Using the Oxford Global Economic Model

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Presented at the 35th USAEE /IAEE North American Conference
Houston, TX, USA
November 13, 2017
Important two-way relationship between oil and U.S. economy calls for joint impact analysis (1)

• Oil remains a key energy source for the U.S. economy
  • 37% of total primary energy consumption in 2016
  • 92% of transportation fuels
  • Total (direct and indirect) value-added contribution is ~$1.3 trillion
    • ...about 10.3 million jobs or 5.6% of U.S. employment

• The oil market was deeply involved in the “Great Recession”
  • Recession was preceded by strong economic growth (2003-2007)
    • ...steadily increasing oil prices and dwindling U.S. oil production
  • Global oil prices peaked at ~$150/bbl in mid-2008 ➔ 6 months into the recession
    • ...and collapsed to about $40/bbl by mid-2009
  • Unlike economic growth, oil prices recovered quickly
    • Reached $125/bbl by 2012 ➔ likely contributed to sluggish economic recovery
    • Collapsed again in 2015 due largely to increased US oil production

• Study is part of DOE’s efforts to anticipate and understand
  • ...impacts of alternative future scenarios for US economy and energy market
Methodology – Overview of the Oxford Global Economic Model (OxfEM)

• Quarterly global macro-econometric forecasting and policy tool
  • Developed over 30+ years by Oxford Economics Inc.
  • Global coverage: 80 countries, 6 regional blocs and Eurozone
  • Regions are linked through trade, capital flows, prices and policies
  • Equation blocks:
    • Real economy: Supply, Demand, Energy, Investment, Trade
    • Nominal/financial/fiscal economy: Prices, interest rates, capital markets, taxes
    • Energy markets: Oil, Coal, Natural Gas
  • Model is updated frequently (monthly to quarterly)
    • Has three concurrent versions 5-yr, 10-yr and 25-yr horizon

• Used by 100+ organizations
  • EIA uses OxfEM in preparing the International Energy Outlook (IEO)
Overall structure of OxfEM is similar to other macro-econometric models*

- **Supply & prices (Keynesian in short-run; Neo-classical in long-run)**
  - **Short-run**: supply and prices depend on real wages and nominal rigidities
    - ...involuntary unemployment
  - **Long-run**: potential output defined by NAIRU**
    - ...full employment
  - Inflation targeting monetary policy is used to prevent run-away inflation

- **Error-correction functions are used to specify behavior**
  - Demand (households; government)
  - Investment (industry; households; government)
  - International trade (Non-fuel goods; fuels; services)

- **Oil, coal and natural gas demand and supply functions**
  - Refined products (gasoline, diesel, jet, fuel oil, others) were recently added

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**NAIRU: Non-accelerating inflation rate of unemployment or natural unemployment rate: the rate of unemployment arising from all sources except fluctuations in aggregate demand.
Scenarios simulated with OxfEM

• January 2017 version is used in this study
  • ...simulations over 2017-2021

• **Baseline scenario** (modified OxfEM pre-defined Baseline scenario)
  • Stronger US growth (2.3% in 2017; 2.5% in 2018)
  • Higher inflation and interest rates
    • Fiscal stimulus (mid-2017): $500 billion in tax cuts over 10 years;
      • $125 billion infrastructure investment; Delayed spending cuts

• **Global fiscal boost scenario:**
  • Coordinated increases in government expenditures in advanced economies

• **Global stagnation scenario:**
  • Continued tepid global demand leads to stagnation

• **Tighter China policy scenario:**
  • Controls on credit to slow down rate of debt growth

• **Europe downturn scenario:**
  • Larger negative Brexit impacts, European banks stress
Real GDP growth and federal deficit differ for pre-defined vs. modified Baseline scenarios

• Stimulus in pre-defined Baseline has positive growth impacts
  • ...quarterly growth rate difference of up to 0.3%
  • ...but temporary as impacts die out by end of 2018

• Federal deficits effect of stimulus lasts much longer
  • Increase of up to $275 billion by end of 2021 relative to no stimulus case
World oil prices are sensitive to the scenarios evaluated in this study

- Baseline oil price stays near $50/bbl in 2017 & 2018
  - Rises gradually to about $75/bbl by 2021
- Changes in the oil price relative to Baseline
  - Increases by up to $10/bbl under the “Global fiscal boost” scenario
  - Decreases by up to $21/bbl under the “Global stagnation” scenario
  - Smaller decreases in the other two scenarios
    - ...decreases reach $8/bbl under “Tighter China policy” scenario
Oil stocks play a crucial role in supply-demand balancing in the global stagnation scenario

- Decreases in oil price under the global stagnation scenario increase demand, but reduce supply

- World oil stocks decrease by up to 24% under the “Global stagnation” scenario

- “Global fiscal boost” scenario shows increases in world oil demand, supply and stocks

### World oil market impacts (fourth quarter): 2018-2021

<table>
<thead>
<tr>
<th>Year</th>
<th>Baseline No Stimulus</th>
<th>Global Secular Stagnation</th>
<th>Global Fiscal Boost</th>
<th>Regional: China Tightening</th>
<th>Regional: Europe Downturn</th>
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<tbody>
<tr>
<td>2018</td>
<td>99</td>
<td>0.34</td>
<td>0.05</td>
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<tr>
<td>2019</td>
<td>100</td>
<td>0.53</td>
<td>0.21</td>
<td>-0.31</td>
<td>-0.05</td>
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<tr>
<td>2020</td>
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<td>0.41</td>
<td>0.47</td>
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<tr>
<td>2021</td>
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<td>0.25</td>
<td>-0.49</td>
<td>-0.05</td>
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<tr>
<td>2018</td>
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<td>-0.57</td>
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<td>-0.10</td>
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<tr>
<td>2019</td>
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<td>-0.04</td>
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<tr>
<td>2020</td>
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<td>0.29</td>
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<tr>
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<td>2021</td>
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<td>-0.99</td>
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</table>
US petroleum supply and demand remains stable between 2018 and 2021

- **Baseline:** US crude (product) demand increases (decreases) by 0.4 mmbd
  - Reflects slight increases in both crude and product exports

- **Relative to the Baseline**
  - "Global stagnation" scenario show largest demand increases
    - Due to lower oil prices
    - ...but implied oil demand elasticity range is: -0.2 to -0.02
  - US oil production changes little
    - -0.5% to 0.14%
    - ➔ very low price sensitivity of US oil production in OxfEM
  - Worthy of further investigation
    - ...product demand & supply relatively new in OxfEM

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<td><strong>US oil production, annualized (Baseline – mmbd)</strong></td>
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<tr>
<td>2018</td>
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<td><strong>US oil, demand, annualized (Baseline – mmbd)</strong></td>
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<tr>
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<td>0.00</td>
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<tr>
<td>2019</td>
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<tr>
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<tr>
<td><strong>US refined oil, demand (Baseline - mmbd)</strong></td>
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<td></td>
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<tr>
<td>2018</td>
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<td>0.96</td>
<td>0.26</td>
<td>0.18</td>
<td>0.00</td>
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<td>1.27</td>
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<td>2020</td>
<td>17.3</td>
<td>1.18</td>
<td>0.72</td>
<td>1.35</td>
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US refined product demand impacts are qualitatively similar across scenarios: 2018 to 2021

- Baseline gasoline and diesel demand changes over time small
- Relative to Baseline
  - Increase slightly under “Global fiscal boost” & “Global stagnation” scenarios
  - Regional scenarios show a mix of increases and decreases
- Drivers of demand growth differ across scenarios
  - “Global fiscal boost” scenario: Income-driven demand growth
  - “Global stagnation” scenario: Net demand effects of lower product prices and economic slowdown are positive
Real US GDP growth could vary significantly with global and domestic changes

- Baseline growth rates decline from near 2.4% to as low as 1.5%
  - “Global fiscal boost” scenario has higher growth rates than Baseline
    - Suggests significant US benefits from a coordinated global stimulus
  - “Global stagnation” scenario has the lowest growth rates
  - Regional scenarios could reduce US growth significantly in 2018 & 2019
    - ...due to global interactions, but growth recovers in 2020 & 2021
Conclusions: Integrated macroeconomic-petroleum impacts analysis in OxfEM provides useful insights

• World oil prices are sensitive to the scenarios evaluated
  • Baseline oil price stays near $50 into 2018, rises gradually to $75 by 2021
  • Changes under alternative scenarios in the range of -$20/bbl to +$10/bbl
  • Oil stocks are crucial to managing supply-demand imbalance

• US oil and product demand (and production) are stable
  • Low sensitivity to oil prices; imports and exports both increase slight

• Economic impacts of the scenarios vary significantly
  • “Global fiscal boost” scenario has higher US growth rates than Baseline
  • “Global stagnation” scenario leads to considerable US slowdown

• Results depend on structure, size and timing of shocks
  • Alternative scenarios would help clarify underlying drivers of results
  • Ability to change model equations allows for potentially rich experiments
  • Plan is to link OxfEM with a US petroleum infrastructure model (TRIM*)

*TRIM: Transportation and Refining and Infrastructure Model
ACKNOWLEDGMENTS
This material is based upon work supported by the US Department of Energy under the Energy Policy and Systems Analysis Office, and performed at Oak Ridge National Laboratory under contract number DE-AC05-00OR22725. The views in this paper are those of the authors, who are also responsible for any errors or omissions.

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Supplemental Slides
Outline of presentation

• Important two-way relationship between oil and U.S. economy

• Methodology
  – Overview of the Oxford Global Economic Model (OxfEM)
  – Overall model structure

• Scenarios simulated with OxfEM

• Petroleum market results
  – World oil market impacts
  – Domestic oil market impacts

• Macroeconomic results
  – Overall economic impacts
  – Trade and financial markets
Methodology – Summary of OxfEM Structure (2)

• Short-run allows for involuntary unemployment
  • ...prices, quantities, policies adjust to restore supply-demand equilibrium
• Long-run full employment
  • ...supply-demand imbalances lead to only price responses
  • ...but NAIRU is a function of wage rates, wage taxes and prices in OxfEM.
Methodology – Summary of OxfEM Structure (2)

- **Price determination**
  - **Short-run**: prices respond to maintain supply-demand balance
  - **Long-run**: vertical Phillip’s (inflation-unemployment rates) curve
  - Taylor’s rule links interest rates, inflation and output gap to control inflation

- **Short-run allows for involuntary unemployment**
  - ...prices, quantities, policies adjust to restore supply-demand equilibrium

- **Long-run full employment**
  - ...supply-demand imbalances lead to only price responses
  - ...but NAIRU is a function of wage rates, wage taxes and prices in OxfEM
Inflation rates for 3 of 4 scenarios are lower than in the Baseline

- Baseline inflation rates decline from ~2.8% (2017) to 1.25% (2021)
  - Global fiscal boost scenario has higher inflation due to fiscal spending
  - All other scenarios have lower inflation rates
    - Primarily due to reduced economic activity
    - “Tighter China policy” scenario show the lowest inflation rates
      - Probably due to additive effect of accommodative US monetary policy
2016 data show U.S. lead in the global oil market

- Petroleum demand: 19.7 million bpd
  - Growing moderately
- Petroleum production: 12.35 million bpd
  - Shale oil surge has added nearly 5 million bpd since 2011
- Petroleum imports: 10 million bpd
  - Crude: 7.85 million bpd down from peak of 10 million bpd in 2006
- Petroleum exports: 5.2 million bpd (mostly products)
  - Crude was only about 0.6 million bpd but increasing
Changes in the producer price index across scenarios

• Differences in pattern of changes in PPI and CPI

World Map of Crude Oil Exports 2016

How to read this map: Countries appear bigger as their crude oil exports are higher. E.g. Saudi Arabia. Conversely, countries with smaller crude oil exports appear smaller. E.g. South Africa. The color shows the percentage of total of crude oil exports.

Source and Article: https://howmuch.net/articles/world-map-of-crude-oil-exports-2016
http://www.worldstopexports.com/worlds-top-oil-exports-country/
The following are from recent slide deck by Oxford Economics Inc.
The Oxford model is an eclectic model designed to capture the key relationships in the global economy.

- Keynesian in the short run
- Monetarist in the long run

In the short run, shocks to demand will generate economic cycles that can be influenced by fiscal and monetary policy.

But over the long-run, output is determined by supply side factors: investment, demographics, labour participation and productivity.
HOW OUR COUNTRY MODELS WORK

The broad structure of our models is similar across countries, with amendments to reflect country specific factors such as dependence on commodities, exchange rate regime, and flexibility of the labour market. The key relationships in a typical model include:

- **Consumer spending** is driven by real income, wealth and interest rates.

- **Investment** is driven by the return on investment and changes in capacity utilisation.

- **Exports** depend on world demand and competitiveness.

- **Wages** move with inflation, productivity and unemployment relative to the natural rate.

- **Prices** are a mark-up on unit costs, are profit margins are a function of the output gap.

- **Monetary policy** is modelled to reflect central bank behaviour.

- **Exchange rates** are determined by relative productivity and net external assets in the long run, and by movements in relative interest rates in the short run.
INTEGRATED GLOBAL MODEL WITH MULTIPLE LINKAGES

- **Trade volumes**
  World trade for each country is a weighted average of the growth in total goods imports (excluding oil) of all other countries.

- **Competitiveness**
  IMF relative unit labour costs where available.

- **Trade prices**
  A country’s exports are another’s imports.

- **Interest rates and exchange rates**

- **Commodity prices**
  Oil depends on supply/demand balance.
  Metals on industrial growth.

- **Capital flows**
  Including the impact of FDI, credit ratings and bond spreads.
FINANCIAL BLOC

Asset prices are embedded in the Global Economic Model

- Key financial variables include:
  - **Interest rates**: policy rates; money market rates; and bond yields.
  - **Equity prices**: main stock market indices covered in each country.
  - **Exchange rates**: spot rate against US$ & € enabling calculation of other cross rates; and nominal/real effective exchange rates.
  - **Commodity prices**: oil; gold; and other metals.

- Financial linkages between countries.

- Asset prices affect the real economy: wealth effects, cost of credit, government’s debt burden etc.

- Real economy affects asset prices: profit expectations, health of public finances driving bond yields etc.
OUR MODEL PROVIDES YOU WITH KEY SCENARIOS

The Oxford Global Economic Model allows you to assess the impact of key scenarios at a click-of-the-button.

Scenarios are regular updated but cover a variety of risk factors such as:

- Commodity markets – oil price and supply shocks.
- Exchange rate risk.
- Quantitative easing and interest rate moves by leading Central Banks.
- Credit crunch.
- Fiscal austerity.