the series and as $\lambda \to \infty$, the growth component approaches a linear trend. In our computations, we set $\lambda = 14\,400$, as it has been suggested for monthly data.

We measure the degree of comovement of a series with the pertinent cyclical variable by the magnitude of the correlation coefficient $\rho(j)$, $j \in \{0, \pm 1, \pm 2, \ldots\}$. The contemporaneous correlation coefficient $\rho(0)$ gives information on the degree of contemporaneous comovement between the series and the pertinent cyclical variable. In particular, if $\rho(0)$ is positive, zero, or negative, we say that the series is procyclical, acyclical, or countercyclical, respectively. In fact, for data samples of our size it has been suggested [see, for example, Fiorito and Kollintzas (1994)] that for $0.5 \leq |\rho(0)| < 1$, $0.2 \leq |\rho(0)| < 0.5$ and $0 \leq |\rho(0)| < 0.2$, we say that the series is strongly contemporaneously correlated, weakly contemporaneously correlated and contemporaneously uncorrelated with the cycle, respectively. Also, $\rho(j)$, $j \in \{\pm 1, \pm 2, \ldots\}$, the cross correlation coefficient, gives information on the phase-shift of the series relative to the cycle. If $|\rho(j)|$ is maximum for a negative, zero, or positive j, we say that the cycle of the series is leading by j periods the cycle, is synchronous, or is lagging by j periods the cycle, respectively.

The Hodrick–Prescott filter is almost universally used in the real business cycle research program and extracts a long-run component from the data, rendering stationary series that are integrated up to fourth order. HP filtering, however, has been questioned as a unique method of trend elimination — see, for example, King and Rebelo (1993) and Cogley and Nason (1995). More recently, however, Baxter and King (1995) argue that HP filtering can produce reasonable approximations to an ideal business cycle filter. We therefore believe that the results reported in the next section are reasonably robust across business cycle filters.

3. Data and results

We study monthly data (from Tick Data) on spot-month futures prices for crude oil, heating oil, unleaded gasoline and natural gas — spot-month futures prices are used as a proxy for current cash prices. Since these commodities began trading at different times on the New York Mercantile Exchange (NYMEX), we have a different sample size for each of these commodities. In particular, crude oil began trading in March 1983, heating oil in March 1979, unleaded gasoline in December 1984 and natural gas in April 1990. To investigate the cyclical behavior of energy prices, we match them with the US industrial production index, consumer price level and unemployment rate, using data on these variables up to April 1993. This match produces 122 monthly observations for crude oil, 157 for heating oil, 94 for unleaded gasoline and 37 for natural gas.

Table 1 reports the contemporaneous and the cross correlations (at lags and leads of 1–6 months) between the cyclical components of energy prices and the cyclical component of US industrial production (in panel A), the unemployment rate (in panel B) and consumer prices (in panel C). A number near 1 in the x_t column of panel A indicates strong procyclical movements and a number near -1 indicates strong countercyclical movements. The numbers in the remaining columns indicate the phase shift relative to industrial production. For example, a series that leads (lags) the cycle by 3 months will have its maximum value in the x_{t-3} (x_{t+3}) column.

As panel A of Table 1 shows, energy prices are weakly procyclical, with natural gas prices being more so. Moreover, the cycles of crude oil and heating oil prices coincide with the industrial production cycle, while those of unleaded gasoline and natural gas lag the cycle of industrial production. This has important implications for hedgers and speculators. If speculators, for example, expect an increase in real

Table 1
HP cyclical correlations of spot-month energy futures prices with US output, prices and the unemployment rate

Commodity	Correlation coefficients												
	x_{t-6}	x_{t-5}	x_{t-4}	x_{t-3}	x_{t-2}	x_{t-1}	x_t	x_{t+1}	x_{t+2}	x_{t+3}	x_{t+4}	x_{t+5}	x_{t+6}
A. Cross correlations with US industrial production													
Crude oil	−0.02	0.01	0.07	0.16	0.23	0.29	0.31	0.28	0.24	0.22	0.19	0.14	0.10
Heating oil	−0.05	0.01	0.06	0.11	0.17	0.24	0.29	0.29	0.29	0.27	0.20	0.15	0.11
Unleaded gasoline	−0.19	−0.13	−0.07	0.04	0.15	0.24	0.30	0.32	0.32	0.35	0.27	0.17	0.12
Natural gas	0.04	−0.02	−0.06	−0.02	0.06	0.19	0.34	0.46	0.53	0.51	0.43	0.25	0.01
B. Cross correlations with the US unemployment rate													
Crude oil	0.00	−0.04	−0.10	−0.16	−0.20	−0.23	−0.26	−0.26	−0.24	−0.26	−0.25	−0.22	−0.21
Heating oil	0.01	−0.05	−0.11	−0.16	−0.21	−0.25	−0.28	−0.28	−0.25	−0.25	−0.21	−0.17	−0.14
Unleaded gasoline	0.15	0.08	0.02	−0.04	−0.10	−0.17	−0.26	−0.29	−0.30	−0.35	−0.34	−0.30	−0.26
Natural gas	−0.22	−0.25	−0.19	−0.12	−0.17	−0.21	−0.29	−0.28	−0.28	−0.31	−0.37	−0.29	−0.11
C. Cross correlations with US consumer prices													
Crude oil	0.33	0.44	0.54	0.62	0.68	0.66	0.51	0.32	0.17	0.06	−0.02	−0.05	−0.05
Heating oil	0.17	0.22	0.30	0.36	0.39	0.37	0.28	0.18	0.10	0.08	0.04	0.02	0.04
Unleaded gasoline	0.29	0.39	0.53	0.64	0.72	0.69	0.55	0.40	0.34	0.26	0.15	0.05	−0.02
Natural gas	0.23	0.24	0.24	0.22	0.18	0.10	0.04	−0.04	−0.17	−0.36	−0.51	−0.58	−0.48

Note: Results are reported using monthly data for the following sample periods: crude oil, 1983:3−1993:4; heating oil, 1979:3−1993:4; unleaded gasoline, 1979:12−1993:4; and natural gas, 1990:4−1993:4.

output, they may wish to buy futures since the price of energy commodities is likely to rise.

To investigate the robustness of these results to changes in the cyclical indicator, we report in panel B of Table 1 correlations (in the same fashion as in panel A) using the unemployment rate as the cyclical indicator. Of course, since the cyclical component of industrial production and the unemployment rate are negatively correlated, a negative correlation in panel B indicates procyclical variation and a positive correlation indicates countercyclical variation. Clearly, the results in panel B in general confirm those in panel A. Hence, we conclude that irrespective of the cyclical indicator, energy prices are procyclical.

Panel C of Table 1 shows cyclical energy prices–US consumer prices correlations. Clearly, crude oil and unleaded gasoline prices are strongly contemporaneously correlated with US consumer prices, while heating oil prices are weakly correlated and natural gas prices are independent. Moreover, the cycles of crude oil, heating oil and unleaded gas prices lead the cycle of US consumer prices, suggesting that changes in energy prices might be good predictors of future aggregate price changes. This also raises the possibility that energy prices might be a useful guide for monetary policy, possibly serving as an important indicator variable.

Finally, in Table 2 we show HP cyclical correlations of heating oil, unleaded gasoline and natural gas prices with crude oil prices. The results indicate that the contemporaneous correlations are strikingly strong in the case of heating oil and unleaded gasoline but not as strong in the case of natural gas. This is consistent with the conclusion reached by Serletis (1994) that crude oil, heating oil and unleaded gasoline prices are driven by one common trend, suggesting that it is appropriate to model these prices as a cointegrated system. Natural gas prices, however, seem to react to a separate set of fundamentals.

4. Conclusion

In this paper we investigated the cyclical behavior of energy prices using monthly data and the methodology suggested by Kydland and Prescott (1990). Based on stationary HP cyclical deviations, our results are robust to alternative measures of the cycle and indicate that crude oil and heating oil prices are synchronous and procyclical whereas unleaded gasoline and natural gas prices are lagging procyclically. Moreover, energy prices are positively contemporaneously correlated with consumer prices and their cycles lead the cycle of consumer prices, suggesting a possible role for energy prices in the conduct of monetary policy.

However, the apparent phase-shift between energy prices and consumer prices should not be interpreted as supporting an effect from energy prices to consumer prices since using lead–lag relationships to justify causality is tenuous. Clearly, the investigation of the empirical relationship between energy prices and consumer prices, by looking at the performance of energy prices as indicators of inflation, is an area for potentially productive future research. Such an examination could

Table 2
HP cyclical correlations of spot-month heating oil, unleaded gasoline and natural gas futures prices with spot-month crude oil futures prices

Commodity	Correlation coefficients												
	x_{t-6}	x_{t-5}	x_{t-4}	x_{t-3}	x_{t-2}	x_{t-1}	x_t	x_{t+1}	x_{t+2}	x_{t+3}	x_{t+4}	x_{t+5}	x_{t+6}
Heating oil	−0.14	−0.14	−0.06	0.09	0.37	0.66	0.88	0.76	0.60	0.42	0.27	0.09	0.01
Unleaded gasoline	−0.10	0.00	0.13	0.23	0.47	0.72	0.86	0.66	0.42	0.29	0.25	0.16	0.09
Natural gas	−0.18	−0.28	−0.38	−0.35	−0.18	0.09	0.33	0.38	0.27	0.03	−0.22	−0.33	−0.37

Note: Results are reported using monthly data for the following sample periods: heating oil, 1979:3−1993:4; unleaded gasoline, 1979:3−1993:4; and natural gas, 1990:4−1993:4.

utilize current state-of-the-art econometric methodology, such as, for example, integration and cointegration theory as well as error-correction modeling (if applicable), using either the single-equation approach or a multi-equation (VAR) framework.

We also presented evidence regarding cyclical correlations of heating oil, unleaded gasoline and natural gas prices with crude oil prices. We show that the contemporaneous crude oil–heating oil and crude oil–unleaded gasoline correlations are very strong, providing further support to the conclusion of Serletis (1994) that these prices are driven by only one common trend which means, according to the interpretation of Stock and Watson (1988), that the same underlying stochastic components presumably affect the crude oil, heating oil and unleaded gasoline markets. The natural gas market, however, doesn't seem to be linked to the crude oil market.

The results presented in this paper pertain to the US. Of course, the cyclical behavior of energy prices in countries with different industrial structures and/or levels of oil dependency would be expected to be different. Therefore the international generalizability of this work is also an area for future research.

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References

Baxter, M., King, R.G., 1995. Approximate band-pass filters for economic time series. NBER Working Paper No. 5052.

Cogley, T., Nason, J.M., 1995. Effects of the Hodrick–Prescott filter on trend and difference stationary time series: implications for business cycle research. J. Econ. Dyn. Control 19, 253–278.

Fiorito, R., Kollintzas, T., 1994. Stylized facts of business cycles in the G7 from a real business cycles perspective. Eur. Econ. Rev. 38, 235–269.

Hamilton, J.D., 1983. Oil and the macroeconomy since World War II. J. Political Econ. 91, 228–248.

King, R.G., Rebelo, S.T., 1993. Low frequency filtering and real business cycles. J. Econ. Dyn. Control 17, 207–231.

Kydland, F.E., Prescott, E.C., 1990. Business cycles: real facts and a monetary myth. Fed. Reserve Bank Minneapolis Q. Rev. Spring, 3–18.

Lucas, R.E. Jr., 1977. Understanding business cycles. In: Brunner, K., Meltzer, A.H. (Eds.), Stabilization of the Domestic and International Economy, Vol. 5 of the Carnegie-Rochester Conference Series on Public Policy. North-Holland, Amsterdam, pp. 7–29.

Mork, K.A., 1988. Oil and the macroeconomy when prices go up and down: an extension of Hamilton's results. J. Political Econ. 97, 740–744.

Prescott, E.C., 1986. Theory ahead of business cycle measurement. Fed. Reserve Bank Minneapolis Q. Rev. 10, 9–22.

Serletis, A., 1994. A cointegration analysis of petroleum futures prices. Energy Econ. 16, 93–97.

Stock, J., Watson, M.W., 1988. Testing for common trends. J. Am. Stat. Assoc. 83, 1097–1107.