Energy Supply Chain: Game Theory Study and Risk Management

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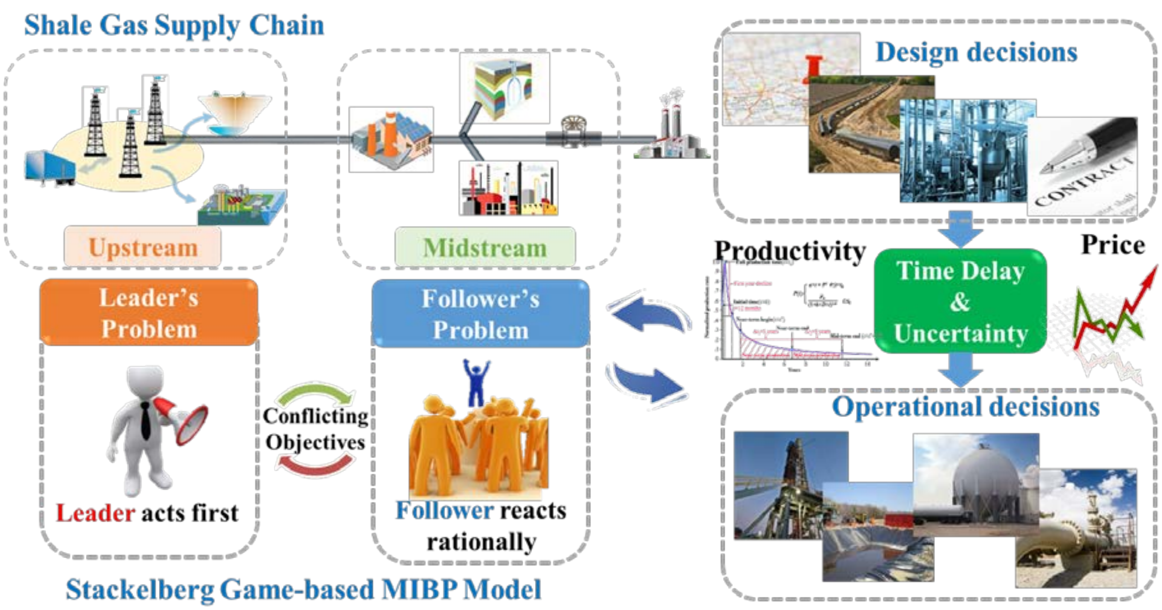
The management of a supply chain may involve multiple noncooperative stakeholders. Each stakeholder pursues distinct objectives, which lead to conflicts of interest and compromised strategies. Consequently, the optimal strategies obtained from centralized optimization model may be overly optimistic or even infeasible under a noncooperative environment. Game theory-based models, such as the Cournot model, the Bertrand model, and the Stackelberg game, can be applied to tackle this research challenge. In traditional game theory models, all the stakeholders determine their design and operational strategies simultaneously to reach a Nash equilibrium.[5] However, in practice, there always exist time delays and uncertainty between the design and operational decisions, which may significantly affect the overall performance of a supply chain and even result in infeasibility issue.



The objective of this project is to develop a novel game theory-based model to systematically address the optimization of noncooperative supply chains under uncertainty. We will couple a Stackelberg-game based mixed-integer bilevel program with a two-stage stochastic program to address the optimization under uncertainty in a noncooperative supply chain. The application will focus on the shale gas industry (i.e. unconventional natural gas sector). Specifically, the upstream shale gas producer is identified as the leader, and the midstream shale gas processors are considered as the followers. At the first stage, both types of players will interact with each other to determine their best design strategies, such as the drilling schedule, construction of processing plant, and pipeline installment, etc. Then the uncertainties are revealed, and both types of players reach the second stage to determine their operational strategies based on their previous design decisions and given uncertainty information. These operational decisions include the natural gas production profile, transportation planning of shale gas, and planning of processing activities. With this modeling framework, we can address the impacts of uncertainty in the optimization of a noncooperative supply chain.