



# Economic Letter

## Real-time Data Inaccuracies Pose Challenges to Gauging the Oil Market

by Justin J. Lee and Jesse Thompson

**ABSTRACT:** Initial estimates of global oil market balance, or the implied change in global inventories, are frequently used to identify supply shortages or surpluses. These have important implications for future oil prices. Initial inventory data undergo various revisions, which may contribute to inefficiencies in oil pricing.

There is no direct measurement of global crude oil inventory outside of domestic stocks estimates prepared by the Organization for Economic Cooperation and Development (OECD).<sup>1</sup>

The implied change in global petroleum inventories (or stocks) is often derived from the difference between estimated global daily production and consumption.

This is an indicator of the extent to which the market anticipates production surplus or shortage. Often, initially released production and consumption data are revised. These changes frequently send conflicting signals of surplus or shortage, potentially contributing to inefficient pricing.

Market participants use this and other data to assess profitability of futures or equity. Moreover, they look closely at consumption figures, which tend to be initially less reliable than those depicting production.

### Tracking World Inventory

Inventory changes signal whether the market is in surplus or shortage. The United States is one of the only countries with large and frequently measured petroleum stocks. Other members of the OECD also provide measurements of inventory changes that account for a

large portion of total global stocks.

By comparison, non-OECD countries, particularly China, members of OPEC and many emerging economies—where global energy demand growth is centered—don't provide such information. Thus, market participants use period-to-period global implied changes in world petroleum inventory as a proxy for changes in actual global inventory.

The U.S. Energy Information Administration (EIA) publishes the *Short-Term Energy Outlook*, containing monthly estimates of world petroleum production and consumption.<sup>2</sup> The implied change in inventory can be calculated by taking the difference between the two EIA series. For each month, the U.S. agency releases its most recent initial estimates, as well as revisions to earlier data.

Initial estimates are a guide that market participants use to form or update beliefs about current and future prices. Understanding data revisions provides context with which to interpret initial estimates of market balance.

Such revisions mainly correct survey reporting errors by the EIA and the International Energy Agency (IEA).

For example, initial estimates of monthly U.S. production from the EIA are drawn from a sample of more volatile weekly data. A second round of rev-

sions comes from aggregated production data compiled into monthly state-level data. Finally, there are annual revisions to historical data that can go back several years, as well as revisions based on methodological changes.<sup>3</sup>

## Tracking Revisions

To track the revisions, the monthly releases of world production and consumption and U.S. production and consumption from the EIA are collected.<sup>4</sup> Because these datasets provide timely

figures, it becomes possible in real time to track revisions as more complete data become available.<sup>5</sup> Similarly, the IEA's monthly *Oil Market Report* data are tracked through various revisions.<sup>6</sup>

Market participants, partly relying on these sources of information, make decisions whether to buy or sell crude oil or other petroleum-related equities. If the initial estimates are subject to substantial revisions or if the IEA and EIA data are at odds, trades may be completed that might not otherwise occur. This is especially true when participants are unaware or uncertain of how to account for potential future revisions.

Inaccuracies in petroleum data, therefore, may have real-time impacts on the price of crude oil, motor fuels such as gasoline and distillates. Market participants also compile information from myriad other sources that sometimes influence their analysis of unrevised data.

All else constant, the implied crude oil inventory is indirectly related to the price of crude oil. When the world produces more oil than it consumes, the excess is stored—in inland oil tanks, ships and pipelines. This is generally supportive of lower petroleum prices.

The spot price of Brent crude oil, an international benchmark, closely followed the evolution of implied global stocks in real time, despite market participants seemingly being unaware of the likely magnitude or direction of future revisions (*Chart 1*).

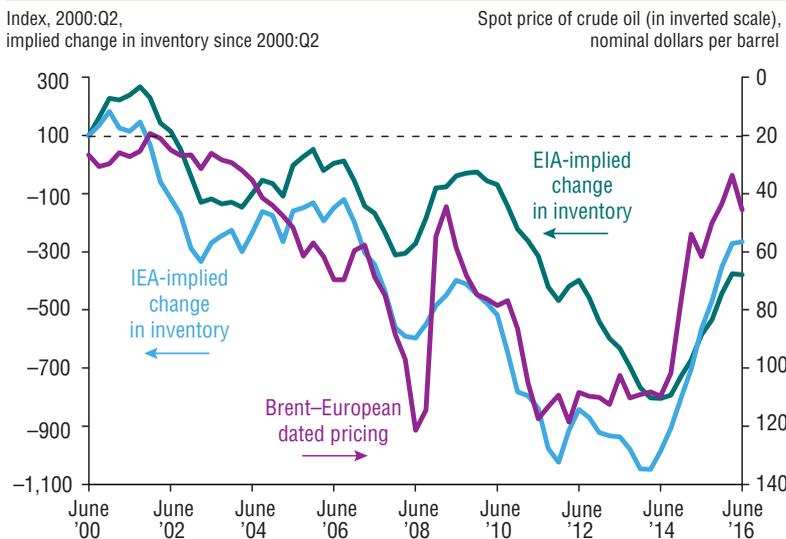
After 12 months of revisions, both data-releasing agencies' implied stock changes followed the same trend: The EIA and IEA indicated that the implied inventory in mid-June 2016 had risen to around levels last seen in 2010 in the aftermath of the global recession. The nominal, or stated price, of crude oil declined accordingly.

## Initial Data, Wrong Signal

A data point can be revised years after the initial estimate, but the magnitude of revisions beyond the initial 12 months is relatively small, and the qualitative interpretation of the implied inventory change is little altered.<sup>7</sup>

A confidence band of one standard deviation—a measure of the dispersion

**Chart 1** Current Prices Consistent with Revised Changes in Inventory

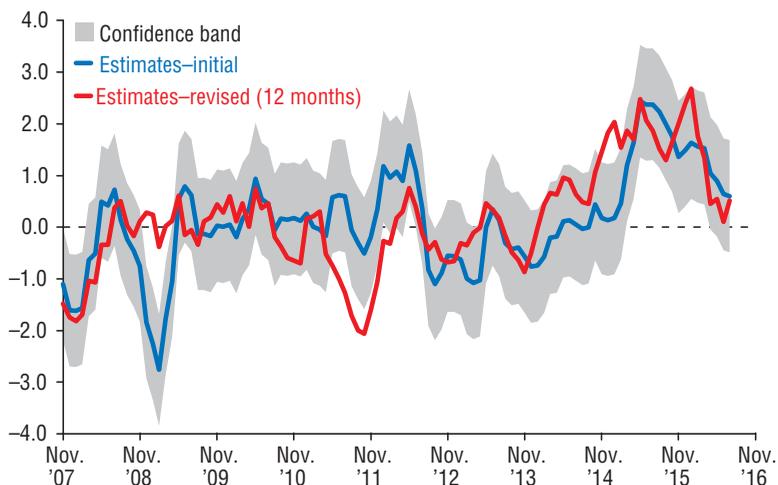


NOTES: Chart shows data ended June 2016, which are revised after at least 12 months. Brent crude oil price is computed by averaging daily nominal price of dated Brent into quarterly frequency.

SOURCES: Federal Reserve Bank of Dallas; Federal Reserve Economic Data—Federal Reserve Bank of St. Louis; International Energy Agency, *Oil Market Report* (July 2017); Energy Information Administration, *Short-Term Energy Outlook* (July 2017); authors' calculations.

**Chart 2** Initial Estimates Unreliably Identify Imbalance

Implied monthly change in inventory, million barrels per day\*



\*Three-month centered moving average.

NOTE: The confidence band is calculated by measuring one standard deviation of revisions. (Revisions are defined as the difference between initial estimates (blue line) and revised estimates after 12 months (red line).)

SOURCES: Federal Reserve Bank of Dallas; Energy Information Administration; authors' calculations.

of values around the mean—of revisions helps assess whether the initial estimates of market imbalance are substantive (*Chart 2*).<sup>8</sup> Historically, 17 percent of revised implied change in global inventory fell outside of the confidence band, sending false signals about the trajectory of global inventory.

Typical revisions to production and consumption estimates are small relative to the size of the global oil market (roughly 97 million barrels consumed daily) but large relative to the size of implied inventory changes.

Initial estimates of implied changes in inventory were revised by an average 840,000 barrels per day from late 2007 through early 2016, based on calculations using EIA data. This data produced a largely inaccurate result—a quarter of the time, the market indicated surplus (or shortage) when the opposite was true. Furthermore, over three-quarters of the time, initial estimates of imbalance were indistinguishable from zero using the confidence band.

### Three Large Episodes

Three episodes of inaccurate signals were particularly large relative to historical norms.

Beginning in early 2009, roughly coinciding with the end of the global recession, initial data suggested a significant decline in global petroleum stocks.

However, revised estimates later showed that the implied stock level was essentially flat.

Initial estimates from mid-2011 implied relatively flat inventories, but the revised data indicated that significant draws were occurring. In late 2014, implied stock builds were also shown to be much larger than initially estimated.

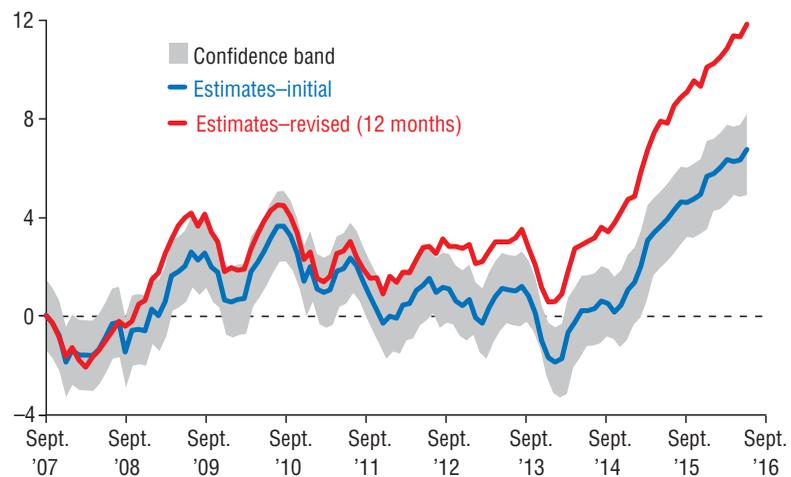
On the whole, revisions to estimated consumption levels tended to be slightly larger than revisions to production. Consumption was the main contributor to revisions following the global recession; the OECD consumption was regularly overestimated from 2008 to 2015. Subsequently, consumption in non-OECD countries exceeded what initial estimates suggested, driven by solid economic growth and rising gasoline and diesel demand, particularly from China from 2011 to 2015.

Implied inventories have risen sharply since 2015. Steady increases in petroleum demand failed to match substantial U.S. and OPEC production growth. Most notably, the EIA's report of monthly U.S. crude oil production has been systematically revised upward since 2015, as reflected in the overall implied level of U.S. crude oil inventory (*Chart 3*).

The same exercise can be repeated using the quarterly data produced by the IEA. The initial IEA quarterly report incorporates some revised monthly data before its initial estimates are issued. The IEA revisions in this sample had an absolute average revision of about 423,000 barrels per day, with a standard deviation of 302,000 barrels per day.

## Chart 3 Underestimated Production Drove Revisions Upward

Implied change in inventory since August 2007, million barrels per day

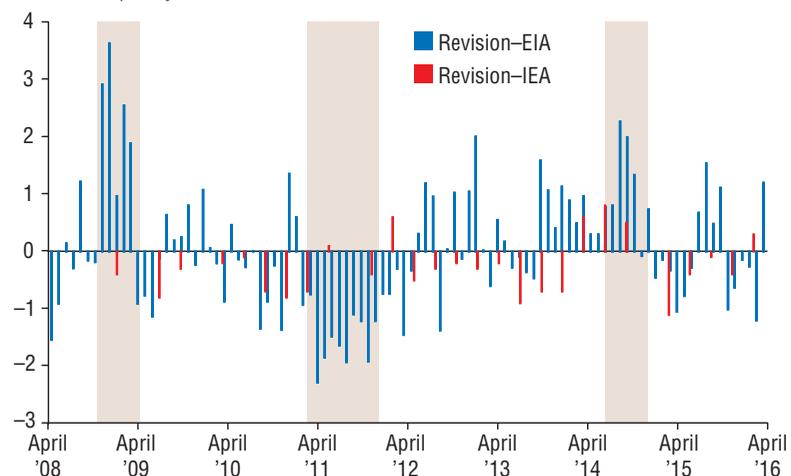


NOTE: The confidence band is calculated by measuring one standard deviation of revisions. (Revisions are defined as the difference between initial estimates (blue line) and revised estimates after 12 months (red line).)

SOURCES: Federal Reserve Bank of Dallas; Energy Information Administration; authors' calculations.

## Chart 4 Revisions to Oil Market Imbalance Vary Substantially

Difference between revised, initial estimates of implied change in inventory, million barrels per day



NOTE: Shaded regions show episodes where initial estimates significantly mischaracterized imbalance given the size of the EIA revisions.

SOURCES: Federal Reserve Bank of Dallas; Energy Information Administration; International Energy Agency; authors' calculations.

The magnitude of these revisions is substantially lower than those for the EIA's data series—whose initial estimates are timelier—but this is largely a function of a timing of the releases.

When interpreting initial data from the different agencies, analysts should be aware of the differences in methodology and the behavior of revisions, not just the magnitude of the revisions (*Chart 4*).

## Prices Reflect Multiple Revisions

The scale of revisions to implied global inventory changes suggests that initial estimates of imbalances between production and consumption need to be substantial to conclude market surplus or shortage.

Market participants should account for the uncertainty of revisions when interpreting these initial estimates. However, even with the uncertainty in the real-time data, oil prices—on average—tend to move as expected based on revised global implied stocks.

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## Notes

<sup>1</sup> Analyzing fluctuation of crude oil inventory is crucial to understand the oil market dynamics. See, "The Role of Inventories and Speculative Trading in the Global Market for Crude Oil," by Lutz Kilian and Daniel P. Murphy,

*Journal of Applied Econometrics*, vol. 29, April/May 2014, pp. 454–78.

<sup>2</sup> The EIA's *Petroleum Supply Monthly* is another source of the data. The data from the *Short-Term Energy Outlook* and the *Petroleum Supply Monthly* may differ due to timing of the releases.

<sup>3</sup> For example, OPEC production numbers would be revised because of membership changes over time; reclassification of products might occur when blending natural gas liquids into crude streams causes mismeasurement of crude inputs into refineries. In 2015, the EIA changed its methodology and started collecting production information directly from universal oil and gas firms in the U.S.; significant changes to the magnitude of revisions are not identified yet as a result of this change.

<sup>4</sup> The U.S. consumption measure is a measure of refinery intake volume. The U.S. production measure includes domestic production and imports (foreign production) of crude oil. Exports of crude oil from the U.S. were negligible over the sample period.

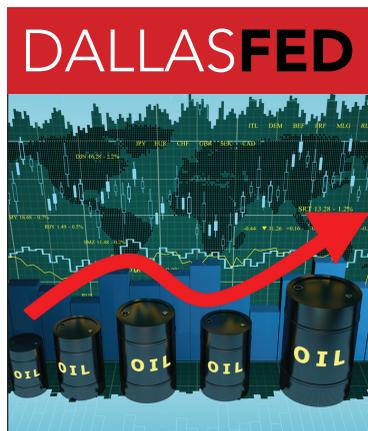
<sup>5</sup> For more extensive application, consult "Frontiers of Real-Time Data Analysis," by Dean Croushore, *Journal of Economic Literature*, vol. 49, no. 1, March 2011, pp. 72–100.

<sup>6</sup> Different agencies have different definitions of petroleum products. For example, the EIA's measure of petroleum includes crude oil (as well as lease condensates), natural gas liquids, biofuels, other liquids and refinery processing gains. The IEA defines petroleum as components of crude oil, natural gas liquids and non-conventional oils. This discrepancy is one of the sources of difference in measure.

<sup>7</sup> Previous literature documented that petroleum production revisions largely occur within 24 months of initial release. The literature documented substantial revisions after the first year and no substantive revisions after two years. For full documentation, consult "Real-Time

Forecasts of the Real Price of Oil," by Christiane Baumester and Lutz Kilian, *Journal of Business & Economic Statistics*, vol. 30, December 2011, pp. 326–36.

<sup>8</sup> The magnitude and direction of revisions must neither be applied to statistical nor probabilistic interpretation. There is no evidence that the revisions conform to any well-defined distributional properties. The revisions are not independent and identically distributed.



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