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STRATEGIC INVESTMENT DECISIONS IN CRUDE OIL PRODUCTION CAPACITY AND THE IMPACT ON FUTURE SUPPLY BOTTLENECKS

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OVERVIEW

In its most recent World Enery Outlook (WEO), the International Energy Agency (IEA) [11] sounded the alarm regarding future energy supplies: a considerable reduction in investment activity may lead to medium-term supply shortfall and, consequently, drastic price spikes. The reasons for the reduced investment are the current economic crisis, a difficult funding environment, a low oil price compared to levels during the past two years, and, most importantly, high uncertainty with regard to future demand (contingent on an economic recovery) and international legislation to curb greenhouse gas (GHG) emissions and combat climate change.

This work investigates the incentives of crude oil suppliers to invest in additional production capacity, specifically considering this uncertainty. Four scenarios of future crude oil demand development are considered:

- a business-as-usual scenario, with a quick economic recovery and no serious international action to combat climate change
- a *450 scenario* (compare [11]), with a sustainable economic recovery and international agreements to reduce GHG emissions
- a prolonged global recession
- a scenario in which emerging economies quickly leave the trough and continue on a business-as-usual scenario, while developed economies pass to a sustainable economy with restricted GHG emissions

The work focuses on two important crude oil suppliers, namely Saudi Arabia and Russia.

METHODOLOGY

The structure of the current crude oil market can be described as a three-level game: in the first round, the crude oil suppliers decide on investment in production capacity expansions under uncertain demand development; in the second round, the uncertainty is resolved and the Stackelberg leader (Saudi Arabia) decides on its optimal quantity; in the last round, the Stackelberg followers decide on their optimal production levels in a hybrid Nash-Cournot and perfectly competitive market. This is treated in a multi-period framework, spanning the next two decades. This ensures that current investments have sufficient time to be amortized.

The game is implemented by combining Real Options (RO), an investment analysis framework specifically allowing for uncertainty and the postponement of decisions (i.e., “wait and see”), and Variational Inequalities (VI, the generalization of the Karush-Kuhn-Tucker conditions to find equilibria among several non-cooperative optimization problems). [4,6]

RO have regularly been applied to crude oil investments, but the crude oil price is then usually assumed to be an exogenuous stochastic process.[12,3,1] This may be plausible in a per-field profitability analysis, but ignores strategic aspects when one considers massive investment decisions by major suppliers.

VI and complementarity models have come into fashion in recent years to investigate market equilibria in the natural gas and electricity markets.[5,8] This approach allows to elegantly include Nash-Cournot and/or Stackelberg market power, but faces some limitations as to including stochasticity. Research is under way on these constraints.[7] A recent optimization model for the crude oil market was presented at the IAEE 2008 Conference, Istanbul, but this approach does not consider non-cooperative behaviour.[2]

For this work, I chose to combine a market equilibrium approach with RO theory, as this allows more flexibility for the problem at hand. The latter problem (both stages of the Stackelberg market) is an extension of previous work, and implemented in GAMS using the NLPEC solver.[9,10] As shown in these works, the global crude oil market can best be described as a Stackelberg market, with Saudi Arabia the Stackelberg leader, while all OPEC members exert Nash-Cournot market power and the other suppliers acting perfectly competitive. The market equilibrium is computed for each supplier under investigation for both possibilities: *"invest now"* (i.e. the base year 2009) or *"wait and have the option to invest later"*, and for each demand development scenario. The numerical simulation then yields the supplier profits for each option; this serves as the basis for the RO analysis.

EXPECTED RESULTS AND CONCLUSIONS

This is work in progress, numerical results are still outstanding at the time of writing.

The results will give an insight into whether it is optimal for the important suppliers Saudi Arabia and Russia to invest, or whether other political or economic reasons are behind their reduced investment levels at the moment. In addition, the numerical simulation allows to gauge trajectories of the crude oil price in the next decade in a number of economic and capacity investment scenarios.

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