Globalized supply chain has saved solar installers in the U.S., Germany, and China $67B 2008-2020

Solar prices will be 20-30% higher in 2030 if countries move to produce domestically

Quantifying the cost savings of global solar photovoltaic supply chains

John Paul Helveston [1,]
🐦 @JohnHelveston
✉ jph@gwu.edu

Gang He [2, 3,]
🐦 @drganghe
✉ gang.he@stonybrook.edu

Michael R. Davidson [4, 5,]
🐦 @east_winds
✉ mrdavidson@ucsd.edu

[1] Department of Engineering Management & Systems Engineering, George Washington University, DC, USA.
[2] Department of Technology and Society, College of Engineering and Applied Sciences, Stony Brook University, Stony Brook, NY, USA.
[3] Corresponding author
[4] Department of Mechanical and Aerospace Engineering, University of California San Diego, La Jolla, CA, USA.
[5] School of Global Policy and Strategy, University of California San Diego, La Jolla, CA, USA.

Introduction

Achieving carbon neutrality requires deploying renewable energy at unprecedented speed and scale, yet countries sometimes implement policies that increase costs by restricting the free flow of capital, talent and innovation in favour of localizing benefits such as economic growth, employment and trade surpluses.

Global solar PV module production, 2010-2022
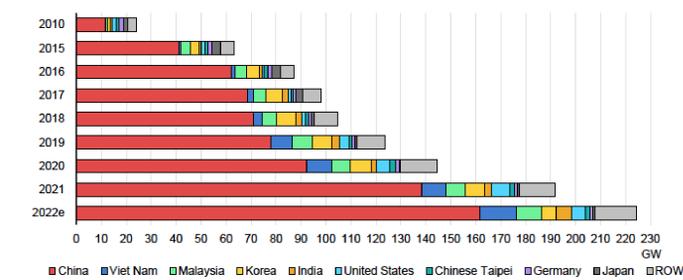
Notes: ROW = rest of world. Values for 2022 are estimates.

Source: IEA analysis based on BNEF (2022a), IEA PVPS, SPV Market Research, RTS Corporation and PV InfoLink.

China dominates global solar PV production, 78% in 2021.

Objectives

1. Assess the cost savings from a globalized solar photovoltaic (PV) module supply chain.
2. We develop a two-factor learning model using historical capacity, component and input material price data of solar PV deployment in the United States, Germany and China.
3. Discuss the policy implications of on-shoring solar PV production.

Methods

Two-factor learning curve model:

$$\ln p_{it} = \ln \alpha_i + \beta_i \ln q_t + \gamma_i \ln s_t$$

Learning rate:

$$L_i = 1 - 2^{\beta_i}$$

Hybrid learning in the "National Market" scenario:

$$q_t - q_{(t-1)} = (q_{it} - q_{i(t-1)}) + (1 - \lambda_i)(q_{jt} - q_{j(t-1)})$$

Where, q_{it} is the cumulative installed capacity in country i in year t, q_{jt} is the cumulative installed capacity in all other countries in year t, and λ_t is a value ranging from 0 to 1. This defines a scenario whereby incremental capacity installed in each year increasingly comes from national as opposed to global installations as λ_t shifts from 0 to 1.

Results

Learning rates: Estimated learning rates during 2006 and 2020 are 20% in Germany, 26% in the U.S., and 33% in China.

Historical prices: If each country had pursued a gradual transition to strict nationalistic policies while installing at the same rate over a ten year period, solar PV module prices in 2020 would have been significantly higher than their actual historical prices: 54% higher in China ($387 versus $250 per kW), 83% in higher Germany ($652 versus $357 per kW), and 107% higher in the U.S. ($877 versus $424 per kW).

**Estimated Module Prices Under Global vs. National Market Scenarios**
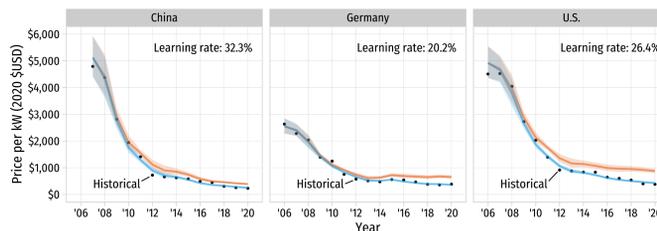
Historical savings: We estimate that the globalized PV module market has saved PV installers US$24 (19–31) billion in the United States, US$7 (5–9) billion in Germany and US$36 (26–45) billion in China from 2008 to 2020 compared with a counterfactual scenario where domestic manufacturers supply an increasing proportion of installed capacities over a ten-year period.

**Annual Module Savings Under Global vs. National Market Scenarios (2008 - 2020)**
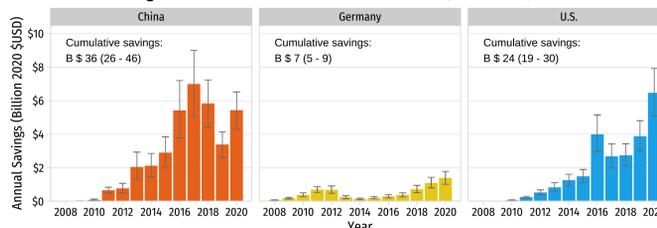
Projected prices: Projecting the same scenario forwards from 2020 results in estimated solar module prices that are approximately 20–30 per cent higher in 2030 compared with a future with globalized supply chains.

Projected Module Prices Under Global vs. National Market Scenarios (2020 - 2030)
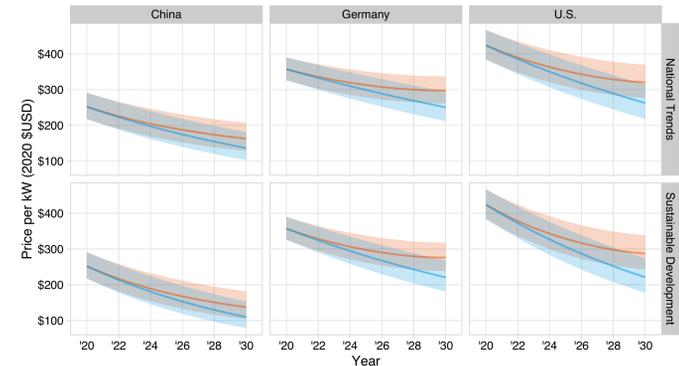
Projected savings: Based on the projected installed capacities, the estimated cumulative future savings from 2020 to 2030 across all three countries from global versus national markets is $15 billion (2020 $USD) with a 95% confidence interval of $13–$16 billion under the National Trends scenario, and $29 ($27–$32) billion under the Sustainable Development scenario.

Projected Annual Module Savings Under Global vs. National Market Scenarios (2020 - 2030)
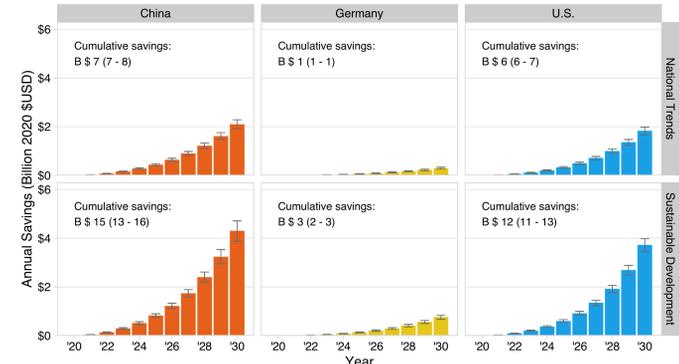
Discussions

- Trade disputes and domestic employment
- Technology "crowding out"
- Additional domestic and diversified sourcing drivers

Limitations

1. We considered but did not dis-aggregate the learning mechanisms
2. We did not include price elasticity, we assume same historical installed capacity to provide most policy relevant results

Learn more

Helveston, John, Gang He, and Michael Davidson. 2022. "Quantifying the Cost Savings of Global Solar Photovoltaic Supply Chains." *Nature.* 612(7938): 83–87. https://doi.org/10.1038/s41586-022-05316-6.

Code and data: https://doi.org/10.5281/zenodo.6989075

Visual-app: https://jhelvy.shinyapps.io/solar-learning-2021