Not All Oil Price Shocks Are Alike:
Disentangling Demand and Supply Shocks in the
Crude Oil Market

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First Objective of this Paper

- A common approach in both empirical and theoretical work on oil price shocks is to evaluate the response of macroeconomic aggregates to changes in the price of oil.

Implicit in this approach is a thought experiment in which one varies the price of oil holding all other variables constant. This thought experiment is not well defined.

- Since cause and effect are not well defined, when relating changes in the real price of oil to macroeconomic outcomes, we have to address the problem of identifying the structural shocks underlying the real price of oil.

The first objective of this paper is to propose a model that allows the identification of these shocks and helps us understand their relative importance in determining the real price of oil.
Second Objective of this Paper

- The implicit view in the literature and in statements of policy-makers is that an increase in the price of oil has the same effect on the economy regardless of the underlying cause of that increase.

The second objective of this paper is to demonstrate that this interpretation is incorrect.
How Do We Measure Monthly Global Real Economic Activity?

(1) For many countries measures of real economic activity are not available at monthly frequency.

(2) It is not straightforward to weight appropriately each country’s contribution to global real economic activity. Commonly used exchange-rate weighted averages are at best crude proxies. To make matters worse, the relative importance of individual countries for global economic activity is shifting over time. For example, the contribution of Asian countries has increased in recent years.

(3) Technological change may render the link from value added to industrial output and from industrial production to the demand for industrial commodities unstable.

For these reasons, in this paper, I propose an alternative measure of global real economic activity based on a global index of *dry cargo single voyage freight rates*. The index is measured at monthly frequency and can be constructed as far back as January 1968.
A New Approach Based on Ocean Shipping Freight Rates

- My approach to measuring global real economic activity is not without precedence. Similar techniques have been used in economic history to measure business cycles.

- Economists have long observed a positive correlation between ocean freight rates and economic activity (see, e.g., Isserlis 1938, Tinbergen 1959, Stopford 1997, Klovand 2004).

It is widely accepted that world economic activity is by far the most important determinant of the demand for transport services (see, e.g., Klovland 2004).

- The proposed index is a direct measure of global economic activity in industrial commodity markets that does not require exchange-rate weighting, that automatically aggregates real economic activity in all countries, and that already incorporates shifting country weights, changes in the composition of real output, and changes in the propensity to import industrial commodities for a given unit of real output.
Construction of the Index in Practice

- The index of global real economic activity is based on representative single voyage freight rates collected by Drewry Shipping Consultants Ltd. for various bulk dry cargoes including grain, oilseeds, coal, iron ore, fertilizer and scrap metal.

- Monthly quotes are provided for different commodities, routes and ship sizes.

- Freight rates are typically quoted in U.S. dollars per metric ton. Data are available since January of 1968. There is no continuous series for the entire sample period.
Figure 3: Index of Global Real Economic Activity based on Dry Cargo Bulk Freight Rates
1968.1-2005.9

NOTES: The monthly raw data were manually collected from Drewry’s Shipping Monthly, various issues since 1970. The two oldest series in the first panel are indices compiled by Drewry’s. The remaining series are differentiated by cargo, route and ship size.
Further Discussion of the Rationale of the Proposed Index (1)

- A concern is that dry cargo freight rates may increase during oil price shocks simply because the provision of shipping services uses bunker fuel oil as an input. There are several reasons to think that this link is not quantitatively important.

(1) The freight rate index moved very little when the real price of oil dropped sharply in 1985/86. Similarly, during the Persian Gulf War in 1990/91, freight rates first dropped, when oil prices rose sharply, and then rose, as the price of oil dropped again. This evidence is consistent with the view that the cost share of bunker fuel oil in ocean shipping is small.

(2) Records in the *Oil and Gas Journal* indicate that during 1970-1973 the real price of bunker fuel changed very little, yet the index of real economic activity underwent fluctuations of the same magnitude as during later times.
NOTES: The bunker fuel rate data are from the *Oil and Gas Journal*, various issues since 1970. All rates refer to Bunker C fuel, as recorded for the Caribbean, the Gulf Coast and California. The index is based on equal-weighted growth rates, computed using observations for the last week of each month. The real economic activity index is based on Figure 4.
Further Discussion of the Rationale of the Proposed Index (2)

- Why not include data on crude oil tanker rates available from Drewry’s Shipping Monthly?

Typically these rates strongly co-move with dry cargo rates, but tanker rates at times may be subject to important oil-specific supply shocks, which makes them unsuitable as a measure of real economic activity:

(1) Attacks on shipping in the Persian Gulf may raise the insurance premium for tankers (and hence tanker rates). The same applies to transportation surcharges, as tankers are rerouted, although by 1973 most tanker traffic bypassed the Suez Canal, making this argument largely obsolete. While the closure of sea lanes or canals may also force the re-routing of dry-cargo shipping with concomitant increases in average freight rates, in practice that effect is of much less importance for the dry cargo market.

(2) Events such an oil embargo may lower the demand for tankers (and hence tanker rates) simply because there is no oil to be shipped, not because consumers’ demand for oil has decreased, making it impossible to gauge the state of demand in the crude oil market.
A VAR Model of the Real Price of Crude Oil

- Structural VAR model based on monthly data for \( z_t = (\Delta prod_t, rea_t, rpo_t) \), where
  \( \Delta prod_t \) is the percent change in global crude oil production,
  \( rea_t \) denotes real economic activity,
  \( rpo_t \) defers to the real price of oil.

- In estimating the model, I allow for up to two years worth of lags. Consider the structural representation

\[
A_0 z_t = \alpha + \sum_{i=1}^{24} A_i z_{t-i} + \varepsilon_t,
\]

where \( \varepsilon_t \) denotes the vector of serially and mutually uncorrelated structural innovations.
I postulate that $A_0^{-1}$ has a recursive structure such that the reduced form errors $e_t$ can be decomposed according to $e_t = A_0^{-1} \varepsilon_t$.

$$e_t \equiv \begin{pmatrix} e_t^{\Delta prod} \\ e_t^{rea} \\ e_t^{rpo} \end{pmatrix} = \begin{bmatrix} a_{11} & 0 & 0 \\ a_{21} & a_{22} & 0 \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{pmatrix} \varepsilon_t^{\text{oil supply shock}} \\ \varepsilon_t^{\text{aggregate demand shock}} \\ \varepsilon_t^{\text{oil-specific demand shock}} \end{pmatrix}$$

The restrictions on $A_0^{-1}$ may be motivated as follows:
Figure 5: Responses to One-Standard Deviation Structural Shocks
OLS Point Estimates with One and Two-Standard Error Bands

NOTES: Estimates based on restricted VAR(24) system described in text. The confidence intervals were constructed using a recursive-design wild bootstrap.
Figure 6: Historical Decomposition of Real Price of Oil
1975.2-2005.9

NOTES: See Figure 6.
How do the structural innovations in model (1) relate to U.S. macroeconomic aggregates such as CPI inflation or real GDP?

Problem 1:
Real GDP is not available at monthly frequency. We need to know the structural innovations at quarterly frequency.

- Solution 1: Estimate structural VAR model (1) on quarterly data?

- Solution 2: Interpolate U.S. real GDP data using industrial production?

- Solution 3: Construct measures of the quarterly shocks by averaging the monthly structural innovations for each quarter:

\[
\hat{\zeta}_{ji} = \frac{1}{3}\sum_{i=1}^{3} \hat{\varepsilon}_{j,t,i}, \quad j = 1, \ldots, 3,
\]

where \( \hat{\varepsilon}_{j,t,i} \) refers to the estimated residual for the \( j \)th structural shock in the \( i \)th month of the \( t \)th quarter of the sample.
Problem 2:
The structural shocks, $j = 1, 2, 3$, are by construction strictly exogenous with respect to the information set in model (1), but, with the exception of the first shock, are not necessarily exogenous with respect to U.S. macroeconomic aggregates.

Table 2. Correlation of $\tilde{\zeta}_{jt}$ with Autoregressive Residuals for U.S. Real GDP Growth and CPI Inflation

<table>
<thead>
<tr>
<th></th>
<th>Oil Supply Shock</th>
<th>Aggregate Demand Shock</th>
<th>Oil-Specific Demand Shock</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. Real GDP Growth</td>
<td>0.146</td>
<td>0.055</td>
<td>-0.035</td>
</tr>
<tr>
<td>U.S. CPI Inflation</td>
<td>0.081</td>
<td>-0.128</td>
<td>0.243</td>
</tr>
</tbody>
</table>

NOTES: Autoregressive residuals for U.S. data based on AR(8) models.
Figure 9: Responses of U.S. Real GDP Growth and Real GDP Level to Each Structural Shock
OLS Point Estimates with One and Two-Standard Error Bands

NOTES: All results are based on equation (4).
Figure 10: Responses of U.S. CPI Inflation and CPI Price Level to Each Structural Shock
OLS Point Estimates with One and Two-Standard Error Bands

NOTES: All results are based on equation (5).
Are There Stagflationary Effects?

- The conditional covariance of real GDP growth and CPI inflation at horizon $h$ is constructed as
  $$C(h) = \Delta \pi_{h}^{imp} \Delta y_{h}^{imp}$$
  where $z_{h}^{imp}$ denotes the response of variable $z_t$ at horizon $h$ to a given oil shock (see Den Haan 2000, p. 8).

- Stagflation in the form of rising prices and falling output means that this measure will be negative. It is natural to conduct a one-sided test of the null of zero conditional covariance against the stagflationary alternative.

- Evidence: Only oil-specific demand shocks tend generate stagflationary responses.
Figure 14: Cumulative Contribution of All Structural Shocks Combined to U.S. Macroeconomic Real GDP Growth and CPI Inflation
1978.IV-2005.III
Conclusions

● All the major real oil price increases since the mid-1970s can be traced to increased global aggregate demand and/or increases in oil-specific demand.

The latter demand shifts are consistent with sharp increases in precautionary demand in the wake of exogenous political events in the Middle East.

● In contrast, disruptions of crude oil production play a less important role, suggesting that the traditional approach of linking oil price increases to exogenous shortfalls in crude oil production must be re-thought.

● A substantial component of U.S. real growth and CPI inflation since the 1970s can be traced to external shocks. The relative contribution of domestic and external factors varies over time.

● The effects of demand and supply shocks in global crude oil markets on U.S. real growth and CPI inflation differ substantially, necessitating different policy responses.