Fuel Subsidies, the Oil Market, and the World Economy

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Disclaimer

The results presented here are my own and do not necessarily reflect the official views of the Federal Reserve Bank of Dallas nor the Federal Reserve System as a whole.
The results presented here are currently preliminary in nature. Not for citation at this point in time.
Introduction

- Consumer subsidies on fuel products found in many countries
- Subsidies found in both producing and non-producing countries
- But oil producers are most important subsidizers
Introduction

- IEA WEOs, IMF country reports, others
- Coady et al. (2006), del Granado et al. (2010), other IMF papers
- Hartley and Medlock (2009)
- Plante (2014)
We explore how these subsidies qualitatively and quantitatively impact:

- World oil market
- Macroeconomic variables
- Welfare
Data

- Group 24 countries as “subsidizers”
- Identified using retail fuel price data
- List includes most subsidizing producers
## Table: Countries identified as subsidizers

<table>
<thead>
<tr>
<th>Country</th>
<th>Country</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algeria</td>
<td>Indonesia</td>
<td>Qatar</td>
</tr>
<tr>
<td>Angola</td>
<td>Iran</td>
<td>Saudi Arabia</td>
</tr>
<tr>
<td>Azerbaijan</td>
<td>Iraq</td>
<td>Sudan</td>
</tr>
<tr>
<td>Bahrain</td>
<td>Kuwait</td>
<td>Syria</td>
</tr>
<tr>
<td>Bolivia</td>
<td>Libya</td>
<td>Turkmenistan</td>
</tr>
<tr>
<td>Brunei</td>
<td>Malaysia</td>
<td>UAE</td>
</tr>
<tr>
<td>Ecuador</td>
<td>Nigeria</td>
<td>Venezuela</td>
</tr>
<tr>
<td>Egypt</td>
<td>Oman</td>
<td>Yemen</td>
</tr>
</tbody>
</table>
Some statistics about the 24 countries:

- Consume 13.5 percent of world’s oil
- Produce 48 percent of world’s oil
- Current retail prices about 1/3 of U.S. prices (ex. tax)
Simple Model

- Two country model with countries $a$ and $o$
- Country $o$ produces oil, represents subsidizers
- Country $a$ produces oil and non-oil goods
- Countries $a$ is a net importer of oil
- Superscripts denote countries for $j = a, o$
Simple Model

- $O^j$ denotes consumption of oil in $j$

- Denote $\theta^o$ as share of world oil consumption due to $o$

- Consumers in $o$ pay $P_s \leq P_o$

- Absolute value of price-elasticity of demand is $\epsilon$
Simple Model

- $Y^o_j$ denotes supply of oil in $j$
- Denote $\chi^o$ as share of world oil production due to $o$
- Price elasticity of oil supply is $\eta_j$
- World price of oil, $P_o$, adjusts to clear oil market,

$$O^a + O^o = Y^a_o + Y^o_o.$$ (1)
Experiment

- Consider unspecified percent change in $P_s$ ($\%\Delta P_s$)

- Calculate how $\%\Delta P_s$ affects oil market

- Consider two cases:
  1. Perfectly inelastic supply ($\eta_j = 0$)
  2. Elastic supply ($\eta_j > 0$)

- For discussion will focus on $\%\Delta P_s < 0$
Results (Perfectly Inelastic Supply)

Change in country $o$ oil consumption:

$$\%\Delta O^o = -\epsilon \%\Delta P_s. \quad (2)$$
Results (Perfectly Inelastic Supply)

Change in country $o$ oil consumption:

$$\% \Delta O^o = -\epsilon \% \Delta P_s.$$  \hspace{1cm} (2)

Change in world price of oil:

$$\% \Delta P_o = -\frac{\theta^o}{(1 - \theta^o)} \% \Delta P_s.$$  \hspace{1cm} (3)
Results (Perfectly Inelastic Supply)

Change in country $o$ oil consumption:

$$\%\Delta O^o = -\epsilon \%\Delta P_s. \quad (2)$$

Change in world price of oil:

$$\%\Delta P_o = -\frac{\theta^o}{(1 - \theta^o)} \%\Delta P_s. \quad (3)$$

Change in country $a$ oil consumption:

$$\%\Delta O^a = \epsilon \frac{\theta^o}{(1 - \theta^o)} \%\Delta P_s. \quad (4)$$
Results (Supply Elasticity > 0)

Change in country $o$ oil consumption:

$$\%\Delta O^o = -\epsilon \%\Delta P_s.$$  \hspace{1cm} (5)
Results (Supply Elasticity $>0$)

Change in country $o$ oil consumption:

$$\%\Delta O^o = -\epsilon \ %\Delta P_s. \quad (5)$$

Change in world price of oil:

$$\%\Delta P_o = \frac{-\theta_o \epsilon}{(1-\theta^o) \epsilon + (1-\chi^o) \eta_a + \chi^o \eta_o} \ %\Delta P_s. \quad (6)$$
Results (Supply Elasticity $>0$)

Change in country $o$ oil consumption:

$$\%\Delta O^o = -\epsilon \%\Delta P_s.$$  \hspace{1cm} (5)

Change in world price of oil:

$$\%\Delta P_o = \frac{-\theta_o \epsilon}{(1 - \theta^o)\epsilon + (1 - \chi^o)\eta_a + \chi^o \eta_o} \%\Delta P_s.$$ \hspace{1cm} (6)

Change in country $a$ oil consumption:

$$\%\Delta O^a = \epsilon \frac{\theta_o \epsilon}{(1 - \theta^o)\epsilon + (1 - \chi^o)\eta_a + \chi^o \eta_o} \%\Delta P_s.$$ \hspace{1cm} (7)
Some statistics about the 24 countries:

- Consume 13.5 percent of world’s oil
- Produce 48 percent of world’s oil
- Current retail prices about 1/3 of U.S. prices (ex. tax)
Introduction

- Two country DSGE model
- Countries a and o represent same blocs as before
- Households maximize utility subject to budget constraints
- Endogenous production of oil and non-oil goods
- Focus on steady states (comparative statics analysis)
Production of non-oil good

Firm’s problem:

$$\max_{N_t^a, K_{t-1}^a, O_{y,t}^a} \Pi_{a,t}^a = Y_{a,t}^a - W_t^a N_t^a - r_t^a K_{t-1}^a - P_{o,t} O_{y,t}^a,$$  \hspace{1cm} (8)

where technology is

$$Y_{a,t}^a = Z_{y,t}^a N_t^a \alpha \left[ \omega_y^a K_{t-1}^{a 1-\nu} + (1 - \omega_y^a) O_{y,t}^a 1-\nu \right]^{\frac{1-\alpha}{1-\nu}}.$$

\hspace{1cm} (9)
Production of oil in $a$

Oil producing firm maximizes

$$\max_{Y_{o,t}} \Pi_{o,t}^a = P_{o,t} Y_{o,t}^a - X_{o,t}^a,$$  \hspace{1cm} (10)

where

$$X_{o,t}^a = \kappa_a \left( Y_{o,t}^a \right)^{1 + \frac{1}{\eta_a}} \left( 1 + \frac{1}{\eta_a} \right).$$  \hspace{1cm} (11)
Production of oil in a

Oil producing firm maximizes

$$\max_{Y_{o,t}^a} \Pi_{o,t}^a = P_{o,t} Y_{o,t}^a - X_{o,t}^a,$$  \hspace{1cm} (10)

where

$$X_{o,t}^a = \kappa_a \frac{(Y_{o,t}^a)^{1+\frac{1}{\eta_a}}}{1 + \frac{1}{\eta_a}}.$$

- Price elasticity of supply given by $\eta_j$ for $j = a, o$
- Costs increasing in oil output
- Lower marginal cost as $\eta$ increases
The household maximizes lifetime utility

\[ E_0 \sum_{t=0}^{\infty} \beta^t \left( \frac{C_t^{a,1-\sigma}}{1-\sigma} - \kappa \frac{N_t^{a,1+\mu_n}}{1+\mu_n} \right), \]  

(12)

with aggregate consumption given by

\[ C_t^{a} = \left[ (1 - \gamma_o^{a}) A_{c,t}^{a,1-\mu_c} + (\gamma_o^{a}) O_{c,t}^{a,1-\mu_c} \right]^{\frac{1}{1-\mu_c}}, \]  

(13)

and subject to the budget constraint

\[ A_{c,t}^{a} + P_{o,t}^{a} O_{c,t}^{a} + I_t^{a} = W_t^{a} N_t^{a} + r_t^{a} K_{t-1}^{a} + \Pi_{a,t}^{a} + \Pi_{o,t}^{a}. \]  

(14)
Current Account

Current account equation for \( a \)

\[
P_{o,t} \left( O_{c,t}^a + O_{y,t}^a - Y_{o,t}^a \right) = Y_{a,t}^a - A_{c,t}^a - I_t^a - X_o^a.
\]  

(15)

Oil import bill for \( a \)

\[
P_{o,t} \left( O_{c,t}^a + O_{y,t}^a - Y_{o,t}^a \right).
\]
Oil production in o

- Government-run oil company produces oil using non-oil good

- Portion of oil sold domestically at subsidized price $P_s$ (set by modeler)

- Remainder exported to country a at world price $P_o$
Oil production in \( o \)

Oil producer problem:

\[
\max_{Y_{o,t}} \Pi^o_t = P_{o,t}(Y_{o,t}^o - O_{c,t}^o) + P_{s,t} O_{c,t}^o - X_{o,t}^o
\]  

(16)

where the cost function is similar to country a’s:

\[
X_{o,t}^o = \kappa_o \frac{(Y_{o,t}^o)^{1+\frac{1}{\eta_o}}}{1 + \frac{1}{\eta_o}}.
\]  

(17)
Oil production in oil

- Oil revenues transferred to government
- Government budget constraint

\[ P_t^o (Y_o^o - O_{c,t}^o) + P_s^o O_{c,t}^o - X_{o,t}^o = T_t. \]  \hspace{1cm} (18)

- Revenues enter the economy in non-distortionary manner
Household in $o$

Household maximizes lifetime utility

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{(C_o^t)^{1-\sigma}}{1-\sigma},$$  \hfill (19)

with

$$C_o^t = \left[(1 - \gamma_o^o)A_{c,t}^{1-\mu_c} + (\gamma_o^o)O_{c,t}^{1-\mu_c}\right]^{\frac{1}{1-\mu_c}},$$  \hfill (20)

and subject to the budget constraint

$$A_{c,t}^o + P_{s,t}O_{c,t}^o = T_t.$$  \hfill (21)
### Calibration

**Table: Oil market variables**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil production in $o$</td>
<td>48 percent of world production</td>
</tr>
<tr>
<td>Consumption of fuel in $o$</td>
<td>13.5 percent of world consumption</td>
</tr>
<tr>
<td>Ratio of subsidized fuel price to world price</td>
<td>.35</td>
</tr>
<tr>
<td>Consumption-expenditure share of fuel in $a$</td>
<td>5 percent</td>
</tr>
<tr>
<td>Firm use of oil in $a$</td>
<td>2 percent of $a$’s GDP</td>
</tr>
<tr>
<td>Elasticity of oil supply ($\eta_a$, $\eta_o$)</td>
<td>.30</td>
</tr>
<tr>
<td>Elasticities of oil demand</td>
<td>.75</td>
</tr>
</tbody>
</table>
Exercise

- Model calibrated to recent data
- Policy experiment: Set subsidized price in o equal world price
  - Subsidies removed in all 24 countries
- Comparative statics exercise
- Calculate how variables change across steady states
Results

Percent change in variables across steady states

**Prices**
- market oil price \( (P_o) \) -6.2
- subsidized oil price \( (P_s) \) 176
Results

Percent change in variables across steady states

**Prices**
- market oil price $(P_o)$: -6.2
- subsidized oil price $(P_s)$: 176

**Country o variables**
- oil production $(Y_o)$: -1.9
- oil consumption $(O_c)$: -45.9
- consumption of good A $(A_c)$: 15.8
- transfers (T) / Revenues: 21.4
## Results

Percent change in variables across steady states

### Prices
- Market oil price ($P_o$) -6.2
- Subsidized oil price ($P_s$) 176

### Country o variables
- Oil production ($Y_o^o$) -1.9
- Oil consumption ($O_c^o$) -45.9
- Consumption of good A ($A_c^o$) 15.8
- Transfers (T) / Revenues 21.4

### Country a variables
- Oil production ($Y_o^a$) -1.9
- Oil used in consumption ($O_c^a$) 4.9
- Oil used in production ($O_y^a$) 4.2
- Consumption of good A ($A_c^a$) 0.004
- Non-oil GDP 0.23
Welfare Results

- Welfare changes converted to (aggregate) consumption equivalents
- How much do I need to change consumption in the new steady state to get utilities equal?
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  - How much do I need to change consumption in the new steady state to get utilities equal?

- Importer’s welfare gain: 0.2% of consumption
Welfare Results

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  - How much do I need to change consumption in the new steady state to get utilities equal?

- Importer’s welfare gain: 0.2% of consumption

- Exporter’s welfare gain: 0.9% of consumption
Welfare Results

- Welfare changes converted to (aggregate) consumption equivalents
  - How much do I need to change consumption in the new steady state to get utilities equal?

- Importer’s welfare gain: 0.2% of consumption

- Exporter’s welfare gain: 0.9% of consumption

- Larger relative gains to exporter, larger absolute in importer
Table: Results for different elasticities of supply

<table>
<thead>
<tr>
<th>Variables</th>
<th>η^a = η^o = 0.3 (Baseline)</th>
<th>η^a = 0.3; η^o = 0.6 (Alternative 1)</th>
<th>η^a = 0.3; η^o = 1.0 (Alternative 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prices</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>market oil price (P_o)</td>
<td>-6.2</td>
<td>-5.08</td>
<td>-3.89</td>
</tr>
<tr>
<td>subsidized oil price (P_s)</td>
<td>176</td>
<td>179</td>
<td>183</td>
</tr>
<tr>
<td>Country o variables</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>oil production (Y_o^o)</td>
<td>-1.9</td>
<td>-3.08</td>
<td>-3.89</td>
</tr>
<tr>
<td>oil consumption (O_c^o)</td>
<td>-45.9</td>
<td>-43.0</td>
<td>-38.2</td>
</tr>
<tr>
<td>consumption of good A (A_c^o)</td>
<td>15.8</td>
<td>23.03</td>
<td>34.75</td>
</tr>
<tr>
<td>transfers (T) / Revenues</td>
<td>21.4</td>
<td>30.87</td>
<td>46.91</td>
</tr>
<tr>
<td>welfare</td>
<td>0.86</td>
<td>2.18</td>
<td>3.83</td>
</tr>
<tr>
<td>Country a variables</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>oil production (Y_a^a)</td>
<td>-1.9</td>
<td>-1.55</td>
<td>-1.18</td>
</tr>
<tr>
<td>oil used in consumption (O_c^a)</td>
<td>4.9</td>
<td>3.98</td>
<td>3.02</td>
</tr>
<tr>
<td>oil used in production (O_y^a)</td>
<td>4.2</td>
<td>4.25</td>
<td>3.21</td>
</tr>
<tr>
<td>consumption of good A (A_c^a)</td>
<td>0.004</td>
<td>0.003</td>
<td>0.002</td>
</tr>
<tr>
<td>non-oil GDP</td>
<td>0.23</td>
<td>0.19</td>
<td>0.14</td>
</tr>
<tr>
<td>welfare</td>
<td>0.23</td>
<td>0.19</td>
<td>0.14</td>
</tr>
</tbody>
</table>
Conclusions

- Considered impacts of fuel subsidies in a two-country model
- Calibrated model to match recent data
- Removing subsidies would lower world price of oil by about 6%
- Welfare improves in both countries
### Table: Statistics about the 24 countries

<table>
<thead>
<tr>
<th>Year</th>
<th>Share of world oil consumption</th>
<th>Share of world oil production</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992</td>
<td>9.5</td>
<td>46.1</td>
</tr>
<tr>
<td>1993</td>
<td>9.9</td>
<td>47.3</td>
</tr>
<tr>
<td>1994</td>
<td>10.0</td>
<td>47.6</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>13.1</td>
<td>48.3</td>
</tr>
<tr>
<td>2011</td>
<td>13.4</td>
<td>48.1</td>
</tr>
<tr>
<td>2012</td>
<td>13.5</td>
<td>47.9</td>
</tr>
</tbody>
</table>

Sources: IMF, EIA