MARKET DYNAMICS AND POWER RISKS IN GREEN TECHNOLOGY MATERIALS: PLATINUM UNDER THE EU 2030 HYDROGEN TARGET

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Overview

The EU's ambitious decarbonisation strategy, highlighted by the European Green Deal and the REPowerEU initiative, positions hydrogen as a cornerstone of the energy transition. Achieving the EU's 2030 hydrogen production target necessitates significant advancements in electrolyser technology, which demands a reliable and sustainable supply of critical raw materials (CRMs) like platinum. Platinum, a key component in PEM electrolysers, faces supply challenges due to its geological scarcity and the concentration of its production in a few global regions, notably South Africa.

This study evaluates the implications of market dynamics, geopolitical influences, and policy measures, particularly the 2024 Critical Raw Materials Act (CRMA). By employing a leader-follower Stackelberg game framework, the analysis investigates the strategic behaviours of dominant suppliers, the effectiveness of EU policy interventions, and the potential of alternative supply strategies, including recycling and stockpiling. The work aims to provide actionable insights for policymakers and industry stakeholders, addressing critical questions about supply chain resilience, cost-effectiveness, and long-term sustainability.

Methods

The study utilises a deterministic bi-level optimisation model to simulate interactions between a dominant supplier—South Africa—and fringe suppliers within the platinum market. The model is grounded in the principles of game theory, particularly the Stackelberg framework, which captures the strategic decisions of the dominant player as a leader and the responsive behaviours of fringe suppliers as followers. This approach allows for analysing market clearing mechanisms, pricing strategies, and supply dynamics under various scenarios.

Key data inputs include platinum demand projections from the European Commission's Joint Research Centre, cost structures for production and recycling, and geopolitical risk assessments. The model incorporates CRMA provisions, such as the 65% import cap from a single supplier and strategic stockpiling benchmarks. Sensitivity analyses explore the impact of demand fluctuations, production cost changes, and alternative policy measures on market outcomes.

Recycling potential is analysed through scenario modelling, highlighting its role in reducing dependency on primary suppliers. Additionally, stockpiling strategies are evaluated to determine their effectiveness in mitigating price volatility and ensuring supply stability during disruptions.

Results

The analysis reveals South Africa's significant influence on the platinum supply chain, with the potential for strategic behaviours that maximise its market power. However, the implementation of CRMA provisions could significantly alter this dynamic. Diversification of supply sources, mainly through increased imports from Zimbabwe and North America and enhanced recycling efforts within the EU, emerges as a critical factor in reducing dependency and stabilising supply.

Stockpiling is identified as an effective mechanism to mitigate the impacts of supply disruptions and price volatility. The study finds that stockpile sizes equivalent to approximately twice the annual demand could provide a buffer against geopolitical and market shocks, ensuring continuity in hydrogen production.

Recycling, while pivotal, faces challenges due to the limited existing infrastructure and the technical complexities of recovering platinum from diverse applications. The findings underscore the need for targeted investments in recycling technologies and infrastructure to augment the resilience of the EU's CRM supply chain.

Strategic behaviour analysis highlights a potential shift in market power dynamics. While South Africa dominates, fringe suppliers—notably Russia and North America—are poised to increase their market shares, driven by competitive production costs and policy-driven incentives. This shift could lead to a more balanced global market, reducing the EU's vulnerability to single-source dependencies.

Conclusions

The EU's hydrogen economy, a pivotal component of its decarbonisation strategy, relies heavily on a secure and sustainable supply of platinum. This study demonstrates the critical role of policy interventions like the CRMA in fostering supply chain resilience and its implications on global trade dynamics within the EU's transition to renewable gas.

The findings highlight the strategic nature of exporters' behaviour in shaping market outcomes, with South Africa's competitive advantage diminishing over time as other exporters improve their cost efficiencies. Diversified supply chains and enhanced recycling practices are shown to be essential for ensuring stability in the European market. Stockpiling, while effective in mitigating supply disruptions, requires further investigation to determine optimal sizing and its performance under different demand and supply scenarios.

Limitations of the modelling framework are acknowledged, particularly its assumption that fringe exporters are passive participants. Future research should incorporate their strategic behaviour and explore alternative pricing mechanisms, long-term partnerships with fringe producers, and a deeper examination of recycling dynamics and demand elasticity. These directions offer valuable insights for policymaking to strengthen the EU's position in critical raw materials markets while supporting its energy transition.