Green Hydrogen for Development? Identifying Opportunities through Economic Complexity along the Value Chain in Africa

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Overview

To meet climate targets, hard-to-abate sectors such as heavy industry, high-grade heat applications, and heavy-duty transport require effective decarbonization strategies. Among the various solutions being explored, "green" hydrogen has emerged as an energy carrier and feedstock, offering the potential to reduce emissions in these hard-to-abate areas where other clean technologies may be less effective[1]. As the global demand for low-carbon hydrogen rises, a new green global value chain (GGVC) is taking shape, creating new economic windows of opportunities[2]. These opportunities span various stages, from the manufacturing of key components like electrolyzers to competitive production in renewable-energy-rich regions. In addition, there are promising downstream opportunities to process hydrogen into value-added products, such as high value chemicals, steel and refinery products[1].

Countries in the Southern Hemisphere with high solar radiation and wind speeds may be well-positioned to capitalize on their renewable energy resources to produce green hydrogen at low cost[2]. While extensive research has been conducted on green hydrogen production costs and export potential, particularly for resource-rich African nations, the potential of hydrogen as a driver for broader economic diversification and the integration into this GGVC remains underexplored. Existing studies often overlook the opportunity to align hydrogen development with industrial growth strategies, particularly in low- and middle-income countries (LMICs), where economic complexity and industrial readiness vary widely.

This paper examines the potential of the African continent, endowed with abundant renewable energy resources, for participating in both upstream and downstream activities of the green hydrogen economy, next to being sole production hubs. By integrating geospatial LCOH modeling with economic complexity analysis, a way to analyse how related a nation's economy is to a specific set of products[3], we aim to identify pathways for industrial diversification for each African country. The findings contribute to bridging the gap between hydrogen's production potential and designing reasonable implementation strategies for the participation in the value chain. Notably, it serves to support African policymakers to design hydrogen development policies that are more likely to enable capturing value locally, which can lead to jobs and industry development. Beyond hydrogen, this study develops a framework for understanding and capitalizing on the potential of green value chains in developing countries and can be applied to other GGVCs, like Battery or Carbon Dioxide Removal.

Methods

This study combines economic complexity analysis and geospatial modeling to identify opportunities in the green hydrogen value chain. Economic complexity, a framework that assesses a country's ability to produce and export products based on its industrial capabilities and knowledge intensity, was employed to estimate the industrial readiness of countries regarding selected upstream and downstream in the green hydrogen value chain[3]. Examples include the manufacturing of electrolyzers, renewable energy components (upstream) and the use of hydrogen for green steel or urea (downstream). For this, HS6-digit-based product codes were matched to the hydrogen value chain through a comprehensive grey and academic literature review resulting in a list of 330 upstream and 55 downstream products. The Development Technology Opportunity (DTO) index, derived from economic complexity metrics such as relatedness and revealed comparative advantage (RCA), was utilized to measure a country's readiness to participate in these value chain steps[4]. DTO combines proximity to high-complexity industries and export performance, providing a benchmark for industrial competitiveness[4]. For the calculation, data of the Observatory of Economic Complexity was leveraged to access the most up-to-date metrics of relatedness and RCA for each product and for all countries[5]. The second parameter, hydrogen cost competitiveness, was assessed using the Levelized Cost of Hydrogen (LCOH). Geospatial techno-economic modeling, based on the GeoH2 framework, is utilized to estimate LCOH across regions[6]. This approach incorporates data on renewable energy potential, infrastructure, and transportation logistics to calculate hydrogen production costs, resulting in a minimum LCOH for each country, which is used as an estimate to gauge competitiveness. By integrating these two parameters—DTO for industrial readiness and LCOH for production cost competitiveness—this study identifies distinct strategies for African nations to position themselves in the emerginy GGVC of hydrogen.

Results

Based on preliminary results, we find that on average along the selected value chain segments, African countries perform below the "global frontier", represented by the average DTO score for China, the USA, and the EU. While this general pattern is unsurprising, leading African nations can be competitive in selected downstream products, such

as green steel, urea, refinery and ammonia, suggesting potential for value chain upgrading in the processing of hydrogen. The study identifies four archetypes of African nations based on the relative combination of cost competitiveness (LCOH) and value chain upgrading potential (DTO scores) as shown in Figure 1. Countries like Egypt and South Africa (low LCOH, high DTO) are well-positioned for integrated hydrogen ecosystems. Nations such as Mauritania and Namibia (high LCOH, low DTO) face challenges due to low industrial readiness but can explore import-export-focused strategies. Tanzania and Tunisia (high DTO, high LCOH) could leverage their industrial strengths by importing hydrogen or exporting tactical knowledge or materials and equipment. Lastly, countries with both high LCOH and low DTO across all value chain segments like Cameroon and Benin, will face difficulties to participate in the hydrogen GGVC as it would require vast investment and knowledge transfer. Finally, we identify collaboration opportunities, which improve opportunities compared to individual country-by-country hydrogen strategies. Such cooperation can include transporting low-cost hydrogen from producers like Namibia to industrial hubs such as South Africa, facilitating knowledge transfer from high-DTO countries, and exporting equipment and materials to low-LCOH nations. These collaborative efforts can address regional disparities, enhance competitiveness, and integrate African nations into the global hydrogen economy.

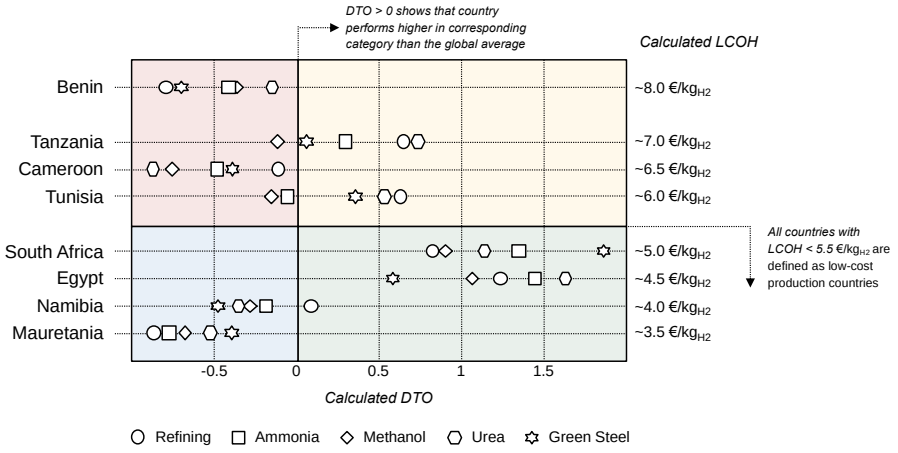

Figure 1: Cost competitiveness (LCOH) and value chain upgrading potential (DTO scores) for selected downstream applications and example countries.

Conclusions

Due to the expected growing demand and high production potential, green hydrogen represents a transformative opportunity for African nations to integrate into emerging GGVC and global energy trade beyond exporging green hydrogen as a the next resource. However, achieving this potential will require targeted investments and strategic policy design, and international collaboration to maximize the use of regional capabilities. Our study demonstrates that, for Africa, this potential largely lies in downstream applications like green steel and urea. Northern and Southern Africa lead in industrial readiness, while Eastern and Western Africa show potential in a few distinct value chain segments. Conversely, collaboration between nations will be crucial. Countries with high DTO scores and thus more advanced industrial capabilities, such as South Africa and Egypt, can support their neighbors by engaging in knowledge transfer and close collaboration and equipment. Nations with low LCOH, such as Namibia and Mauretania, can act as hydrogen production hubs, providing competitively priced hydrogen for processing in regions with greater industrial readiness. By fostering such partnerships, African nations can establish integrated hydrogen value chains, building an economy that leverages each country's unique strengths and has better chances to compete against the global frontier.

Key References

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