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A monthly crude oil spot price forecasting model using relative inventories

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Abstract

This paper presents a short-term forecasting model of monthly West Texas Intermediate crude oil spot prices using readily available OECD industrial petroleum inventory levels. The model provides good in-sample and out-of-sample dynamic forecasts for the post-Gulf War time period. In-sample and out-of-sample forecasts from the model are compared with those derived from other models. The model is intended for the practicing forecaster and designed to be simple enough to implement easily in a spreadsheet or other software package, with the variables easy to update. The simplicity and ease of updating make this model attractive for investigating various scenarios to see the impacts that market changes can have on monthly crude oil spot prices if inventories, production, imports, or demand change. Finally, the model structure can easily be updated periodically should there be a fundamental market change or a shift in the normal level of inventories.

Keywords: Forecast modeling; Crude oil price; Petroleum inventory

1. Introduction

In this paper, we develop a simple and practical model for forecasting monthly crude oil spot prices under normal market circumstances[1] using readily available data. The objective of this model is to provide a dynamic forecast of monthly West Texas Intermediate (WTI) prices for the post Gulf War I time period using readily available data (WTI spot prices and OECD petroleum inventories) readily available and that can be implemented in spreadsheet applications. Thus, the model is intuitively appealing and useful to industry and government decision-makers in forecasting prices and in investigating the impacts on price of changing market fundamentals, such as petroleum inventories, production, imports, and demand. Because of the few variables involved, the results from the forecast model can be easily

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[1] This model deals with the fundamental relationship between inventories and prices and does not take into account transitory geopolitical situations giving rise to various risk premiums, such as the War premium or terror premium.

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interpreted. The model is also practical from a maintenance standpoint in that it is based on two readily available data series.

We focus on the concepts of normal and relative levels of petroleum market variables such as demand, field production, net imports, and inventory. This is similar to the natural rate theory widely applied in macroeconomic modeling and empirical studies. We decompose the observed level of a petroleum market variable into two components: the normal level, determined by historical seasonal movements and trends, which reflects the normal market demand and operational requirements; and the relative level, the difference between the observed and normal levels, which reflects short-run market fluctuations. Seasonality exists in petroleum market variables such as demand, field production, and net imports. Since change in inventory equals the difference between demand and supply (the sum of field production and net imports), petroleum inventory demonstrates seasonal movements as well. Long-term inventory trends exist due to the trends in government inventories, increases in long-term product demand, and the larger distribution and storage infrastructure needed to meet demand growth and product differentiation. It is the relative levels of demand, field production, net imports, and inventory that respond to the unexpected short-run variations in the market.

Among these relative level variables, it is the relative inventory that matters most in the short run for the determination of crude oil price.[2] On the demand side, many consumers have few options and little discretion as to how much volume they can use in the short term. People must heat their homes in the winter and drive to work regardless of price. This implies that short-term demand elasticity is small. On the supply side, supply chains that move crude oil from its source of production to refineries, and then move product from refineries to consumers, are long and cannot be adjusted quickly when unexpected shifts in supply or demand occur. Empirically, we have found that the short-run demand elasticity is indeed much less than the short-run inventory elasticity in the United States and the production elasticity is virtually zero. Since total petroleum inventory levels are a measure of the balance, or imbalance, between petroleum production and demand, they reflect changing market pressures on crude oil prices, and thus provide a good market barometer for crude oil price change in the short run. Intuitively, relative inventory levels must be negatively related to prices, with distributed lagged effects.

The observed behavior of WTI spot prices and total OECD industrial inventories since Gulf War I supports this argument. The large swings in WTI spot prices during the late 1990s are coupled with counter-swings in OECD total inventories, particularly when measured in relative terms. For example, in 1998 production consistently exceeded demand; as a result, inventories grew to unusually high levels. Demand growth slowed during this period in part due to warm winters in the Northern Hemisphere and the Asian financial crisis, while supply increased substantially as Iraqi crude oil came back into the export market in 1997 through the "Oil-for-Food" Program. WTI spot prices fell to near $10 per barrel by the end of 1998 due to the excess of production over demand and the resulting inventory build. The supply/demand balance reversed in 1999 when OPEC cut back production to a level well below demand, and the demand for crude oil simultaneously increased as the Asian economies recovered. With demand exceeding production during 1999, inventories were drawn down to help meet demand. The excess inventories that had been built up fell rapidly to well below normal levels, and WTI spot prices correspondingly rose to over $30 per barrel by early March 2000. More recently, we have observed that the loss of Venezuelan crude oil production during the oil workers' strike in that country resulted in a large drop in U.S. crude oil inventories, while demand changed very little, even though crude oil prices climbed about $5 per barrel.[3]

2. A forecast model

The basic idea underlying the forecast model is the natural rate theory. Theoretically, the normal inventory

[2] For example, see Ye, Zyren, and Shore (2002) and Ye, Zyren, and Shore (2003).

[3] Energy Information Administration, data from *Weekly Petroleum Status Report* and discussions from EIA's web summary of the weekly data, "This Week in Petroleum," during January 2003. http://www.eia.doe.gov/oil_as/petroleum/info_glance/petroleum.html.