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A new approach to modelling natural gas markets[1]

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International gas markets are becoming interdependent and global due to the shale gas revolution and the increasing ability of countries to import/export liquefied natural gas. As a result, there is an increased need for international and realistic gas market models. Research into natural gas markets is intrinsically an interdisciplinary field involving researchers from mathematics, engineering and economics. Hence, there are several examples of natural gas market models in the literature.

In this research we develop a new methodology for modelling natural gas markets by combining two existing methodologies, rolling optimisation and Mixed-Complementarity Problems (MCPs). Rolling optimisation involves solving connected optimisation problems where results of one optimisation are used in the following optimisation. This technique models uncertainty and replicates real-world decisions better than single optimisation problems. Single optimisation problems assume that all decisions made (e.g., the amount gas to produce) are made at one time point. MCPs allow for a game theoretic framework where multiple players compete to optimise their own position (e.g., maximising their profits) subject to constraints, with some (if not all) players having an ability to affect market price. In this work we present the benefits of combining these two approaches. Specifically, we show how the new methodology models unexpected market events (e.g., sudden loss of a supply source) more realistically. In addition, we also demonstrate that the new approach can be up to 50% more computationally efficient when compared with more traditional modelling frameworks. We apply the methodology to a model representative of the natural gas market in the Pennsylvania, Jersey, Maryland (PJM) region of the USA.

In addition, energy market models previously did not take into account how different players in such markets change their risk preferences over time as more information is revealed. For example, if a gas producer is initially risk-seeking and willing to take risks in search of large profits but fails and actually makes a loss, then it is likely they would be more cautious and risk-averse in the future. The approach taken in this research can better capture this behaviour as it allows

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players in the market to change the probabilities they associate with different demand scenarios. Modelling this behaviour has not been previously seen in energy markets models due to computational difficulties in solving the problem. The approach taken in this peer-reviewed research provides a framework to overcome these challenges, models natural gas markets in a more realistic manner and thus provides more practicable results for energy market players and policymakers.