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Do demand and supply shocks explain USA's oil stock fluctuations?

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ABSTRACT

In this paper using historical monthly data on the US oil stocks (Crude Oil and Petroleum Products Ending Stock-coppes), industrial production, energy use for transportation, oil production, and oil imports, we examine whether supply and demand shocks explain the apparent decline in the volatility of the growth of COPPES since about the mid-1980s. We find that nearly 70% of the variation in the US COPPES growth is explained by its supply and demand factors, each sharing about half of this variation. This is on account of sharp decline in the contribution of persistence to the US COPPES growth variation from about 47% in the pre-break period to about 17% in the post-break period. This reduction is taken up by increased contribution of demand and supply factors since mid 1980s, of which growth variances have declined on net since then. This in turn contributes to the stability of the US COPPES growth fluctuations.

1. Introduction

Oil price and its volatility are now central issues in policy making. Hamilton [1] notes that seven out of eight postwar US recessions had been preceded by a sharp increase in the price of crude petroleum. This is also true for the most recent global financial crisis, which began following the 2007–2008 hike in oil price, a period in which oil prices more than doubled. It is little surprising then that recent studies have began to examine the volatility in oil price and oil stock (see for instance, [2,3]).

Hayat and Narayan [3] represent the most recent contribution on this subject. In their work, they establish that the volatility of the US oil stock has declined since 1986. What remains unanswered, however, is what has caused (in terms of economic factors) this decline in volatility of the US oil stocks? We, thus, take this literature forward through providing some answers to this question.

Our approach is as follows. We consider historical monthly data on the crude oil and petroleum products ending stock (COPPES) or the oil stock. The data is for the period January 1956 to November 2008. We also consider corresponding data for the US industrial production, US energy use for transportation, US oil production and the US oil imports apart from transportation data which starts from January 1973. In our empirical analysis, we specifically examine the role of the demand shock (proxied by the US industrial production and the US transportation) and the role of the supply shock (proxied by the US oil production and the US oil imports) in explaining the decline in volatility of the growth in US oil stocks (See Fig. 1).

Essentially, our research question leads to testing two specific hypotheses as follows:

1. That the decline in the variance of the growth of the US oil stock (or COPPES) is due to the decline in the coefficient of its own lags (or persistence),
2. That the decline in the variance of the growth of the US oil stock is due to demand and supply factors.

These hypotheses are examined based on two approaches. First, we undertake an analysis of the variance (ANOVA) of the growth rate of the US oil stock (or COPPES). From this ANOVA, we unravel that the supply and demand factors are the main contributors to the decline in the growth volatility of the US oil stock in the post-1986 period. In this period, the contribution of COPPES persistence in COPPES growth volatility was found to be trivial. Second, we undertake a forecast error variance decomposition analysis, commonly known as the innovation accounting technique. This approach essentially distinguishes the contributions of shocks to each of the variables in explaining the forecast error variance of the growth of COPPES. From this analysis, we unravel evidence that while in the short-run demand and supply shocks are trivial, in the long-run they cumulatively explain about 70% of the forecast error variance of the growth of COPPES.

We organize the balance of the paper as follows. In Section 2, we discuss the methodology for modeling the growth of COPPES. In Section 3, we discuss the results. In the final section, we summaries the main findings.

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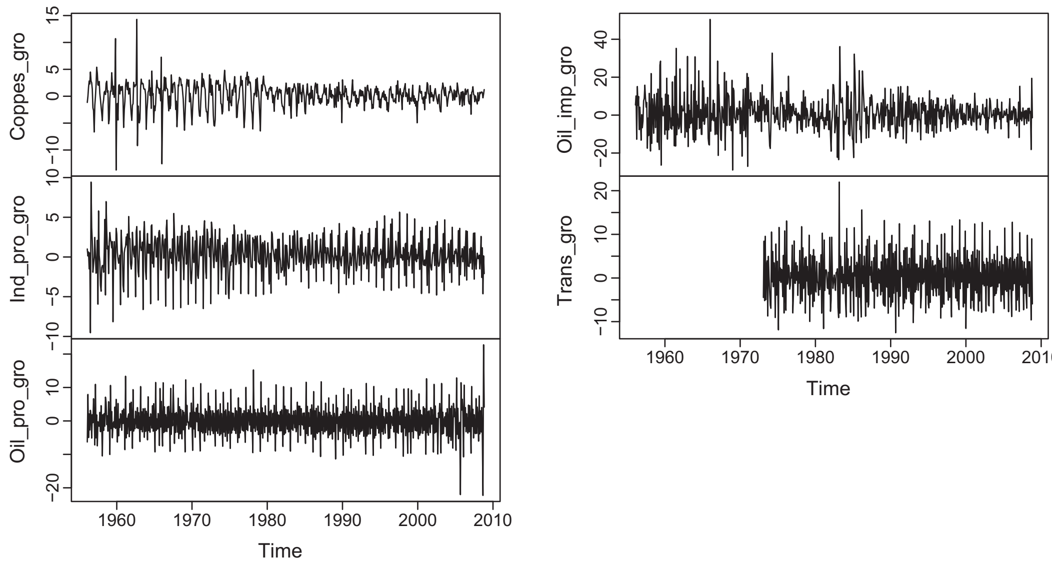

Fig. 1. The monthly growth rates of not seasonally adjusted data from February 1956 to November 2008 apart from transportation growth which starts from February 1973.

Table 1
Descriptive statistics for pre- and post-break periods.

	$\dot{x}^{coppes}$	$\dot{x}^{indpro}$	$\dot{x}^{oilpro}$	$\dot{x}^{oilimp}$	$\dot{x}^{trans}$
Pre-break					
Mean	0.26	0.29	0.16	1.07	0.28
Sd	2.80	2.58	4.72	11.04	5.83
n_1	366	366	366	366	162
Post-break					
Mean	0.04	0.22	-0.06	0.46	0.23
Sd	1.30	2.04	5.51	6.05	5.63
n_2	268	268	268	268	268
Decline in sd (%)	−53.75	−20.81	16.69	−45.21	−3.47

Note: sd stands for the standard deviation and n_1 and n_2 are the sample sizes in pre- and post-break periods respectively.

2. Methodology

As mentioned earlier, our main interest is in the reduction of the variation of the US COPPES growth variable since August 1986. We use four more variables, namely, US industrial production growth,[1] US transportation growth, US oil production growth, and the US oil imports growth as the determinants to the US COPPES growth variable. We provide some descriptive statistics of these variables for pre- and post-break periods in Table 1. We see that standard deviation of the US COPPES growth declined markedly from 2.8 in pre-break period to 1.3 in post-break period–a decline of around 54%. Likewise, other variables have observed similar declines apart from the US oil production growth.

For analysis of variance to the US COPPES growth, we consider four univariate models for the growth of the US COPPES. The models are presented in Table 2. Model 1 examines the hypothesis that the decline in persistence explains COPPES growth. Model 2 tests part of the hypothesis 2, that demand shock (US industrial production) explains COPPES growth. Model 3 tests hypothesis 2 in part, that demand (US industrial production) and supply (US oil production) factors explains COPPES growth. Model 4 tests hypothesis 2 in full that demand (induction production and transportation) and supply (oil production and oil imports) factors explain COPPES growth fluctuations. As mentioned, we initially use the ANOVA technique and then a system of equation based VAR model to examine these hypotheses.[2]

In ANOVA setting, if we find a decline in σ_η^2 of Models 1–4 from the pre- to the post-break period, it will mean that the persistence, the demand or/and supply factors are not responsible for the decline in the US COPPES growth volatility. It implicitly implies rejections of hypotheses 1 and 2. In a VAR setting, we can see the contribution coming from the supply shocks, and the demand shocks to the forecast error variance of the US COPPES growth. The higher the contribution of the demand shock, for instance, in the forecast error variance decomposition of the US COPPES growth, the higher the share of the demand side factor in the decline of the variance of growth of the US COPPES because they have got stabilized since mid 1980s. This will support hypothesis 2.

2.1. Analysis of variance to the US COPPES Growth

For the ANOVA to the US COPPES growth, we utilize the models, namely, Model 1, Model 2, Model 3, and Model 4 specified in Table 2. We describe Models 1–4 on the basis of the lag structure of the US COPPES growth ($\dot{x}_t^{coppes}$), the US industrial production growth ($\dot{x}_t^{indpro}$), the US use of energy for transportation ($\dot{x}_t^{trans}$), the US oil production growth ($\dot{x}_t^{oilpro}$), and the US oil imports ($\dot{x}_t^{oilimp}$) employed in the AR setting for the US COPPES growth. For all the three sample periods; namely, the full sample period, the pre-break sample period, and the post-break sample period, the lags for $\dot{x}_t^{coppes}$, $\dot{x}_t^{indpro}$, $\dot{x}_t^{trans}$, $\dot{x}_t^{oilpro}$, and $\dot{x}_t^{oilimp}$ in Models 1–4 were chosen in a way that minimized the AIC of the regression model for that sample period. It is possible that the variation in $\dot{x}_t^{coppes}$ could be explained by variations in contemporaneous growth of $\dot{x}_t^{indpro}$, $\dot{x}_t^{trans}$, $\dot{x}_t^{oilpro}$ and $\dot{x}_t^{oilimp}$. Therefore, contemporaneous effects are included in Models 2–4.

The ANOVA helps to break down the contribution of each of the

[1] We actually estimated a structural break in the variance of the US industrial production growth, which came out at February 1983. That is, the variance of growth of the US industrial production has declined significantly since February 1983.

[2] We tested whether or not the decline in the variance of growth of the US oil production and the US oil supply is significant. We find that the decline in the variance of the US oil production growth is significant and the decline in the variance of the US oil supply is insignificant. The results are with the author and can be provided upon request. Nevertheless, this does not lead to the conclusion that the variation in the US oil supply does not contribute to the variation in the US COPPES growth. We, therefore, conduct a complete analysis of the variance of the US COPPES growth using the ANOVA technique and perform its forecast error variance decomposition.