Concepts, Data Sources, and Techniques

Handbook of Energy Modeling Methods

Short-Term Energy Outlook Crude Oil Price Forecasts

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1. Introduction

In the *Short-Term Energy Outlook* (STEO), EIA's forecasts for monthly average Brent and West Texas Intermediate (WTI) spot prices are calculated outside of the Short-Term Integrated Forecasting System (STIFS). The crude oil price forecast is one of the main determinants of the forecast for many of the petroleum price, consumption, and production variables within STIFS. Crude oil prices also affect a wide range of other non-petroleum forecasts produced by STIFS.

EIA first formulates a forecast for Brent crude oil spot prices and then forecasts WTI spot prices by creating a forecast for the spot price spread between Brent and WTI. EIA considers three main inputs to determine its Brent price forecast:

- A pooling model that provides a single Brent price series that is an average of five separate models
- A linear regression using independent variables from the STEO forecast
- Analyst judgment based on an understanding of global oil market dynamics and EIA's forecast for supply and demand balances

In sections three through five below, we discuss each of these inputs separately.

2. Data sources

EIA purchases the underlying historical time series for Brent and WTI crude oil spot prices from Refinitiv (Thomson Reuters). With permission, EIA republishes these price series on our website. The STEO forecast reflects a monthly average price. For historical data, the monthly average price is calculated by taking a simple average of the daily closing prices for all trading days in the month (typically all weekdays excluding holidays). The spot price for Brent crude oil is based on physical delivery of crude oil in the North Sea in the United Kingdom. The spot price for WTI is based on physical delivery at the Cushing, Oklahoma, storage hub.

3. Pooling model

Each month, EIA runs a set of five real-time Brent crude oil price forecasting models. These linear regression models are based on historical data on economic and oil market activities:

- A vector autoregressive model
- A model based on the spread between oil futures prices and the spot price of oil
- A model using non-oil industrial commodity prices
- A model with a time-varying parameter representing the relationship between (a) the spreads between the U.S. spot prices of gasoline and heating oil and (b) the spot price of crude oil
- A model based on the cumulative change in U.S. crude oil inventories

The pooled forecasts methodology EIA uses is discussed in Baumeister et al.[1] The results of the five models are pooled using a simple average of the five results.

4. Linear Regression

EIA also produces a Brent forecast using a linear regression model based on STEO forecast results. The regression equation models the month-to-month change in the Brent crude oil spot price based primarily on the following independent variables:

- Month-to-month change in U.S. petroleum inventories
- Total monthly petroleum inventories among countries in the Organization for Economic Cooperation and Development (OECD), relative to the previous four-year average inventories for that month
- Month-to-month change in global gross domestic product (GDP)

Inventory levels are a key driver of global crude oil prices. Because oil is storable, supply of oil in one period does not necessarily equal consumption. If supply in a month is more than consumption, oil inventories increase. If supply is less than consumption, oil inventories decrease. Sometimes these mismatches of supply and consumption represent normal seasonal fluctuations. However, because oil has a relatively low short-term price elasticity for both supply and demand, imbalances between supply and demand (including demand for inventories) can occur. The resulting inventory builds or draws can reflect these market imbalances, which market participants perceive and act upon, putting downward or upward pressure, respectively, on oil prices.

EIA uses the change in U.S. petroleum inventories as a proxy for supply and demand balance trends in the global oil market. U.S. petroleum inventory data reported in EIA's *Weekly Petroleum Status Report* are one of the most timely physical market indicators available to analyze oil price movements and to represent trends in the world's largest oil market. The United States accounts for about 20% of global oil consumption and production.

Because no reliable measure for global oil inventories is available, EIA uses OECD petroleum inventory levels to assess the level of storage in the global oil market. The International Energy Agency (IEA) reports total petroleum inventories in OECD member countries (almost half of global oil consumption in 2019) with a two-month lag. Although less timely than U.S. data, OECD inventory data can still provide insight into levels of storage in other markets, particularly Europe and Japan. Much of the oil inventory data outside of the OECD, if it exists, is reported with enough of a time lag that it is less useful in a real-time, short-term forecasting model.

[1] Christiane Baumeister, Lutz Kilian, and Thomas K. Lee, Energy Economics, 46, December 2014, S33-S43

5. Analyst judgment

Ultimately, EIA analysts formulate a Brent price forecast by expert judgment, using the output of the pooled and linear regression models as guides. EIA produces an initial global oil production and demand forecast using a price forecast based on a combination of three variables:

- Price forecasts from the pooled and linear regression models described in Sections 3 and 4 above
- The previous month's STEO price forecast
- Prices paid on the futures market

EIA then iterates price paths and resulting oil market balance outcomes to achieve a price forecast consistent with forecast global oil market balances.

5.1. Forecasting global oil demand

As noted in Section 4, global oil consumption and global oil production are, for the most part, relatively price inelastic over the STEO forecast period. Using international GDP forecasts from Oxford Economics, EIA produces a forecast for global oil consumption based primarily on assumptions of country-level GDP growth. Because global oil demand growth is relatively insensitive to price change, varying the price path will not change EIA's forecast of global oil demand growth enough to meaningfully affect expected global oil market balances. Exceptions may occur in times of rapid and significant price changes.

5.2. Forecasting global oil production

EIA derives its forecast of global oil production from its forecasts of the following:

- U.S. crude oil production
- Organization of the Petroleum Exporting Countries (OPEC) crude oil production
- Non-OPEC, non-U.S. production

U.S. crude oil production is the most price sensitive part of EIA's global supply forecast, particularly in the Lower 48 states region (L48). U.S. L48 crude oil production largely consists of tight oil production, which has a much shorter investment-to-production period than conventional oil projects. Because EIA research shows that changes in oil prices typically affect L48 crude oil production with about a six-month lag, the L48 production forecast is largely set for the first six months of the forecast horizon, based on prevailing prices at the time of the forecast.

The non-OPEC, non-U.S. production forecast mostly reflects long lead time oil production projects, such as deep-water offshore or Canadian oil sands, which are typically publicly announced years in advance of realized production. Based on EIA analysis of decline rates at existing projects combined with EIA's assessment of oil production projects that will come online, EIA develops a forecast for non-OPEC, non-U.S. oil production for the forecast period. In all but exceptional circumstances, the forecast does not change based on the price assumptions in the forecast.

Given a forecast for global oil consumption and total non-OPEC production, EIA estimates the amount of crude oil that OPEC would have to produce to neither build nor reduce global oil inventories, commonly

called the *call* on OPEC crude oil production.[2] EIA creates a forecast of OPEC crude oil production based on stated OPEC policy and EIA analysts' expectations of OPEC behavior. If OPEC produces more crude oil than the call on OPEC, global oil inventories will grow, and if OPEC produces less than the call, global oil inventories will fall.

5.3. Estimating market balances and solving for equilibrium

The oil demand and production forecasts provide an initial forecast of oil market balances during the first six months of the forecast period. Next, EIA assesses whether these market balances fit with the price path that yielded those balances. EIA then iterates using various price paths. Because U.S. oil production is the most elastic part of the forecast, one exercise that is key to determining our price path is to look at forecast U.S. oil production in different scenarios and how the varying levels of production would affect global oil market balances.

In a simplified example, if EIA's initial supply and demand forecasts result in significant inventory builds during the first six months of the forecast, that might indicate that downward oil price pressures could emerge during that period. So, EIA might then run a price path through our models with lower prices forecast for the first six months of the forecast period. However, if that price path leads to less U.S. crude oil production and tighter global oil market balances later in the forecast period, then that could indicate upward oil price pressures later in the forecast. This type of iteration might lead to a Brent price path where prices are falling during the early months of the forecast and then rising toward the end of the forecast period.

5.4. Forecasting WTI prices

After EIA produces its Brent price forecast, EIA forecasts WTI prices based on analysts' expectations for the spread between Brent and WTI monthly average spot prices. Although prices for global crude oils of similar quality tend to move together closely, differences between benchmark crude oils can arise because of various transportation costs and local infrastructure constraints. The price difference between two crude oils that are freely tradeable on global markets reflects the difference in cost of moving those crude oils to the refinery that represents the marginal point of consumption.

For example, in recent years, WTI and Brent crude oils have both been competitive in global export markets, and the price differences between the two crude oils have reflected the additional cost of exporting WTI to the marginal refiner, compared with Brent. Delivering crude oil into and out of Cushing has at times been subject to infrastructure constraints, including pipeline or storage capacity limitations, which can affect prices for WTI relative to Brent. Depending on the existing level of infrastructure, as well as planned infrastructure developments throughout the forecast period, EIA develops a Brent-WTI price spread forecast that reflects the reality of any existing infrastructure constraints and considers the point at which the price spread may settle at an equilibrium level.

[2] Call on OPEC crude oil production = global oil consumption – non-OPEC supply