Mapping the industrial base for the new energy economy: predicting competitiveness in clean energy economic opportunities

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ABSTRACT: Countries all over the world are designing green industrial policies to upgrade their economies and position their firms in global value chains. If successful, these strategies could continue to generate cost declines, locking in decarbonization pathways that draw on new energy technologies. However, there are two central risks. First, countries could make investments in sectors where they cannot be competitive. Second, poor quality information about the opportunity set and the specific nature of economic opportunities will lead many countries to compete in a small number of technologies. Instead, countries need to spread out and compete in their areas of strength but this requires granular tools to map capabilities and opportunities. In this paper, we seek to identify the priority sectors for investment in all countries. This in turn relies on answers to deeper questions. What are the countries' comparative advantages? What does the country have to contribute to net zero supply chains that it could transform into competitive advantages? We present a machine learning model that predicts country competitiveness across 10 clean energy technologies.

Keywords: industrial policy; industrial base; green comparative advantage; exports; machine learning; global value chains

EXTENDED ABSTRACT:

Countries all over the world are designing green industrial policies to upgrade their economies and position their firms in global value chains. The success of China's industrial strategy for wind, solar, and batteries has spurred action in both developing and developed countries. Focused investment and coordination in China and elsewhere drove down the cost of these technologies to the point that they are now competitive with conventional energy incumbents. Now there is competition across a range of technology verticals including heat pumps, electrolyzers, permanent magnets, biofuels, nuclear, geothermal, and transmission equipment. If successful, these strategies could continue to generate cost declines, locking in decarbonization pathways that draw on new energy technologies.

However, there are two central risks. First, countries could make investments in sectors where they cannot be competitive. Countries pursuing green industrial policy must recognize that competitive advantage in high technology areas can be built over time, as China's example shows, but that it is not infinitely elastic in the short-term. Thus, industrial strategies are more likely to be successful if they build on existing strengths while charting pathways into new areas.

Second, poor quality information about the opportunity set and the specific nature of economic opportunities will lead many countries to compete in a small number of technologies. For example, in 2020 and 2021, many countries announced hydrogen or solar manufacturing strategies. This herding and strategic concentration can create real problems for developing countries, as overinvestment in coffee and other commodities did in the 1960s. Rising production pushed down prices, and exposed many countries' bets.

Instead, countries need to spread out and compete in their areas of strength. As Nahm has shown, clean energy technologies are built on complex global divisions of labour in which countries develop niche comparative advantages rooted in their economic institutions. What this means is that countries' opportunities are likely to be far more specific than policy-makers may think, requiring granular tools to map capabilities and opportunities.

For both these reasons, countries need rigorous analytics and strategy to support industrial policy design. In this paper, we seek to help countries address a central problem: what are the **priority sectors** for investment? This in turn relies on answers to deeper questions. What are the countries' comparative advantages? What does the country have to contribute to net zero supply chains that it could transform into competitive advantages?

A number of studies have now set out to identify opportunities. The seminal work of Hausmann and Hidalgo on economic complexity argues that countries' should seek to develop capabilities in products that are related or adjacent in the product space to their current exports. At the core of their approach is the idea that economies possess knowledge and skills that are not easy to acquire.

This is consistent with in-depth qualitative work on manufacturing and innovation clusters. Berger and her collaborators argue that successful industries emerge from dense interactions between the lab and the factory floor because only those interactions can build the knowledge needed to sustain advanced industries.[iv]

Rosenow and Mealy, building on earlier work by Mealy and coauthors, create indices to assess countries decarbonization technology strengths and opportunities. They follow

Hausmann and Hidalgo in arguing that countries have opportunities in areas where their current capabilities align with their current revealed comparative advantage profile.

In this paper, we build on the critical insights of this work to develop a machine learning model that predicts country competitiveness across 10 clean energy technologies. Consistent with the approaches above, we build the model on global export data because it provides the granularity necessary to deeply understand strengths and capabilities. Our model used three sets of independent variables: revealed comparative advantage in products in the supply and process chains for each technology, the co-exports for these products, and a slate of country characteristics (including GDP, manufacturing as a percentage of GDP, etc.).

We used a random forest model for classification and regression against the final product in each technology vertical. The strength of a random forest model is that unlike other strategies, it is broadly inductive and does not require us to make strong assumptions about what will predict competitiveness in final product.

We present results for 10 clean energy supply chains including the top predictors in each technology. We find that advanced economies including China, Japan, Korea, Germany, and the United States are competitive across many verticals. But there are many opportunities for emerging markets and developing economies (EMDE) with India, Malaysia, Thailand, Philippines, Turkey, and Mexico exhibiting particular strength.

The model can support countries' strategic focus by highlighting granular areas of strength. Further it encourages countries to diversify their investments and compete in a range of sectors. But it also provides a non-mechanical view on how countries should think about industrial strategy. A simple, low-risk strategy to compete in a given vertical is to build the industrial base in the underlying areas necessary for that technology. This finding is consistent with seminal and recent findings in the literature on industrial strategy that highlight the importance of investments in the upstream industrial base.[vi] Korea, for example, transformed itself into a modern manufacturing and chemicals powerhouse by strongly subsidizing upstream metal and chemical production and allowing the benefits to flow downstream.

A key finding of our model is that five sets of capabilities are critical for predicting country competitiveness: electronics, machinery, mining and metals, industrial materials, and chemicals. Moreover, each technology has a particular profile corresponding to the kind of industrial base needed to be competitive. For example, solar competitiveness is driven primarily by strength in electronics and industrial materials (e.g. glass), while battery competitiveness is driven by strength in metals and mining and chemicals.