Analysing Oil Prices: The Usefulness and Limitations of Existing Approaches

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1. Introduction

- Understanding oil price behaviour important in current environment of large rises in oil prices and marked increase in volatility
  - Can slow down economic growth
  - Can cause inflationary pressures
  - Create global imbalances
  - Volatility increases uncertainty & discourages much needed investment in oil sector
  - Tight market conditions raised fears about oil scarcity and concerns about energy security
Different Views: Structural or Cyclical?

- Structural transformations placed oil prices in a new high path
  - Erosion of spare capacity in entire oil supply chain (upstream, refining)
  - Emergence of new large consumers
  - New geopolitical uncertainties in the Middle East and elsewhere
  - Re-emergence of oil nationalism in many oil-producing countries
  - Shift in oil pricing regime towards the futures market and growing importance of financial investors and traders

- Oil price behaviour explained in terms of cyclicality of commodity prices
  - Increase in oil price stimulates oil production & slows demand growth → causes oil prices to go down ↔ stimulates demand ↔ oil price to rise

- Different view about oil market reflect divergent expectations about future evolution of oil prices
Three Main Approaches For Analyzing Oil Prices

- Models of long-run oil prices
  - Non-structural models
    - Within context of oil resource exhaustibility
  - The competitive supply-demand framework
  - Informal approach
    - Help identify economic, geopolitical and incidental factors that affect demand and supply and hence oil price movements in certain contexts
    - Can help explain short-term movements in oil prices
2. Upward Trends in Oil Prices and exhaustibility of Oil

- Two features of non-renewable resource
  - Not replaceable or replaced at very slow rate
  - Supply of non-renewable resource limited relative to demand

- Oil has both features
  - Treated as classic example of a non-renewable resource

- Essential implications of exhaustibility
  - Production in one period affect production in future periods and oil behaviour should be analyzed within dynamic context
  - Oil commands a scarcity rent which reflect opportunity cost of using the resource today rather than keeping it for future
Hotelling Model

Hotelling’s main result

- Optimum extraction path would be such that oil price in the ground over time will rise at the interest rate even in the absence of information about demand.
- As the price of the resource keeps rising, demand is slowly choked off and eventually when price reaches very high levels demand for the resource would be eliminated.
Upward trend in Oil Price

- Most analysts using this theory as the basis for understanding oil market conclude that the oil price must rise over time.
- However, various empirical studies show that market prices have been roughly trend less over time.
  - Berck and Roberts, 1996, p. 77 conclude that non-renewable resource prices have a stochastic trend and that the property of increasing prices for most non-renewables is not clear reducing “the prediction of price increase from near certainty to maybe.”
Bearing on Oil Price Projections

- Gradually rising price trend dominated forecasting models
  - When forecasts proved erroneous trend retained but applied to new lower point
  - “it has proven difficult to convince casual observers that although prices might rise, it is neither inevitable nor preordained by either economic law or geology”

- Pindyck (1999) competitive non structural model
  - Real oil price follows a Brownian motion & oil price reverts to an unobservable trending long run-marginal cost but with a fluctuating level and slope over time
  - Limited use and poor predictive performance
  - “putting aside the forecasting performance over the past two decades, the model captures in a non-structural framework what basic theory tells us should be driving price movements”
Revisions

- By relaxing some of model’s initial assumptions studies have shown that oil prices can be revised downward or can even follow a U-shaped path but downward movement can occur only for a short time... scarcity rent will soon kick in
Limitations

- Literature on resource exhaustibility does not provide insights into the oil price issue
  - Application of Hotelling’s model to the entire oil industry reduces its usefulness

- Main criticism directed towards foundation of Hotelling Model: fixed stock and exhaustibility
  - Adelman (1990): Oil reserves should be treated similar to inventories continuously depleted through extraction & augmented through exploration and development

- Implication:
  - No such thing as scarcity rent
  - Models based on exhaustibility can not provide a description of oil prices in the real world
3. The Supply Demand Framework

- Interaction between demand and supply for oil ultimately determines the oil price in the long run.
- Special features of the oil market make the modelling exercise quite complex.
- Various types of uncertainties:
  - Due to unknown future events such as geopolitical factors, supply disruptions, environmental disasters, technological breakthroughs.
  - Due to lack of knowledge about factors such as the long run price and income elasticity of demand, the response of non-OPEC and OPEC behaviour.
Global Oil Demand

- Oil demand as function of income and price
- Oil demand and price usually examined within context of price elasticity of demand
  - Measures relationship between the change in quantity of oil demanded and change in oil price
- Wide variation in estimates
- Some general observations
  - Changes in oil prices have small effect on demand especially in short run
  - Long run price elasticity of demand higher than short one
    - Due to substitution and energy conservation but elasticity still low
  - Price elasticity of demand higher in developed countries
Global Oil Demand

- Relationship between oil demand and GDP growth studied within context of income elasticity of demand
  - Change in quantity of oil demanded and change in income
- Estimates vary widely according to method used, period under study
- General observations
  - Oil demand more responsive to income than prices
  - Long run income elasticity for oil demand higher than short-run income elasticity
  - Large heterogeneity in estimated income elasticity across countries and/or regions
  - Developing countries exhibit higher income elasticity than OECD
  - Responsiveness of oil demand to income declining over time especially in OECD countries
Projections of Oil Demand

- Relationship between oil demand, prices & income used to project oil demand growth
  - Projections highly sensitive to assumptions made about economic growth scenarios
  - Highly sensitive to income and price elasticity
  - Highly sensitive to oil price path chosen
  - Endogeneity of prices and income bias results
  - Ignore potential relationship between oil price increases and growth
# Projections

## Table 3: Projected Oil Demand (Millions of Barrels per day)

<table>
<thead>
<tr>
<th></th>
<th>2003 (Actual)</th>
<th>2010</th>
<th>2015</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMF</td>
<td>79.8</td>
<td>92</td>
<td>102.42</td>
<td>113.5</td>
<td>125.5</td>
<td>138.5</td>
</tr>
<tr>
<td>EIA (2006)</td>
<td>80</td>
<td>92</td>
<td>98</td>
<td>104</td>
<td>111</td>
<td>118</td>
</tr>
</tbody>
</table>

Modelling oil supply much more complex

- Issue of reserves
- Behaviour of various suppliers
- Distinguish between OPEC and non-OPEC
- Different and diverse suppliers outside OPEC ranging from national oil companies, IOCs and independents
- Widely assumed that non-OPEC behaves competitively
- OPEC behaviour much more complex
  - Many diverse theories in literature ranging from cartel to competitive behaviour
Determinants of Non-OPEC Oil Supply

- Two General Approaches: geophysical and economic
- Geophysical factors determine oil supply
  - Production governed by historical cumulative production and size of ultimately recoverable reserves (URR)
  - Based on specific logistic curve that specifies time path of cumulative production possible to fit a symmetrical bell shaped curves for annual rate of production
- Hubbert’s approach been widely criticized
  - Treatment of URR as static variable
  - Geophysical models overestimate depletion effect
Role of Reserves

- Reserves essential in geophysical models
- Issue of reserves is highly contentious
- Wide disagreement on the size of global reserves
- Estimates vary considerably ranging from
  - Very low estimates of less than 2 trillion barrels of oil equivalent (TBOE) (Campbell, 1989; Campbell and Lahererre, 1998)
  - Moderate estimates of reserves between 2 TBOE and 4 TBOE (USGC, 2000)
  - High estimates of reserves of excess of 4 TBOE (Odell, 1983; Shell 2001; and Exxon Mobil, 2005)
- Variation due to different methodologies used, vested interests, whether studies take into account conventional and unconventional, adoption of different definitions
The bulk of this growth is not due to new discoveries but mainly due to reserve (or field) growth.
Economic Based Models

- Economic factors
  - real oil prices, costs, regulatory factors play an important role in determining oil production

- Various studies attempt to estimate price elasticity for non-OPEC oil supply

- Response of non-OPEC production to oil prices especially in short run is close to zero and even negative
  - Producers do not necessarily increase production in face of price rise
  - A decrease in oil prices does not induce producers to reduce production

- Although long run price elasticity is found to be positive estimates are quite low but not necessarily in all studies
Non-OPEC Oil Projections

Table 5: Non-OPEC Oil Production Projections

<table>
<thead>
<tr>
<th></th>
<th>2010</th>
<th>2015</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>EIA(2006)</td>
<td>54.4</td>
<td>58.6</td>
<td>72.6</td>
</tr>
<tr>
<td>EIA(2005)</td>
<td>56.6</td>
<td>61.7</td>
<td>66.2</td>
</tr>
<tr>
<td>IEA(2006)</td>
<td>53.4</td>
<td>55.0</td>
<td>57.6</td>
</tr>
</tbody>
</table>

Given the different models and the wide range of elasticity estimates, it is no surprise that non-OPEC supply projections differ considerably across studies and over time.
Supply of Oil: Role of OPEC

- Modelling OPEC supply creates serious challenge for competitive supply-demand framework
- Describe OPEC as cartel or oligopoly while at same time use competitive supply-demand framework for analysing long run behaviour of oil market
- Close the model by considering:
  - OPEC acts as swing producer equilibrating demand and supply with optimal prices/quantity levels
  - Treat OPEC supply as a residual (Call on OPEC)
    - Hypothetical amount that OPEC needs to produce to close the gap between oil demand and non-OPEC supply
### Table 5: Projections of OPEC Call

<table>
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<th>2010</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>EIA (2006)</td>
<td>32.9-37.9</td>
<td>29.3-43.3</td>
<td>29.8-46.9</td>
<td>30.9-51.0</td>
</tr>
<tr>
<td>(Upper bound-Lower bound)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IMF (2005)</td>
<td>30.6-32.7</td>
<td>43.5-49.2</td>
<td>51.6-61.0</td>
<td>61.3-74.4</td>
</tr>
<tr>
<td>(Upper bound-Lower bound)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IEA (2006) (base line scenario)</td>
<td>35.9</td>
<td></td>
<td></td>
<td>56.3</td>
</tr>
</tbody>
</table>
Limitations

- Calculating OPEC supply as a residual overcomes problem of modelling OPEC’s complex behaviour

- But creates two problems:
  - Is there Incentive for OPEC to expand output?
  - Will the investment materialize?
Implicitly assume that OPEC has incentive to increase market share without any regards to oil prices.

No analysis whether projected output path serves OPEC interests.

Gately (2004) calculates the OPEC’s net present value of profits for different choices of OPEC’s market share:

- Aggressive expansion plans to expand output can yield lower payoff than if OPEC decides to maintain its market share.
- Increase in discounted expected profit from higher output more than offset by lower prices as result of rapid output expansion.
- Projections made by EIA and IEA of rapid increases in market share “are likely to be contrary to OPEC’s own best interests.”
The Underinvestment Problem

- Unfavorable geopolitical factors/ sanctions can prevent capacity expansion
- Relationship between government and national oil company can result in unfavorable environment for investment
- Relationship between governments and/or national oil companies and IOCs
  - As markets have tightened terms and conditions demanded by owners have been hardening over time
- For OPEC uncertainty about demand for OPEC oil constitutes a very important obstacle for investment
  - Calls for security of demand
Limitations of Supply-Demand Framework

- Using this framework to project oil prices is likely to result in mistakes for a number of reasons:
  - highly sensitive to assumptions made about income and price elasticity of demand, the price elasticity of supply, role of reserves, OPEC behaviour
  - Can not capture impact of unexpected shocks
    - Cashin et al, 1999: “it is incorrect to view shocks to commodity prices as generally being a temporary phenomenon that largely reflect short-lived variability in supply interacting with relatively unchanging demand”
  - Does not take into account general geopolitical context and market conditions in which oil prices are determined
    - Supply-demand framework analyses oil prices and makes projections in a ‘neutral context’
4. Informal Approach

- Identify other factors affecting oil prices within a specific context
- provide only a cursory view about how oil market and oil prices might develop in the future
  - Of limited use to make projections
Use of the Informal Approach to Explain Current Drivers

- Current drivers of oil prices
  - Spare Capacity: Can it be re-established?
  - Role of OPEC: Changing role?
  - Noise Traders: Do they matter?
  - Inventories: Is there a new relationship?

- Are these drivers transitory or permanent?
4.1 Rapid Decline in OPEC Spare Capacity

- Spare capacity around 2% of global oil demand in 2004 despite increase in OPEC production capacity

Source: IMF; BP
The Impact of Loss of Spare Capacity Cushion on Prices

- Accelerating Global Demand
- Low Non-OPEC Supply Growth
- Cycle of Underinvestment
- OPEC Spare Capacity Reduced
- Bottlenecks in Downstream

Global oil system’s ability to respond to shocks weakened

- Volatility in oil prices
- Frequent spikes in oil prices
- Accelerated rise in oil prices

Impact of shocks magnified in absence of spare capacity

- Geopolitical shocks
- Weather shocks
- Refinery fires
- Speculators
### Can the Spare Capacity Cushion be Re-established?

<table>
<thead>
<tr>
<th>Spare capacity not outcome of ‘rational’ investment decision</th>
<th>Spare capacity outcome of an historical developments in 1970s &amp; 1980s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Few players today able or willing to invest in new spare capacity</td>
<td>International Oil Companies will not hold spare capacity</td>
</tr>
<tr>
<td>Face several years of capacity constraints even if new investments are made today No short-term relief for oil market</td>
<td>Who should bare the costs of spare capacity?</td>
</tr>
<tr>
<td></td>
<td>Any increase in spare capacity in the coming two years arise mainly due to sharp slowdown in demand rather than increase in production capacity</td>
</tr>
</tbody>
</table>
4.2 OPEC Pricing Power

- Quota decisions can be viewed as signals to market about OPEC’s preferred range of prices
- Signalling mechanism may or may not succeed depending on how market interprets signals
- Weak market conditions
  - When required cuts significant small OPEC members find it difficult to reduce their production
  - Market participants doubt the effectiveness and credibility of OPEC’s policy and may ignore the signal
- Tight market conditions
  - Agreements to increase production easier to reach and implement when global demand rising but OPEC may not respond quickly to upward trend in an environment of imperfect information and uncertainty about future demand
- Another channel: the erosion of spare capacity
An important consequence of the recent shift to the futures market for oil price determination is the wide range of factors that OPEC needs to consider in making its output decisions:

- the level of inventories
- forward curve’s shape
- size of speculative positions in the futures market
- traders’ bearish or bullish sentiments
- Flow of funds in and out of the market

Greatly complicates decision making process for simple reason: OPEC has only one policy tool at its disposal (implementing production cut) with which it would like to achieve a wide range of objectives:

- May have undesired consequences on oil price fluctuations inducing volatility and causing sharp rises or falls in oil prices in some instances
4.3 Speculation and Oil Prices

- Claimed that large component of transactions in markets being driven by noise trading
- Black (1986) defines noise traders as agents who sell and buy assets on the basis of irrelevant information
  - Transact on the basis of extrapolating past trends (technical analysis) or irrational investors’ sentiments (herding) rather than on market fundamentals or the arrival of new information (see for instance Shiller (1981) and Shleifer and Summers (1990) among many others)
Traditional View

- Noise traders exist in financial markets but can be ignored in models of price formation.
- If noise traders hold overvalued assets, arbitrageurs should sell these assets to noise traders and push down their prices.
- If a trader holds overvalued assets, then arbitrageurs should purchase asset from the noise trader and raise the price.
- Net effect: noise traders lose money; sooner or later exit the market.
- Friedman (1953): ‘people who argue that speculation is generally destabilizing seldom realize that this is equivalent to saying that speculators lose money since speculation can be destabilizing in general only if speculators on average sell low and buy high.’
Traditional View Challenged

- Traditional view recently challenged
- The survival of noise traders is possible
  - Shleifer and Summers (1990)
- Even if noise trading in financial markets can persist, the main issue is whether changes in demand due to noise trading are big enough to affect prices and destabilize the market
- Potential of herding: If shifts in demand correlated across noise traders and do not cancel each other out then noise trading is capable of influencing market prices
Speculative Positions and Oil Prices

Notes: Spot Price in Log Scale (left scale); Net long term positions in millions of contracts (right scale)

Source: IMF, World Economic Outlook, 2006
Speculation and Oil Prices

- Three broad generalizations
  - Prices appear less volatile than speculative positions
  - No common trend between prices and speculation: no persistent pickup in net long non-commercial positions when oil prices were trending upward
  - Changes in non-commercial traders’ net long positions may coincide with changes in oil prices
    - This evidence does not establish that speculators influence oil prices
    - Could be the result of changes in fundamentals that affect both oil prices and speculative positions of traders
Role of Hedge Funds

- Haigh, Hranaiova, and Overdahl (2005) use a unique dataset from the Commodity Futures Trading Commission (CFTC) to examine the role of hedgers and speculators in the crude oil market.

- Disaggregated data allow authors to examine role of hedge funds.

- Main findings:
  - Speculators are proving liquidity to hedgers and not the other way around.
  - Large speculators have little influence on oil prices.
  - Evidence of herding is very weak and even if it exists, herding is not destabilising.
    - Traders do not buy when prices are low and sell when prices are high and do not cause an overshooting of oil prices.
4.4 Inventories

- Inventories have risen
- Market oversupplied
- Precautionary Demand
  - Current price structure signalling need for precautionary inventories
  - “Just-in-time inventories are no longer appropriate as OPEC has lost the spare capacity that enabled it to act as a buffer, shifting stock risk management down the crude supply chain to refiners”
It is the Contango

- Contango creating incentive for market participants with storage facilities to accumulate inventories, stock up their tanks, lock a profit by selling futures contracts
- Inventories then shorted in the futures market contango
WTI Forward Price Curve (as of 3 January 2007)
Inventories and Oil Prices

- Associated rise in inventories occurring (until recently) with an upward trend in oil prices
- Conventional wisdom that building up inventories would depress oil prices
- Some argue conventional wisdom may no longer be valid
  - High levels of inventories no longer seen as necessary sign of oversupply and hence do not exert downward pressure on prices
  - Current levels of stocks (although high by historical standards) do not imply that markets are oversupplied
More Plausible Interpretation

- Higher than expected levels of inventories still cause oil prices for prompt delivery to decline
- Other factors pushing prompt prices in the opposite direction shadowing the impact of inventories on oil prices
- Until we able to isolate the impact of other factors, it is difficult to tell
Structural Break?

- Using the informal approach not possible to provide a quantitative assessment of changes in oil market.
- But allows us to provide a qualitative assessment of whether the market witnessed structural changes with a lasting impact on oil price behaviour or whether the recent strength in oil prices caused by temporary drivers.
- Structural changes in three areas:
  - Structural shift in the back end of the forward curve.
  - ‘International oil order’ where non-OPEC supplies incremental global oil demand and OPEC provides capacity cushion has been shaken in recent years.
  - The shift to the futures market for oil price determination.
Back End of the Curve Has Moved Upward
Conclusions

- “Every attempt to predict oil prices would certainly result in mistakes”
- Various approaches allow us to analyse and gain better understanding of various elements of oil market
- Players should acknowledge limitations of various approaches & always keep them in mind when making decisions/policy recommendations
- Pushing hard for policies based on these models’ projections defeat the actual purpose of these models and may result in misguided policies not to say dangerous ones