

مركــزالملــك عبـدالله للدراسـات والبحوث البتروليــة King Abdullah Petroleum Studies and Research Center

Asian Premium or North Atlantic Discount: Does Geographical Diversification in Oil Trade Always Impose Costs?

October 20th, 2015 Busan, South Korea

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Major Global Crude Oil Flows (2012)



Middle Eastern crudes represent ~70% of Asian crude oil imports



Motivation for Our Work (1/2)

- One of the features of oil markets is that regional prices may not be aligned
 - The netback price (delivered price less transportation costs) of Middle Eastern crudes sold into Asia can be higher than the price of the same crude sold into Europe and North America.
 - Some Asian governments view this as evidence of Middle Eastern sellers exercising market power. They complain about an 'Asian Premium' and attempt to develop countervailing strategies.
- For large crude oil producers, the revenue maximizing objective is often constrained by market share objectives
- NOCs try to avoid crude oil sales subject to 'hold-up' problems from being dependent on a monopsonistic buyer
 - Perceived geopolitical benefits to supplying crude to North America
- Market share objectives are also supported by the perceived need to have a diversity of buyers, so as to benefit from risk-reducing portfolio effects



Motivation for Our Work (2/2)

- KAPSARC has developed a framework that explains the inter-regional price differentials and simulates how strategic allocation by large producers alter regional price differentials.
- We have developed KAPSARC's Global Oil Trade Model (GOTM) to compare crude oil allocations that would arise in 2012 under conditions of perfect competition with those in which large ME producers maintain a market share in EU and North America for diversification objectives.
- We aim to quantify the benefit (or cost) of geographical allocation of crude oil exports.



Formulation of the Global Crude Oil Transport Model (GOTM)

- GOTM is a simulation model of the crude oil market that examines the impact of regional crude oil allocations across consuming regions on inter-regional price differentials.
- It is a linear program that determines the least-cost flows of crude oil on the basis of logistics costs and quality deviation costs incurred by refineries.
- Crude oil trade flows are computed for ~290 crude grades and ~780 refineries globally for a benchmark year (2012)
 - Supply and demand regions selected to capture the major crude oil flows for the benchmark year, accounting for the vast majority of actual global crude oil trade in 2010
- GOTM does not compute absolute prices of crude oil, nor does it forecast the quantity produced or consumed. Instead, it solves for relative crude oil price differentials by location, and the direction and volumes of crude oil trade flows while exogenously fixing supply and demand volumes and transport costs.
- GOTM calculates relative crude oil prices as a function of freight costs, refinery configuration, and crude quality (API gravity).
- GOTM provides the capability to vary refinery flexibility in accepting off-spec crude oil, giving insights on the effects of crude heterogeneity on trade flow



Crude Oil Flows – Transport Nodes (Imports and Exports)



APSARC

GOTM – Oil Transportation Mechanism





Refinery Flexibility - A Concise Representation

- Refineries typically run only a limited range of different crude types (determined by API gravities)
- We use a step function to penalize large deviations and allows costless substitution within small API ranges
- The relative width of the steps is scaled with the complexity index of refineries – the more complex the refinery, the wider the step and the more flexible the refinery
- The x-axis represents the ratio of deviation barrels to total demand of refinery j











A Simplified Representation of Refinery Flexibility





Model – Mathematical Formulation

Objective function:



minimize the sum of total freight costs and refinery API gravity deviation penalties:

$$\min \sum_{ij} C_{ij} x_{ij} + \sum_{kj} P_k (Q^+{}_{kj} + Q^-{}_{kj})$$

Subject to the following constraints:

- The sum of crude oil volumes shipped from crude supply region i must not exceed its supply capacity:

$$\sum_{i} x_{ij} \le S_i$$

- The sum of crude oil volumes shipped to refinery j must at least meet its demand requirements:

$$\sum_{i} x_{ij} \ge D_j$$

- Flows from crude i to refinery j must be non-negative:

$$x_{ij} \ge 0$$

- API Balance Equation:

$$\sum_{i} (\frac{S_{API_{i}}}{D_{API_{j}}} - 1)x_{ij} + \sum_{k} Q^{+}_{kj} - \sum_{k} Q^{-}_{kj} = 0$$





Potential Applications for GOTM

- Crude oil markets are changing rapidly
- Qualitative frameworks for understanding crude oil market behavior are limited in scope.
- GOTM model can provide concrete answers to pertinent questions:
 - Implications of future growth of US crude oil supply on oil flows?
 - Lifting the US crude oil export ban on the efficacy of regional allocations?
 - Russian crudes increasingly diverted from Europe to Asia
 - Growth of unconventional production in other regions?
 - Implications of the changing refining landscape globally on the nature of exports?
 - Is crude oil a commodity?



Results and Discussion

The Impact of Current Policies

 We developed two representations of oil markets to understand the market dynamics of crude oil transport

Competitive Market

- Minimizes global transport costs and refiners' costs of deviating from their ideal crude slates
- This scenario allows us to estimate the flows that would occur with completely competitive markets.
- It also provides a baseline for estimating the gains or losses to suppliers' revenues from regional allocations of crude oil and the change in importer costs from strategic purchases.

Diversification

- In this scenario, a large producing region (Middle East) maintains a diversification strategy that aims to supply a fixed share of its crude oil exports to Europe and North America.
- We assume that the Middle East requires 8% and 14% of its total exports to be shipped to Europe and North America respectively.



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Net Oil Imports for Major Regions – Comparison between Competitive Run and Actual (BP, 2012)





Competitive Market vs BP (1/3)

- Broad level of congruence between GOTM and BP 2012 data.
- Key differences.
 - North America imported significantly less crude oil from Latin America than predicted by the model results. These lower imports from neighboring crudeoil suppliers, such as Venezuela and Colombia, are matched by higher import shares (relative to model results) of crude-oil imports from the Middle East and West Africa.





Competitive Market vs BP (2/3)

- Key differences.
 - In Asia, the model results show almost all crude being supplied by the Middle East except for a small share provided by the former Soviet Union, which is due to the export of East Siberian crudes into China by pipeline, and into Northeast Asia and other markets from the Pacific port of Kozmino, as well as exports delivered by pipeline from Kazakhstan to China. However, actual data for 2012 show a significant diversity of crude-oil imports into Asia, including imports from Africa and Latin America.





Competitive Market vs BP (3/3)

- Key differences.
 - One of the major differences is the significant market share of Middle-East crude oil in the US and European markets due to allocation policies of large Middle East exporters.
 - The export of Latin American crude into Asia, largely based on Venezuela's government-togovernment term contracts with India and China is another difference.





The Locational Rents of the Supply Regions

- The dual variables of the supply constraints (relative supply price differentials) represent the price differentials above the baseline world price for oil due to the locational advantage of each region.
- From the figure, the Middle East has no locational advantage and sells their crude at the world baseline price.
- In contrast, the Russian eastern port Kozmino has the highest locational advantage and it sells for almost \$1.5/bbl above the baseline world price.
 - This value approximately equals the difference between the transport cost between Kozmino and an Asian consumer port, and the transport cost between Middle East and the same Asian port.



Relative Supply Price Differentials FOB (\$/bbl)



The Delivered Price of the Demand Regions

- The dual variables of the demand constraints (delivered price) represent the price differentials above the world baseline price that an importer pays due to its location.
- This is basically equal to the transport cost between the suppliers who export to a given demand region and the locational rent accruing to those suppliers.
- For Example, the delivered price (dual variable) for Northeast Asia will approximately be equal to the transport cost between Middle East and Northeast Asia (because Middle East region has a zero supply price).
- It is also equal to Kozmino Supply price and the transport cost between Kozmino and Northeast Asia. Therefore, the delivered price will equal the marginal cost.





How Regional Price Differentials are Determined in the Competitive Scenario



LAM – Latin America, NORSEA – North Sea, WAF – West Africa, ME – Middle East, FSUKOZ – FSU Kozmino, FSUNOV – FSU Novorossiysk, JAPKOR – Northeast Asia, USGC – US Gulf Coast., SWE – Southwest Europe, SWA – Southwest Asia



How Regional Price Differentials are Determined in the Competitive Scenario

- The figure shows how the prices are determined in the competitive equilibrium in a sample of four importing region.
- Because we have the total supply of crude oil is slightly greater than the total demand, one producer will have an excess supply and will have a supply price of zero.
- This producer is considered the marginal producer and in the competitive scenario it is the Middle East.





The Impact of Current Policies

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Diversification

- In this scenario, a large producing region (Middle East) maintains a diversification strategy that aims to supply a fixed share of its crude oil exports to Europe and North America.
- We assume that the Middle East requires 8% and 14% of its total exports to be shipped to Europe and North America respectively.



Net Oil Imports for Major Regions – Comparison between Competitive Run, Diversification Scenario, and Actual (BP, 2012)





Diversification vs BP

- The figure shows import shares of crude oil for North America, Europe and Asia by regional sources of supply.
- It compares the diversification scenario with both the competitivemarket scenario and the estimated inter-regional crude oil flows in 2012 as reported by BP.
- The diversification scenario results are closer to the actual flows compared to the competitive scenario.





Supply Prices: Competitive vs. Diversification

- As a result of the new equilibrium, the relative advantage of each location changes. The figure shows the supply prices in both the competitive and the diversification scenarios.
- The marginal producer becomes West Africa and the Middle East now gains an infra-marginal rent.
- This new equilibrium results from the fact that as the Middle East diverts a significant share of its exports to the West, it induces Asian importers to buy crude from more distant sources, which increases the delivered price in Asia.
- Consequently, the Middle Eastern supply price approximately equals the difference between the transport costs between West Africa and Asia and the transport cost between Middle East and Asia.



Competitive Scenario

Delivered Prices: Competitive vs. Diversification

- The costs of all Asian importing regions increases because West Africa replaces the Middle East as the marginal producer.
- In contrast, prices decreased in all Western regions due to the proximity of the new marginal producer to these regions.



- Diversification Scenario
- Competitive Scenario



Illustrative Supply and Demand Curves Showing How the Regional Price Differentials are Determined in the Diversification Scenario



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Illustration of Model Outcomes:

Consequences of Asia Importing Marginal Barrel from West Africa



Crude Volumes to Asia



Illustration of Model Outcomes:

Consequences of Asia Importing Marginal Barrel from West Africa



Crude Volumes to Asia



Flexible Refinery – Middle East Revenue Gain



Middle East revenues are highest when Asia import its marginal barrel from more distant markets, this cause ME to gain locational rents



Sensitivity of the Results to the Supply and Demand Volumes (1/2)

- In our analysis, we used 2012 data to simulate the market.
- A change in the supply and demand volumes can alter the results.
- As we observed earlier, ME can gain infra-marginal rents only when Asia imports its marginal barrel from a more distant market.





Sensitivity of the Results to the Supply and Demand Volumes (2/2)

- One scenario that can alter our results is an increase in the quantity supplied from FSU through the eastern Russian port of Kozmino.
- Another possible scenario is that Asian importers can purchase volumes from more distant suppliers, this will reduce the quantity demanded from the ME and eliminate their locational rents.





Conclusions

- Large crude suppliers may increase their revenues by allocating volumes to more distant markets, if by doing so they capture locational rents from more proximate buyers.
- Based on the 2012 configuration of global oil markets, Middle Eastern exporters can exploit this opportunity.
- Large crude buyers may reduce their costs by purchasing volumes from more distant suppliers, counteracting the strategies of their nearest suppliers.
- Long term future reconfigurations, such as North American volumes becoming available in the Pacific markets or a Russian supply pivot from Europe to Northeast Asia, might alter the ability of current Middle East exporters to increase revenues while achieving greater customer diversity.





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Thank You