The Simple Economics of Global Fuel Consumption: Digest Version

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Reinhard Ellwanger, Ph.D., Bank of Canada, presenting at the JPMCC's 2nd International Commodities Symposium, which was held at the University of Colorado Denver Business School in August 2018. From left-to-right are Dr. Ellwanger's fellow presenters at the JPMCC's Economics of Energy Markets panel: Dr. Hinnerk Gnutzmann, Ph.D., Leibniz Universität Hannover (Germany) and Dr. Lutz Kilian, Ph.D., University of Michigan, Ann Arbor. Dr. Kilian, in turn, also co-authored an article in this issue of the *GCARD*.

Understanding the Role of Fuel Consumption in the Global Market for Oil

A common view among practitioners and policy makers is that the demand for crude oil is ultimately derived from the demand for oil products. The view rests on the fact that crude oil has no use in and of itself, but is used as a feedstock in the production of fuel and other petrochemical products (henceforth

The JPMCC's August 2018 International Commodities Symposium was organized by Professor Jian Yang, Ph.D., CFA, the JPMCC's Research Director.

jointly referred to as fuel).[1] Thus, consumption of oil takes place in the form of fuel. Fluctuations in global fuel consumption bear important consequences not only for oil prices and the global economy, but also for environmental policies. In this digest article, we summarize the paper[2] that Dr. Ellwanger presented at the J.P. Morgan Center for Commodities' 2nd International Commodities Symposium.

Our paper uses data on global fuel consumption to isolate the role of fuel demand shocks in the global oil market. Oil consumption, production and prices are driven by shocks to flow demand, flow supply, and storage demand. Each of these shocks has a different impact on the oil market and the broader economy. We propose a simple structural framework that measures the importance of each of these drivers and that is useful for policy analysis and forecast scenarios.

Measuring Oil Consumption, Production and the Market Balance

The empirical implementation of our model relies on a measure of global fuel consumption provided by the International Energy Agency (IEA). The series tracks total global oil product consumption, which includes all common uses of fuel, including as combustible and as petrochemical feedstock. The corresponding oil production series, also provided by the IEA, is based on a broad definition of oil production that includes not only crude oil, but also other refinery feedstock, blendstock and biofuels. The broad measure of oil production ensures that consumption and production are directly commensurate.

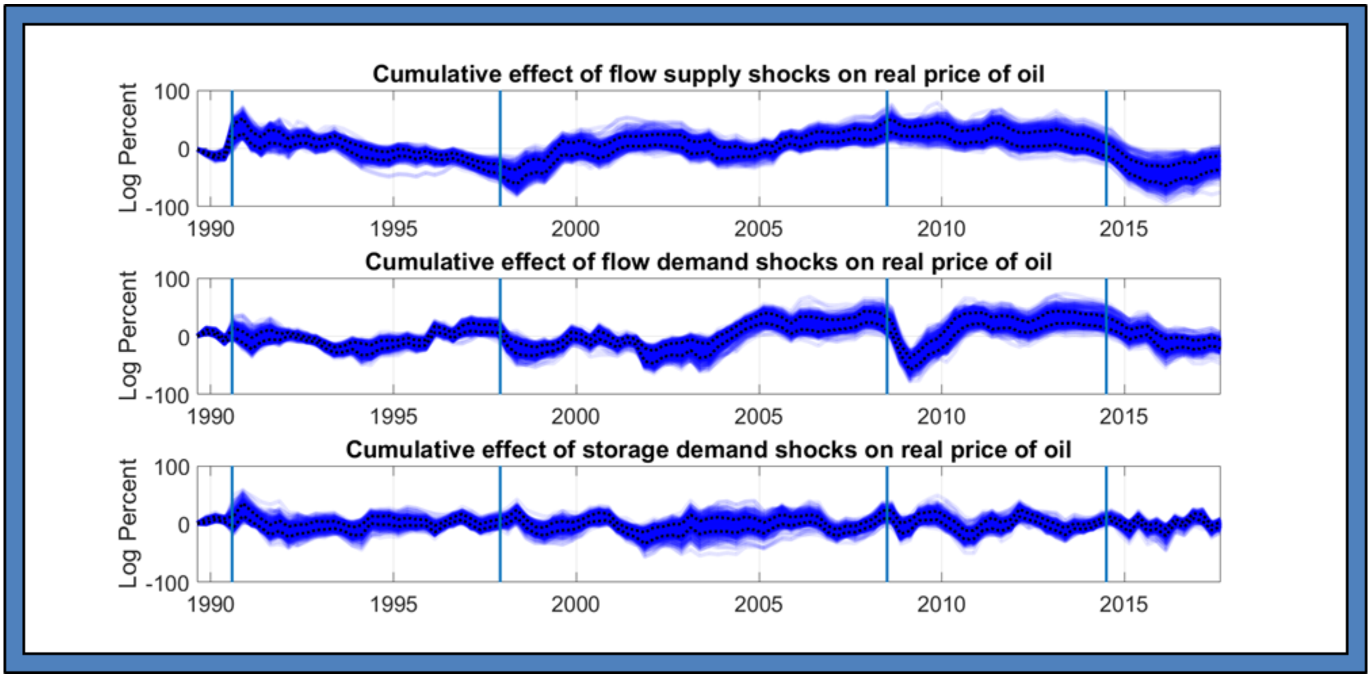
By identity, the difference between total oil production and total oil consumption amounts to the total change in oil inventories. In contrast to most of the existing literature of the oil market, which has focused on only crude oil inventories, this total change in oil inventories also includes changes in inventories of other refinery feedstocks, of blendstocks, and of finished petroleum products. The broader definition of oil inventories ensures that shifts in the storage demand for refined product are attributed to storage demand rather than flow demand shocks. Because the total change in oil inventories is a measure of production relative to consumption, it is often referred to as the market balance.

Implementing a Structural Model of the Global Oil Market

We estimate a structural vector autoregressive (SVAR) model of production, consumption and the real price of crude oil. The model is implemented with quarterly data from 1988Q1 to 2017Q3. The structural shocks are identified with sign restriction that reflect the economic intuition provided in existing studies.[3] Flow demand shocks are shocks that move prices and production and consumption in the same direction. For example, stronger economic growth might increase the flow consumption of fuels, which ultimately shifts the demand for oil and increases prices, and thus incentivizes higher production. Oil supply shocks are shocks that move prices in the opposite direction than production and consumption. For example, geopolitical events might compromise the flow oil production and thereby lead to a run up of global oil prices. Such price increases, in turn, would negatively affect oil consumption through the price elasticity of fuel demand. Finally, prices and quantities could also be affected by shocks to storage demand, which typically arise from changes in market participants' expectations or uncertainty about future demand relative to future supply.[4] Unlike flow demand and supply shocks, storage demand shocks move oil production and consumption in opposite directions.

Sign-identification of SVAR models does not provide a unique model estimate, but rather an entire set of admissible models. We provide a description of all models or selected quantiles to characterize the uncertainty surrounding our estimates. In the comprehensive paper, we also document that impulse responses of a unique structural model that is derived from insights of the relative persistence of the price impacts of demand and supply shocks closely resemble the median impulse responses of all admissible models.

Figure 1
Cumulative Effect of Different Shocks on the Real Price of Oil for All Admissible Models



Note: The vertical bars indicate major events in oil markets, notably the outbreak of the Persian Gulf War in 1990Q3, the onset of the Asian Crisis in 1997Q4, the Financial Crisis in 2008Q3, and the beginning of the 2014-2015 oil price drop in 2014Q3. The dashed lines indicate the pointwise 0.16 and 0.84 quantiles. The estimates take into account both estimation and model uncertainty.

What Drives Fluctuations in Prices and Quantities in the Global Oil Market?

Our results suggest that, on average, shifts in global fuel demand have been the most important driver of oil price fluctuations and explain much of the boom and bust cycles over the last decade (Figure 1). Flow supply shocks have also played a crucial role in many episodes, in particular during the 2014-2015 oil price decline. We also find that shifts in fuel flow demand have also accounted for most of the short- and medium-term variation in global fuel consumption while much of the lower-frequency movements in consumption can be traced back to oil supply shocks. Thus, the estimates suggest that stagnant oil supply during the 2000s were a drag on fuel consumption growth while the oil supply shocks in 2014 and 2015 provided a significant boost to consumption.

Estimates of Key Structural Parameters

Our framework also provides new estimates of the global oil supply and demand elasticity. Consistent with existing micro- and macro-evidence, the short-run oil supply elasticity is estimated to be around 1.5 percent. A particularly interesting result is that, in the short-run, the global fuel consumption appears to be similarly inelastic with respect to global crude oil prices. The median short-run demand elasticity in response to oil supply shocks is -2 percent, which indicates that a 10 percent price increase caused by a shortfall in oil supply would reduce global oil consumption by merely 0.2 percent within the same quarter. This result is startling because existing models of the global oil market suggest that global crude oil demand is considerably more elastic with respect to crude oil prices.[5] Likewise, studies investigating the reaction of local fuel consumption to changes in local fuel prices have documented fuel demand elasticities of the order of -30 percent.[6]

How can this apparent discrepancy be resolved? In the comprehensive paper, we use gasoline and diesel prices from 21 countries and document that there is an imperfect pass-through from global crude prices to local fuel prices. On average, a 10 percent increase in global crude oil prices is associated with a 50-60 percent increase in gasoline and diesel prices in the U.S. But this pass-through is much lower for all other countries, and for some even close to zero. This means that a low global fuel demand elasticity is not necessarily inconsistent with a higher global crude oil demand elasticity – which measures the reaction to refinery crude oil intake rather than fuel consumption – and a higher local fuel demand elasticity – which measures the reaction to local rather than global prices.

Implications

Information on global fuel consumption can be used to provide new insights on the global oil market and its relationship with the global economy. Our proposed framework is also useful for forecast scenarios, in particular when the underlying scenario is based on an explicit specification of the volume of oil consumption. This complements existing frameworks that rely on measures of real economic activity indicators to compare alternative scenarios of future oil demand.[7]

We also provide new estimates of key structural parameters in the oil market, which is important for two reasons. First, these parameters govern the evolution of prices and quantities in the global oil market, and are key to disentangling the various forces acting upon the oil market.[8] Second, they shed light on the effectiveness of global environmental policies. *Ceteris paribus*, a lower global demand elasticity implies that larger changes in global taxes or subsidies would be needed to affect fuel consumption, and that a larger fraction of the associated tax incidence would fall on consumers, refiners, or distributors as opposed to oil producers.

Finally, our results also show that it is important to distinguish between global elasticities and local elasticities. Models of the global oil market often rely on micro- or cross-country-estimates of the local elasticity to provide the bounds or priors for global elasticities that identify structural parameters.

When global and local elasticities are very different, this practice can distort the estimation and inference in such models.

Endnotes

1 See the International Energy Agency's *Oil Market Report* and *World Energy Outlook*, the Organization of the Petroleum Exporting Countries' *World Oil Outlook*, or the *BP Statistical Review of World Energy*.

2 Bilgin and Ellwanger (2017).

3 See, e.g., Kilian and Murphy (2012).

4 Kilian and Murphy (2014).

5 Kilian and Murphy (2014) and Baumeister and Hamilton (forthcoming).

6 Coglianese *et al.* (2016) and Levin *et al.* (2017).

7 See, e.g., Baumeister and Kilian (2014).

8 See, e.g., Knittel and Pindyck (2016).

The views expressed in this article are those of the authors and no responsibility for them should be attributed to the Bank of Canada.

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