KAPSARC
مركز الملك عبدالله للدراسات والبحوث البترولية
King Abdullah Petroleum Studies and Research Center

Commentary

Simulating a Global Oil Market With No Residual Supplier

July 2020

Bertrand Rioux, Abdullah Al Jarboua, Fatih Karanfil, Axel Pierru, Shahd Al Rashed, and Colin Ward

What if OPEC decided to abandon organizing residual production collectively, transitioning the world permanently to a competitive oil market?

To calibrate the oil demand curve, we use the International Energy Agency's "World Energy Outlook 2019" (WEO) Stated Policies Scenario

Motivation and objective of the study

What if OPEC decided to abandon organizing residual production collectively, transitioning the world permanently to a competitive oil market? This commentary is based on a forthcoming KAPSARC paper, "Cooperate or Compete? Insights from Simulating a Global Oil Market with No Residual Supplier" (Rioux et al. 2020). It constructs scenarios in which OPEC members, or OPEC members other than Saudi Arabia, start behaving as competitive price takers in 2020 and stop participating as part of a collective residual oil supplier. This analysis employs a standard economic equilibrium model to simulate the transition to a purely competitive world oil market from 2020 to 2030.

Modeling framework

We have developed an equilibrium model of the global oil market through 2030 with a detailed representation of oil-producing assets globally. Rather than applying a dominant firm model with a competitive fringe, as is standard in oil modeling, the study assumes a perfectly competitive global oil market. Every oil-producing country behaves as a price-taker, with no residual supplier adjusting production to influence prices. Investment and production decisions depend only on how costs compare with prices.

The model is dynamic and captures the transitional adjustments in demand and market prices, and Saudi Arabia's corresponding revenues. The world oil market clears period-by-period, with demand balancing supply on an annual basis. This applies to all hydrocarbon liquids, including crude oil, condensates, natural gas liquids (NGLs), refinery gains and other liquids (biofuels and alcohols destined for the same market as petroleum products). Global demand and supply are represented as a single node, and regional crude flows are not detailed in the analysis.

To calibrate the oil demand curve, we use the International Energy Agency's "World Energy Outlook 2019" (WEO) Stated Policies Scenario (IEA 2019), which accounts for new environmental measures that target a gradual reduction in oil demand growth. Under this scenario, annual demand growth slows to an average of 0.8%, as global demand rises from 98.8 million barrels per day (MMb/d) in 2019 to 107.7 MMb/d in 2030. This scenario assumes that the real price of Brent crude steadily increases to US$88 per barrel (b) in 2025 and US$96/b in 2030. Note that the impact of the coronavirus crisis on demand is not factored into the Stated Policy Scenario. From 2020 to 2030, gross domestic product (GDP) growth averages 3.6%, and oil demand does not peak. In our model, world oil demand responds to the oil price and global GDP through elasticities, and the oil price impacts GDP.

On the supply side, producers maximize their profits in two ways: selling oil produced by existing projects and investing in new ones. Oil is sold at the market price that clears demand, which is adjusted to account for crude quality and regional price markers. To explicitly model supply decisions at the asset level, the model uses a set of linear activities, built using a detailed database of production costs and capacity projects. Supplies are differentiated by quality, field type, location, and ownership, providing a detailed representation of different supply categories.

The model includes investments as additional linear activities and categorizes them as either short-term (shale, or 'tight,' oil projects) or long-term (all other developments, including conventional oil, oil sands, heavy oil, NGLs, and condensates). United States (U.S.) shale oil projects are generally characterized by fast decline rates, and short development lead times and production cycles; most of a single well's total production occurs within a year. Other developments, such as conventional onshore and offshore production, and oil sands, generally have multi-year investment lags and production profiles.

To calibrate oil supplies, the study uses Rystad Energy's UCube global upstream oil and gas database. The model uses the data to represent each OPEC member, including Saudi Arabia, on a stand-alone basis. The database details the distinct resource endowments of each country, their cost structures, and financial and technical constraints. Rystad's production data, extracted for existing projects, includes projected annual output, marginal costs, capital development costs, or, for tight oil, breakeven oil prices.

Rystad's data provides rich information on existing and new project plans, including their projected approval years, production start years, and annual capital development costs. We run a scenario applying the investment plan projected by Rystad out to 2030, and alternative scenarios in which the model can select the approval year for projects planned for development between 2020 and 2050. In the alternative scenarios, an annual investment constraint shared by all suppliers is introduced to represent limits on the capital available for new projects in the global oil industry. Projects are undertaken when discounted net revenues exceed discounted capital expenditures.

Under the Rystad investment plan, an average of US$123 billion is approved for new projects each year. This represents the present value of project capital expenditures, with a 10% real discount rate as is typically used in the oil industry. Note that between 2009 and 2019, an average of US$99 billion was approved each year, with total approvals falling significantly after oil prices started to decline in 2014. In the alternative investment scenarios, we apply annual global investment caps equal to US$75 billion, US$100 billion, US$125 billion and US$150 billion.

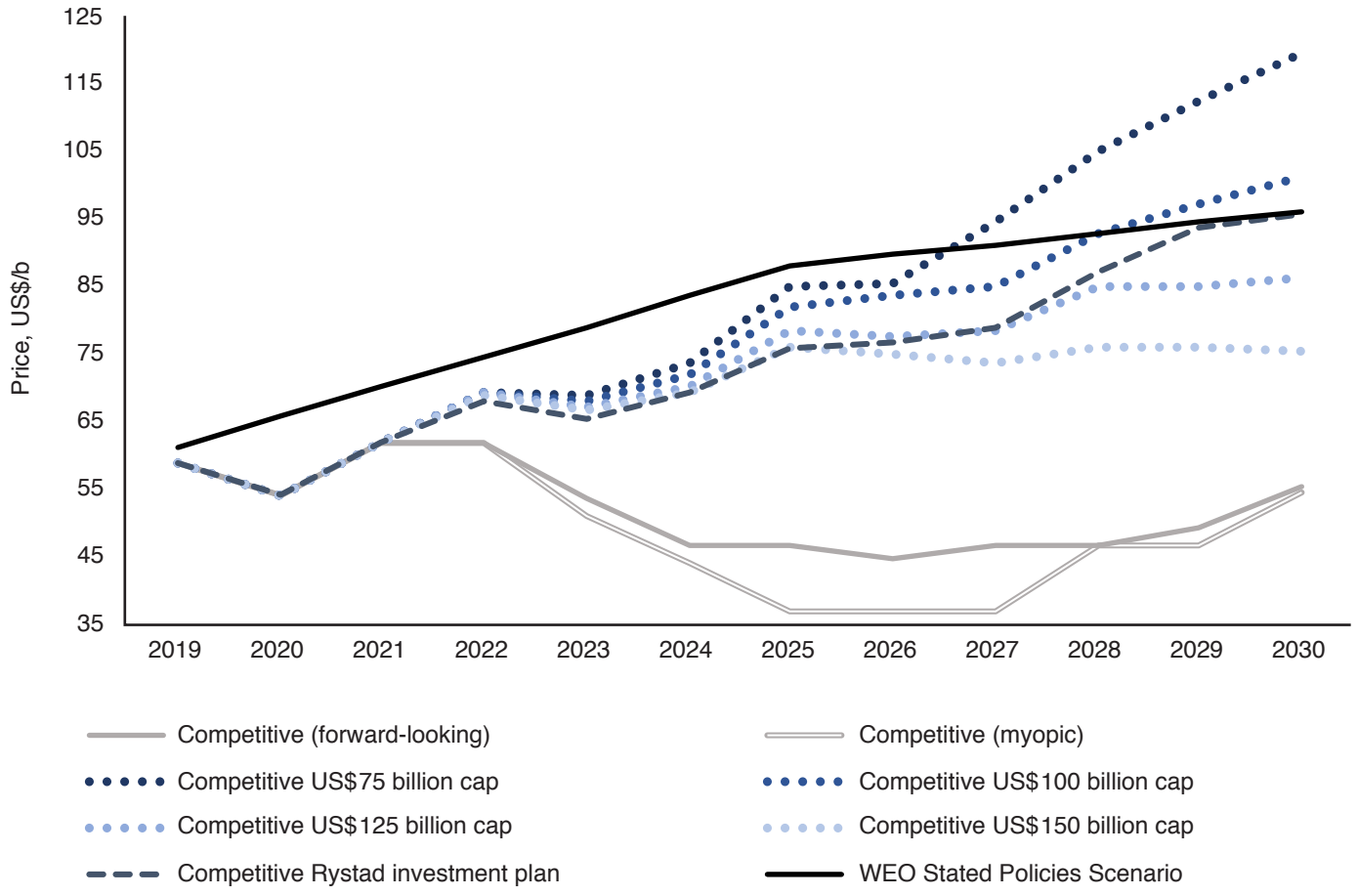
The model also assumes that suppliers can develop any tight oil field up to the annual production level projected by Rystad, as long as oil prices exceed the project's estimated breakeven cost. The Rystad data projects that tight oil production capacity, primarily from the U.S., could peak at more than 17 MMb/d in 2025. To represent possible restrictions, a tight oil cap scenario is also introduced that limits annual capital expenditures to 50% of Rystad's projections, with production capped at around 12.4 MMb/d in 2025.

Results

Figures 1(a) and 1(b) show the results of the competitive market model under the investment constraints described above. In 2020, Brent prices fall US$11/b below the WEO reference case as OPEC ramps up production. Under the Rystad investment plan, between 2020 and 2025 prices are, on average, 14% below the WEO reference case. Overall, the decline in prices generates a slight increase in global GDP growth (0.1%) compared with the WEO reference case.

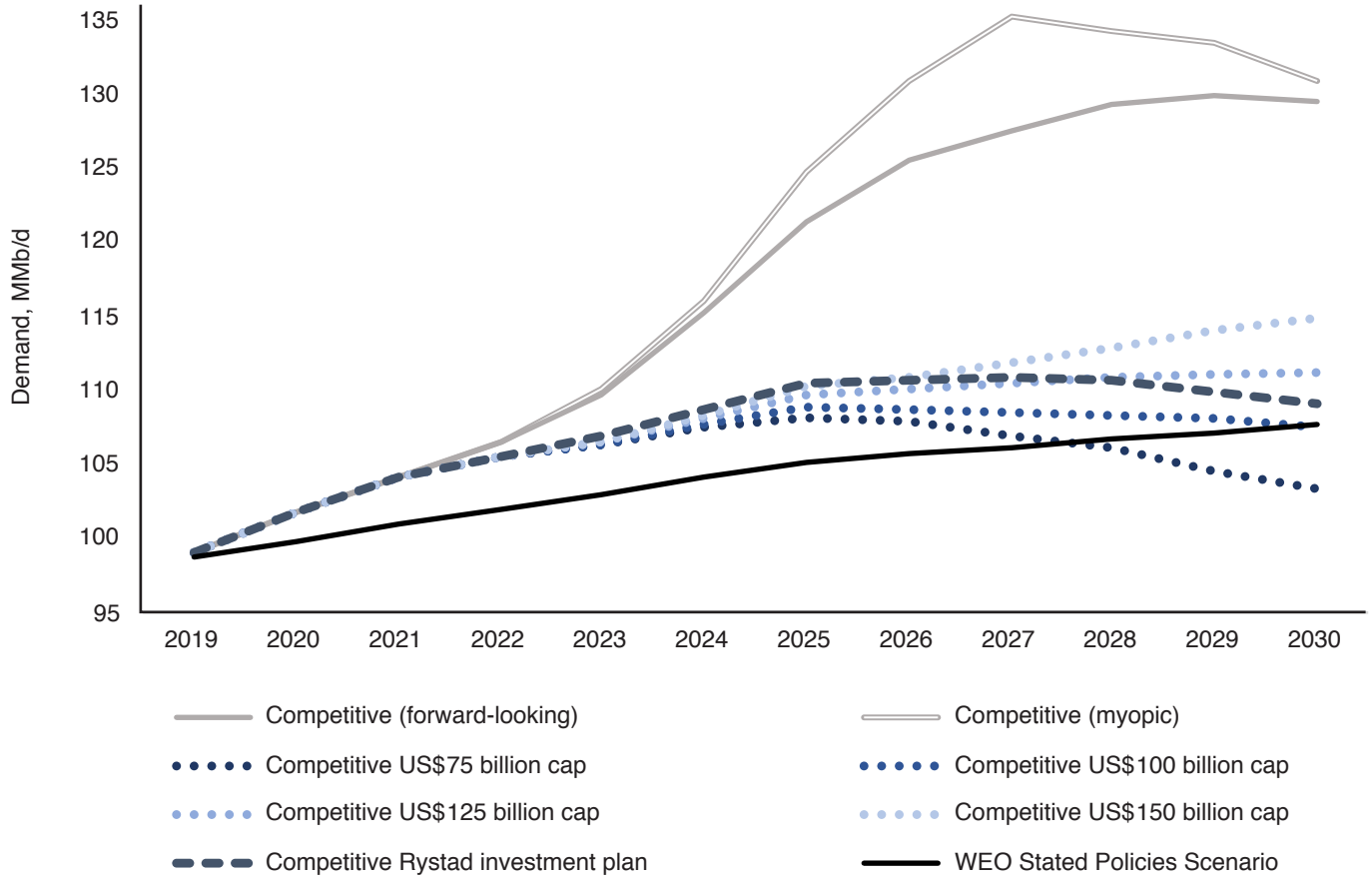
When relaxing the annual investment constraint in the US$125 billion and US$150 billion cap scenarios, the decline in prices persists until 2030. Assuming the present value of capital approved for new projects does not exceed US$100 billion annually, prices are expected to recover and exceed the WEO reference case before 2030. If this were to happen, higher average oil prices would result in a slight contraction of GDP growth relative to the WEO reference case.

Figure 1a. World oil prices in the competitive scenarios.



Source: KAPSARC analysis.

Table 1b. World oil prices in the competitive scenarios.



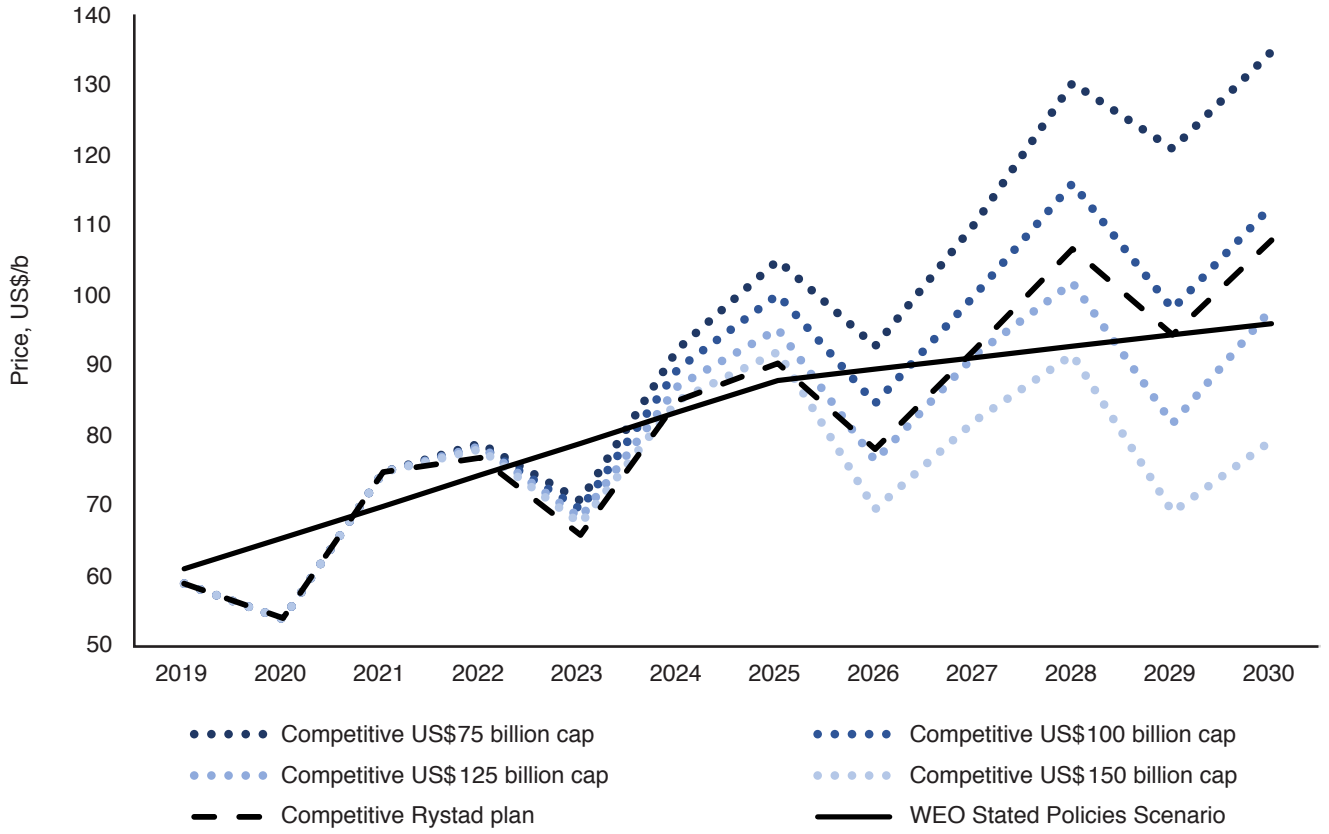
Source: KAPSARC analysis.

Figure 2 shows the modeled price (2a) and demand (2b), assuming that tight oil investments are capped at 50% of the levels projected by Rystad. In Figure 2a, the slowdown in the growth of tight oil production causes both average price and price variation to increase. The standard deviation of the annual rate of change in competitive market prices increases by more than 150% compared with scenarios that do not have a cap on tight oil investments. The model's results suggest that limiting investment in tight oil projects restricts the ability of shale oil to balance the market as a source of marginal production. Given the short-term nature of shale production, it has a more pronounced impact than conventional projects with longer development lead times.

The model's results suggest that limiting investment in tight oil projects restricts the ability of shale oil to balance the market as a source of marginal production

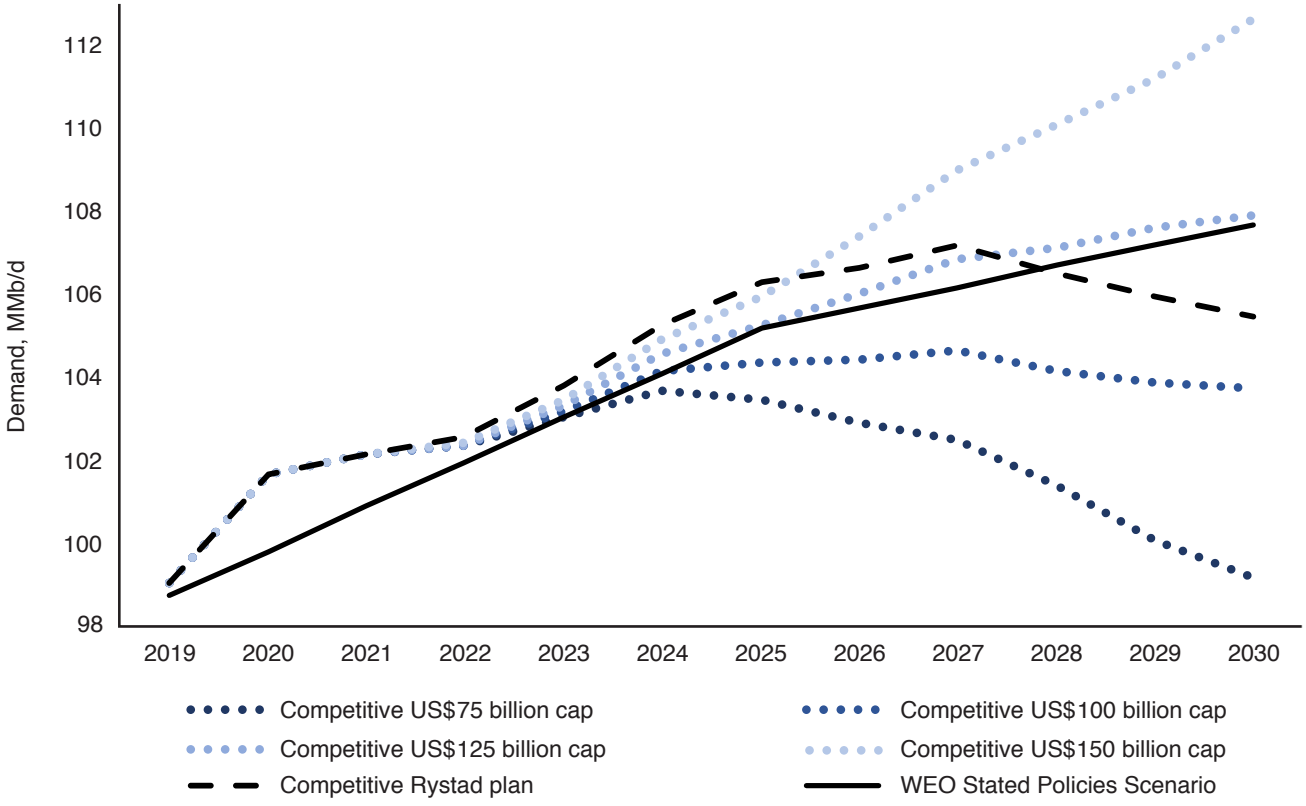
In the next set of figures, we analyze changes in production and compare the expected profits of Saudi Arabia (and OPEC) as a competitive price taker and a residual supplier. The residual supplier adjusts its output to realize the price and demand of the WEO Stated Policies Scenario (the solid lines). This provides a hypothetical benchmark to compare against the competitive scenarios.

Figure 2a. World oil prices in the competitive scenarios, assuming a 50% reduction in annual capital expenditures on tight oil projects.



Source: KAPSARC analysis.

Figure 2b. World oil demand in the competitive scenarios, assuming a 50% reduction in annual capital expenditures on tight oil projects.



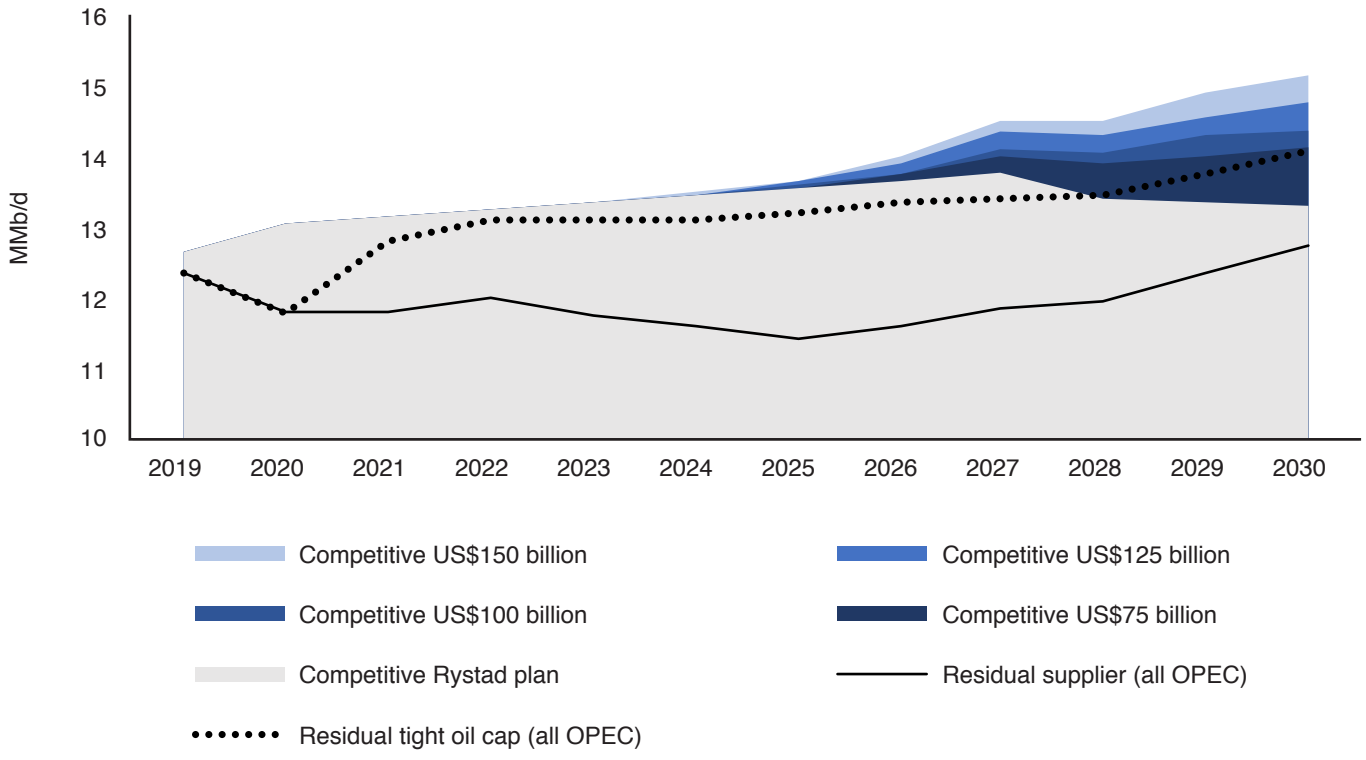
Source: KAPSARC analysis.

Figures 3a and 3b show the total liquids production of Saudi Arabia and OPEC, respectively, under the competitive market scenarios with different investment constraints. This illustrates the growth in their total production, and available capacities, assuming planned OPEC projects can be developed earlier if they are profitable. The lines represent production levels under the residual supplier reference case. Cases with and without the cap on tight oil investments are represented by the solid and dotted lines, respectively. As shown in Figure 3b, by 2025, OPEC withholds up to 6.4 MMb/d of production, compared with the sustainable production levels achieved in competitive market scenarios. Saudi Arabia would need to withhold this amount of production if it did not have the support of other OPEC producers. Saudi Arabia's reduced production coincides with the growth and peak in unconventional tight oil production in 2025.

Saudi Arabia's reduced production coincides with the growth and peak in unconventional tight oil production in 2025

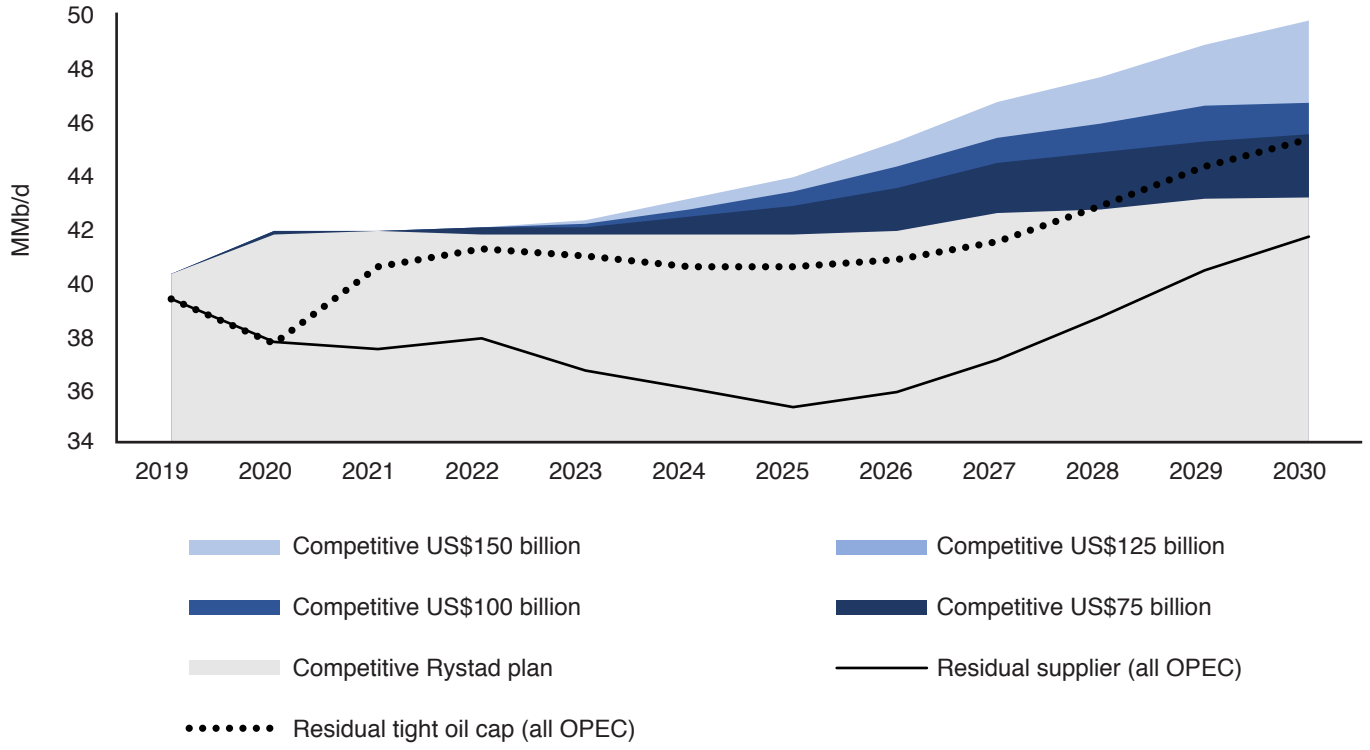
As expected, in the scenario with a 50% reduction in capital available for unconventional projects (representing lower investor confidence), a decline in tight oil production has a much smaller impact on OPEC production. Under this capital constraint, tight oil production remains relatively stable when shifting between the residual supplier (OPEC coordination) and competitive market assumptions. However, in general, tight oil production benefits from higher prices, which are supported by the residual supplier.

Figure 3a. Saudi Arabia's total liquids production.



Source: KAPSARC analysis.

Figure 3b. OPEC's total liquids production.

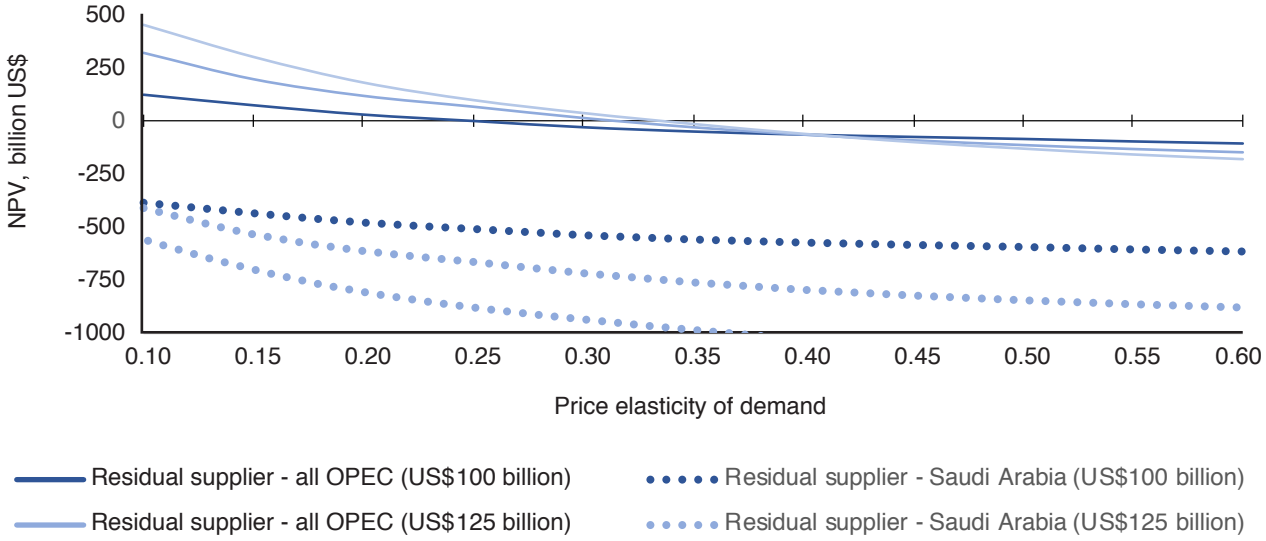


Source: KAPSARC 2020.

Figure 4 summarizes the net present value (NPV) of the difference in Saudi Arabia's profits between the residual supplier and the competitive scenarios for different price elasticities of demand. This illustrates how consumer response to changes in price can impact the value of Saudi Arabia's profits in a perfectly competitive market compared with the reference case where it operates as a residual supplier. The solid lines represent Saudi Arabia coordinating production, with OPEC as the residual supplier, and the dotted lines represent Saudi Arabia acting alone.

Note, the NPV under the residual supplier scenarios are calculated assuming the price and demand levels projected by the WEO, and are constant across different elasticities (for a given investment constraint). Therefore, Figure 4 represents the NPV of the competitive scenarios repositioned with respect to the NPV from the reference case (i.e., vertically inverted and shifted). Profits increase in the competitive scenario for higher price elasticities because consumer demand responds more to the additional production released by OPEC members, and prices recover faster. When Saudi Arabia coordinates production cuts with OPEC, the NPV of its profits are greater than in the competitive scenarios for price elasticities of demand below 0.35 (in absolute terms). Prices in the competitive market increase as the investment constraint is tightened, pulling the NPV curve down for elasticity values below this threshold. When acting as a residual supplier without support from OPEC, the NPV of Saudi Arabia's profits are always lower than in the competitive scenarios (by more than US$300 billion) due to the significant decline in its market share.

Figure 4. Net present value of the difference in Saudi Arabia's profits (residual supplier minus the competitive scenarios) for different price elasticities of demand. The solid lines represent Saudi Arabia coordinating production with OPEC as the residual supplier, and the dotted lines represent Saudi Arabia acting alone.



Source: KAPSARC analysis.

The results suggest that strong coordination among OPEC members will be needed to protect the sensitivity of Saudi Arabia's market share and oil revenues, as a residual supplier, to structural changes in the world oil market. In a purely competitive market, additional production by OPEC producers could cause prices to decline by up to US$14/b between 2020 and 2025 compared with the reference WEO Stated Policies Scenario. However, under realistic capital constraints for conventional and unconventional projects, prices in the competitive scenarios recover to or exceed the WEO levels well before 2030. Therefore, for Saudi Arabia to maintain higher oil revenues than in a competitive market with no residual supplier requires collectively enlarging the role of the residual supplier. This may include coordinating production with non-OPEC producers, such as Russia, a member of the extended OPEC+ group. In a market where residual production is not coordinated by a broad coalition, Saudi Arabia may be better off not acting as the residual supplier alone, but instead prioritizing its market share as a competitive producer.

Strong coordination among OPEC members will be needed to protect the sensitivity of Saudi Arabia's market share and oil revenues, as a residual supplier

Saudi Arabia may be better off not acting as the residual supplier alone, but instead prioritizing its market share as a competitive producer

References

International Energy Agency (IEA). 2019. "World Energy Outlook 2019." https://doi.org/DOE/EIA-0383(2012) U.S.

Rioux, Bertrand, Abdullah Al Jarboua, Fatih Karanfil, Axel Pierru, Shahd Al Rashed, and Colin Ward. 2020. "Cooperate or Compete? Insights from Simulating a Global Oil Market with No Residual Supplier." [pending publication].

About the project

This project investigates a world oil market where there is no residual supplier that adjusts its production to influence prices (i.e., OPEC). A partial equilibrium model is used to simulate oil supply and demand dynamics assuming perfect competition among all producers. The model provides a detailed representation of supplies, characterized as longer-term conventional and shorter-term tight oil production, that can be used to construct a variety of production and investment scenarios. It is also used to compare the financial implications of transitioning to a competitive oil market for the current residual supplier, OPEC, and Saudi Arabia as its largest contributor.

About KAPSARC

The King Abdullah Petroleum Studies and Research Center (KAPSARC) is a non-profit global institution dedicated to independent research into energy economics, policy, technology and the environment across all types of energy. KAPSARC's mandate is to advance the understanding of energy challenges and opportunities facing the world today and tomorrow, through unbiased, independent, and high-caliber research for the benefit of society. KAPSARC is located in Riyadh, Saudi Arabia.

Legal Notice

مركـــز الملـــك عبـــدالله للدراســـات والبحوث البترولية
King Abdullah Petroleum Studies and Research Center

www.kapsarc.org