Clean Tech and Trade in an Era of Nationalism

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Snowmass 2025

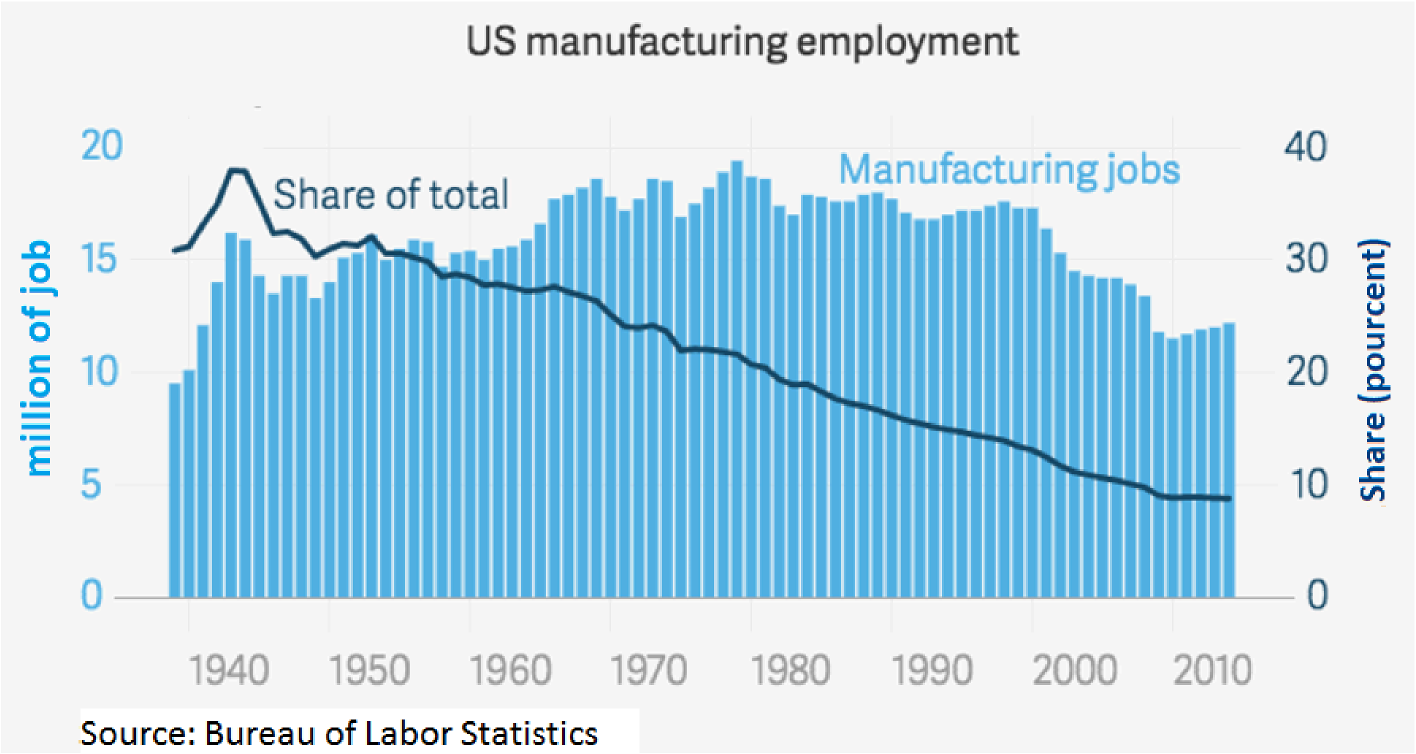
New Political Reality:

Nationalism > Globalization

(Security > Efficiency)

Manufacturing job loss (~5M since 2000)

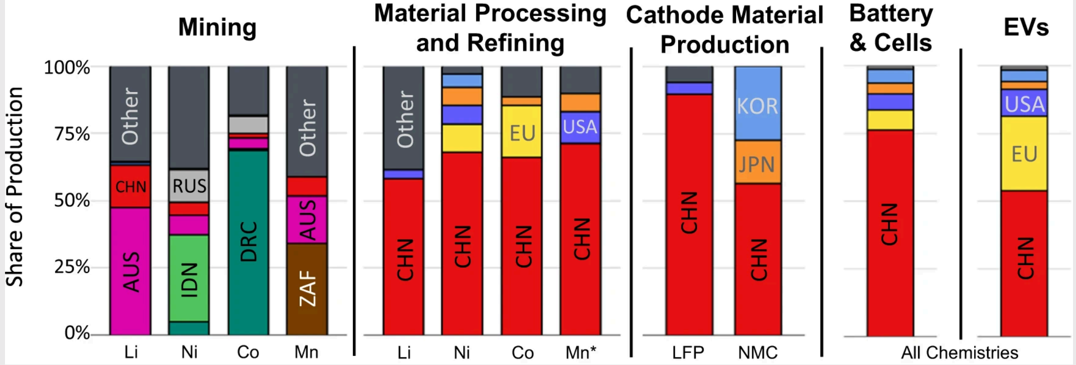
- Long term economic transition towards services
- "Hollowing out" of US industrial base



https://en.wikipedia.org/wiki/Manufacturing_in_the_United_States

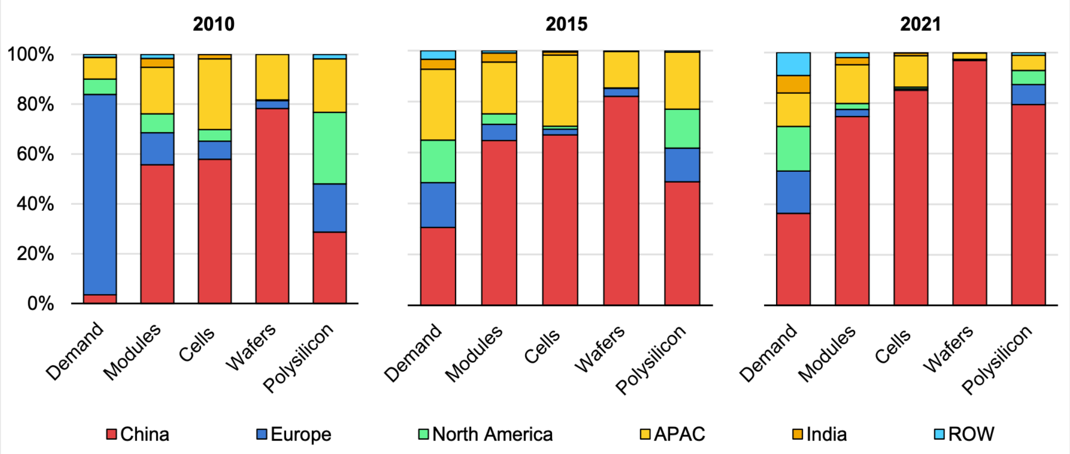
Rise Chinese dominance in clean tech supply chains

EV battery supply chain



Cheng, Anthony L., et al. "Electric vehicle battery chemistry affects supply chain disruption vulnerabilities." Nature Communications 15.1 (2024): 2143.

Solar module supply chain



IEA Special report 2022: Solar PV Global Supply Chains, https://www.iea.org/reports/solar-pv-global-supply-chains

Bipartisan goal: The US needs to counter China's lead in clean energy tech

Keep Chinese clean tech out of US market: Steep tariffs on imported Chinese EVs, batteries, PV modules

Keep Chinese firms out of US clean tech supply chains: IRA restrictions on EV subsidy elligiblity, stricter Foreign Entities of Concern (FEOC) rules

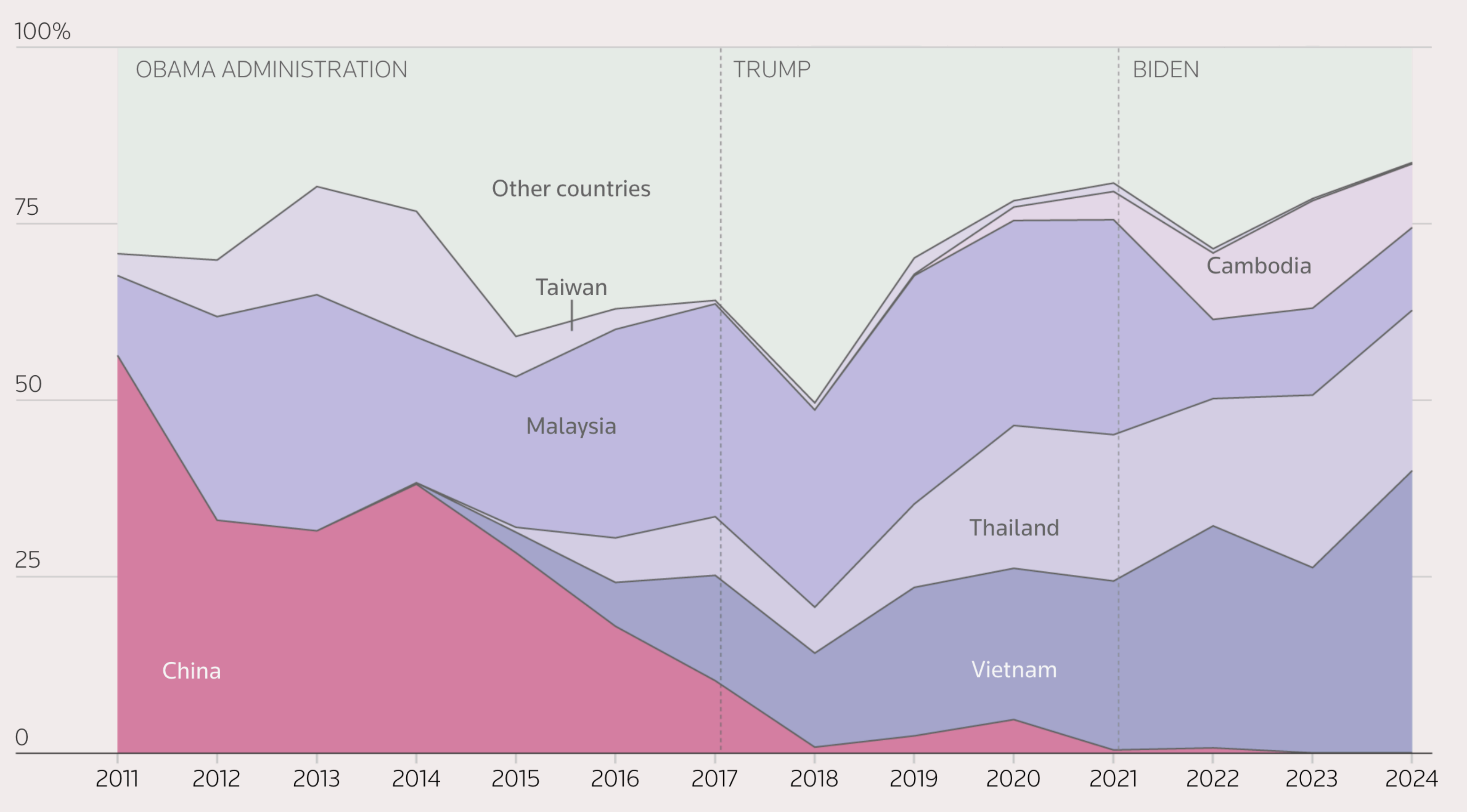
Countering China by Investing in Manufacturing

IRA Strategy: Investing in *manufacturing* will lead to enduring support for clean tech through local jobs & economic benefits

...strategy hasn't entirely worked 😔
(2 years wasn't enough time)

Solar PV

Shift from China to SE Asia (Transhipment)



Source: https://www.reuters.com/graphics/USA-CHINA/SOLAR-HISTORY/gdpzkdeqlvw/

We need diversification

China has enough solar PV capacity to meet annual global demand through 2032.

Source: Wood Mackenzie, https://www.reuters.com/world/china/china-will-dominate-solar-supply-chain-years-wood-mackenzie-2023-11-07/

But do we need *onshoring*?

Solar PV

Total available U.S. federal subsidies: $0.16 / W

Average U.S. module price (Q1 2024): $0.33 / W

Sources:

- https://www.nrel.gov/docs/fy24osti/91209.pdf
- Michael Davidson, "U.S.-China Clean Energy Race: Accelerating Innovation, Manufacturing and Adoption", https://web.sas.upenn.edu/future-of-us-china-relations/climate-and-environment/

Solar PV

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Average cost of production in China: **$0.10 / W**

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Solar PV

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Risk: U.S. producers unlikely to be globally competitive

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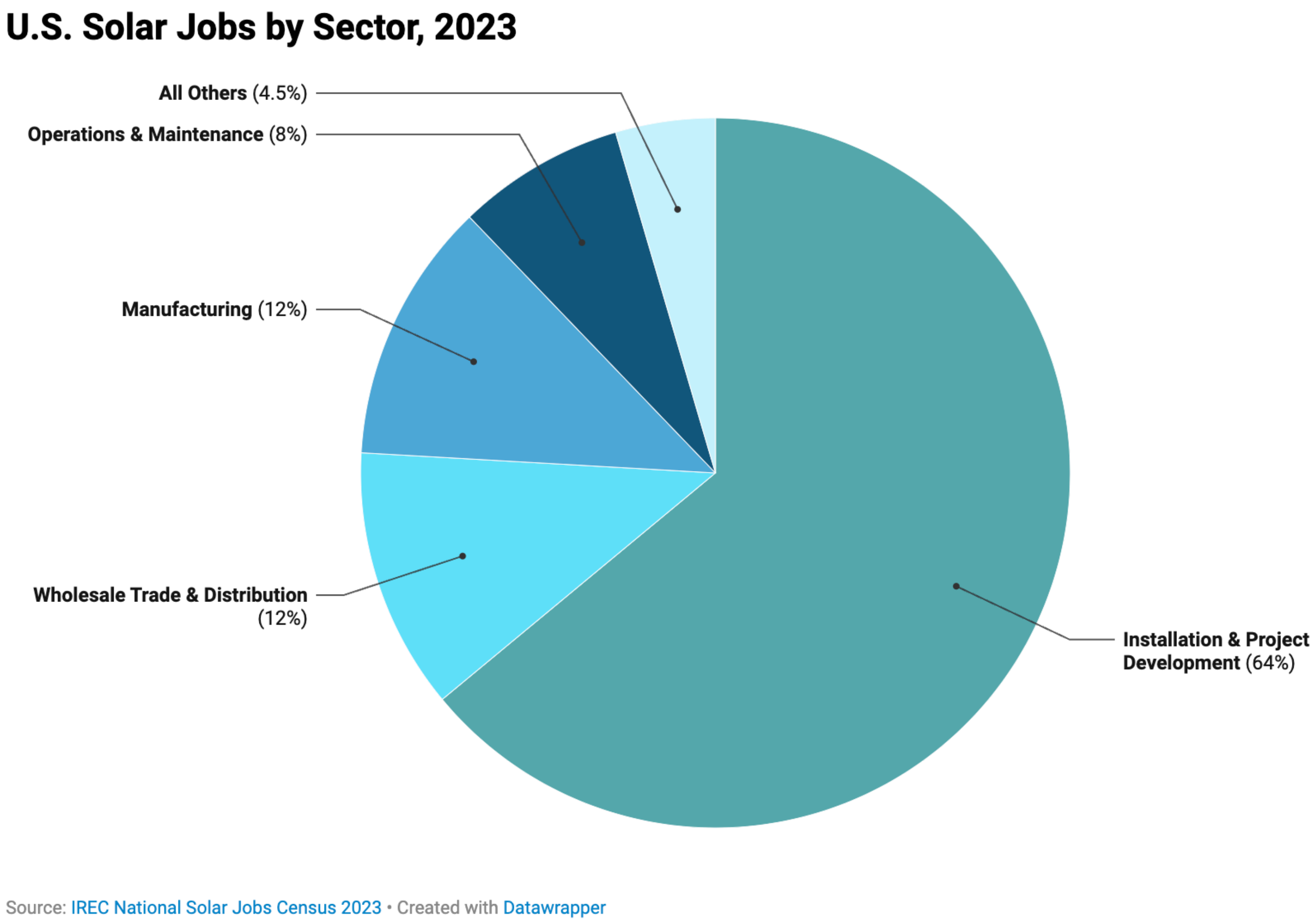
Solar unlikely to produce desired # of manufacturing jobs

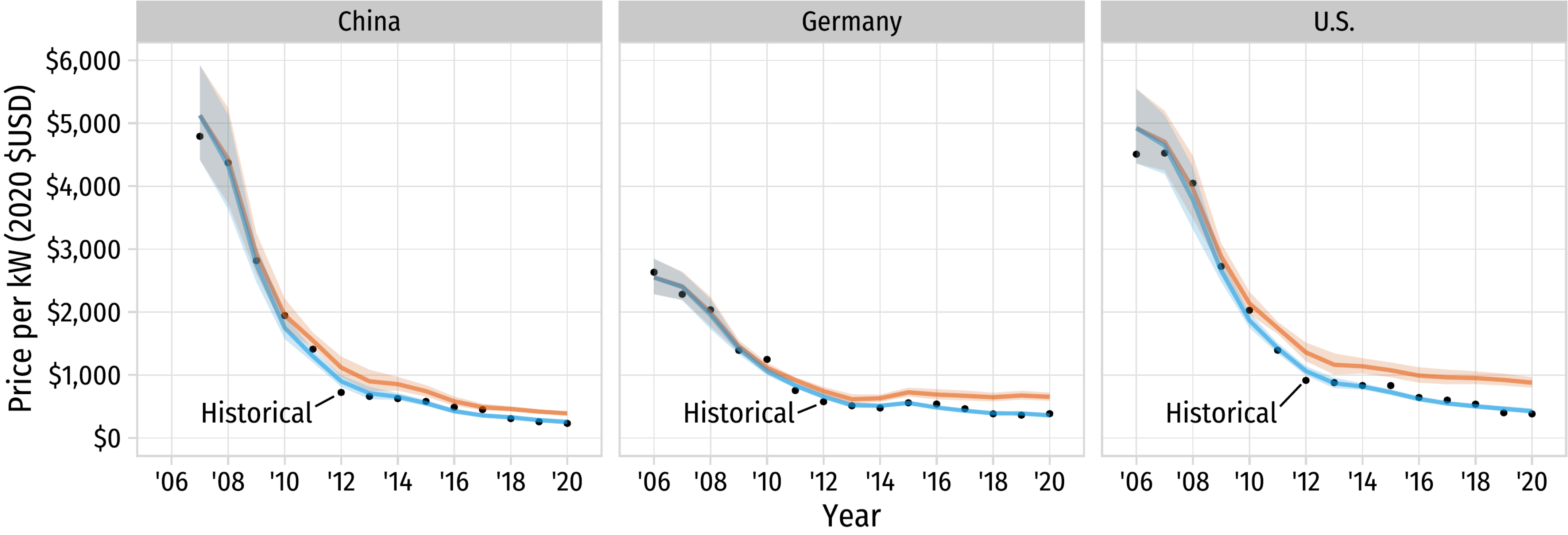


Installation and project development accounts for 2/3 of solar jobs.

Manufacturing is 12% of solar jobs

https://irecusa.org/census-solar-job-trends/

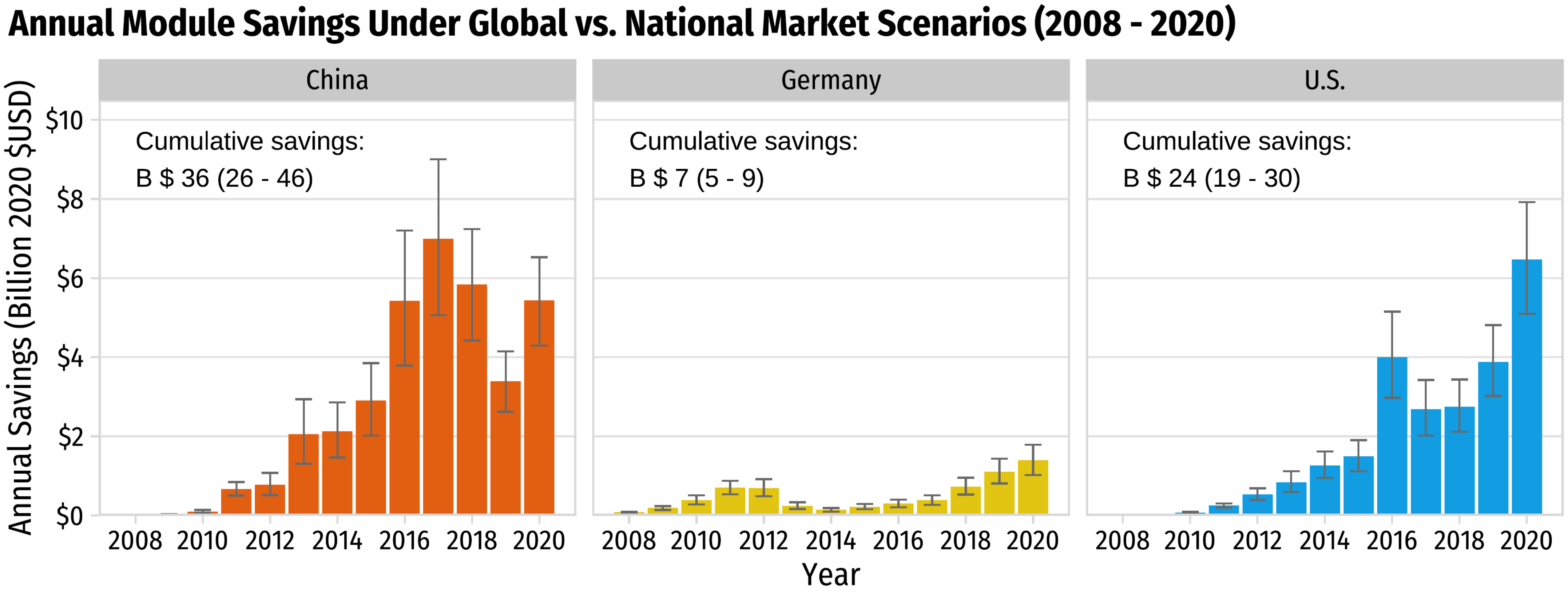
Estimated Module Prices Under Global vs. National Market Scenarios



Higher prices in 2020:

- 54% higher in China ($387 versus $250 per kW)
- 83% in higher Germany ($652 versus $357 per kW)
- 107% higher in the U.S. ($877 versus $424 per kW)

Total savings from global supply chains: $67 B ($50 - $84 B)

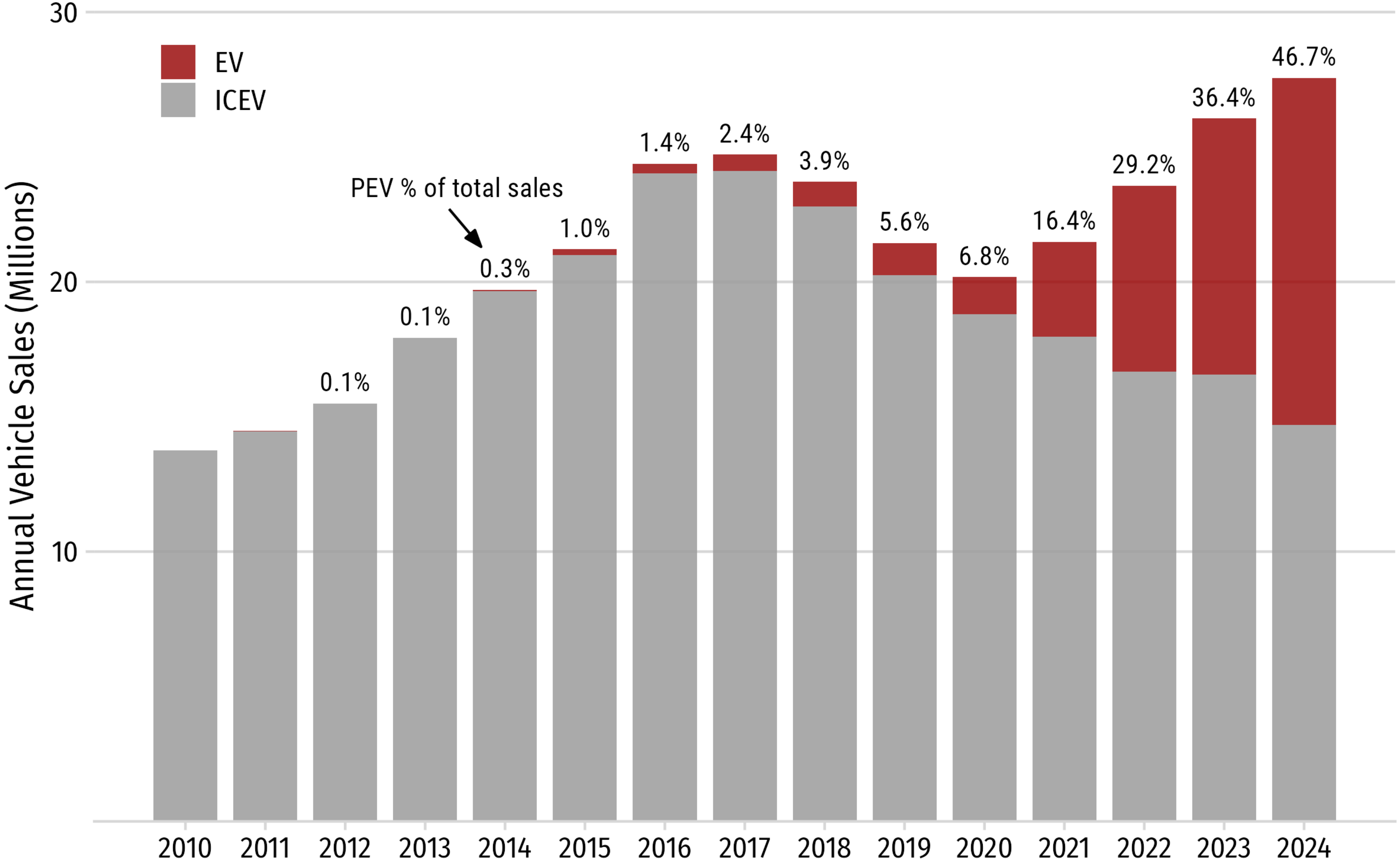


Helveston, J.P., He, G., & Davidson, M.R. (2022) "Quantifying the cost savings of global solar photovoltaic supply chains" *Nature*. 612 (7938), pg. 83-87. DOI: 10.1038/s41586-022-05316-6

Electric Vehicles

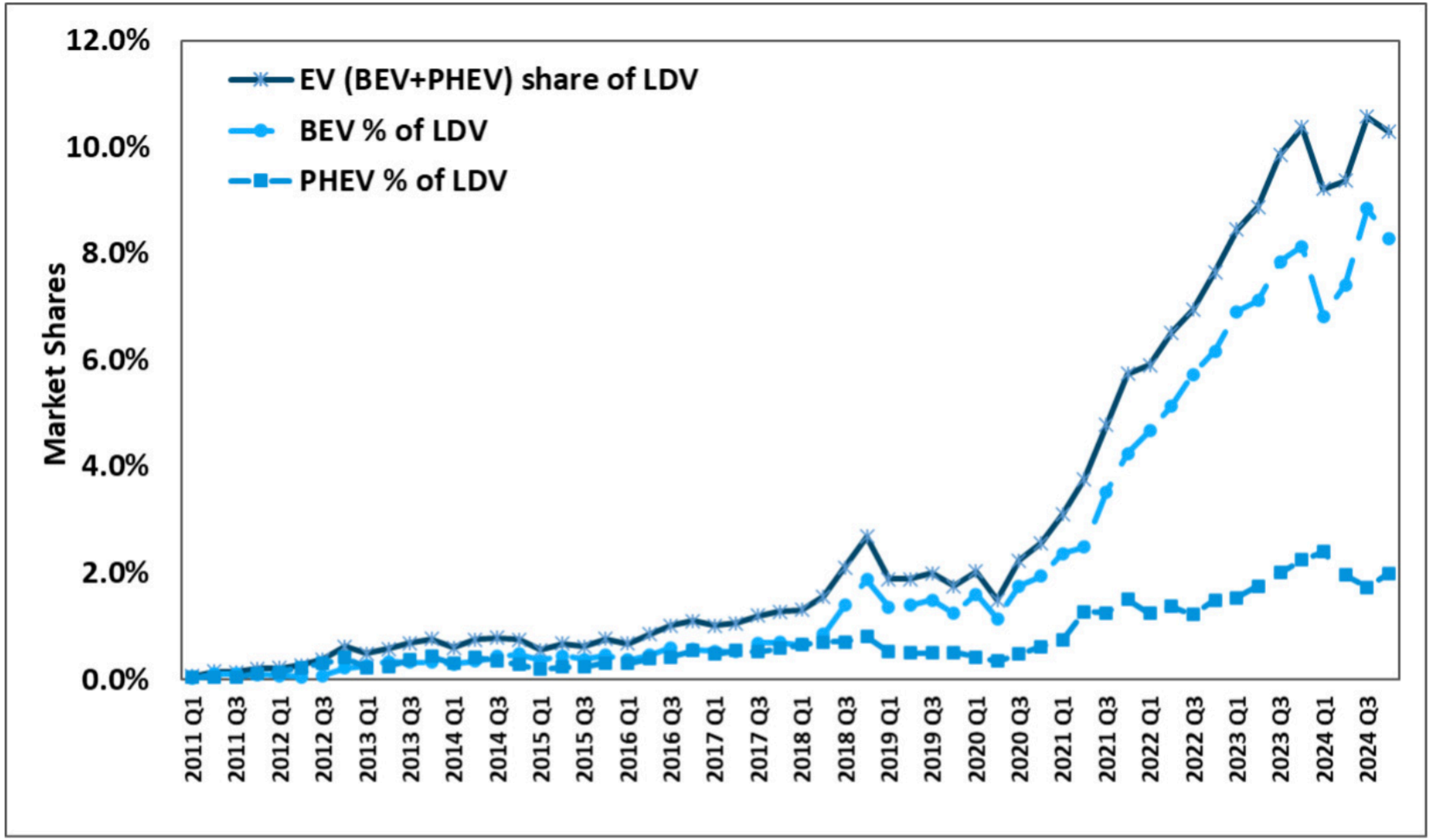
In China, PEV sales grow while ICEV sales slow

After peaking in 2017, internal combustion engine vehicle (ICEV) sales have declined for 7 straight years



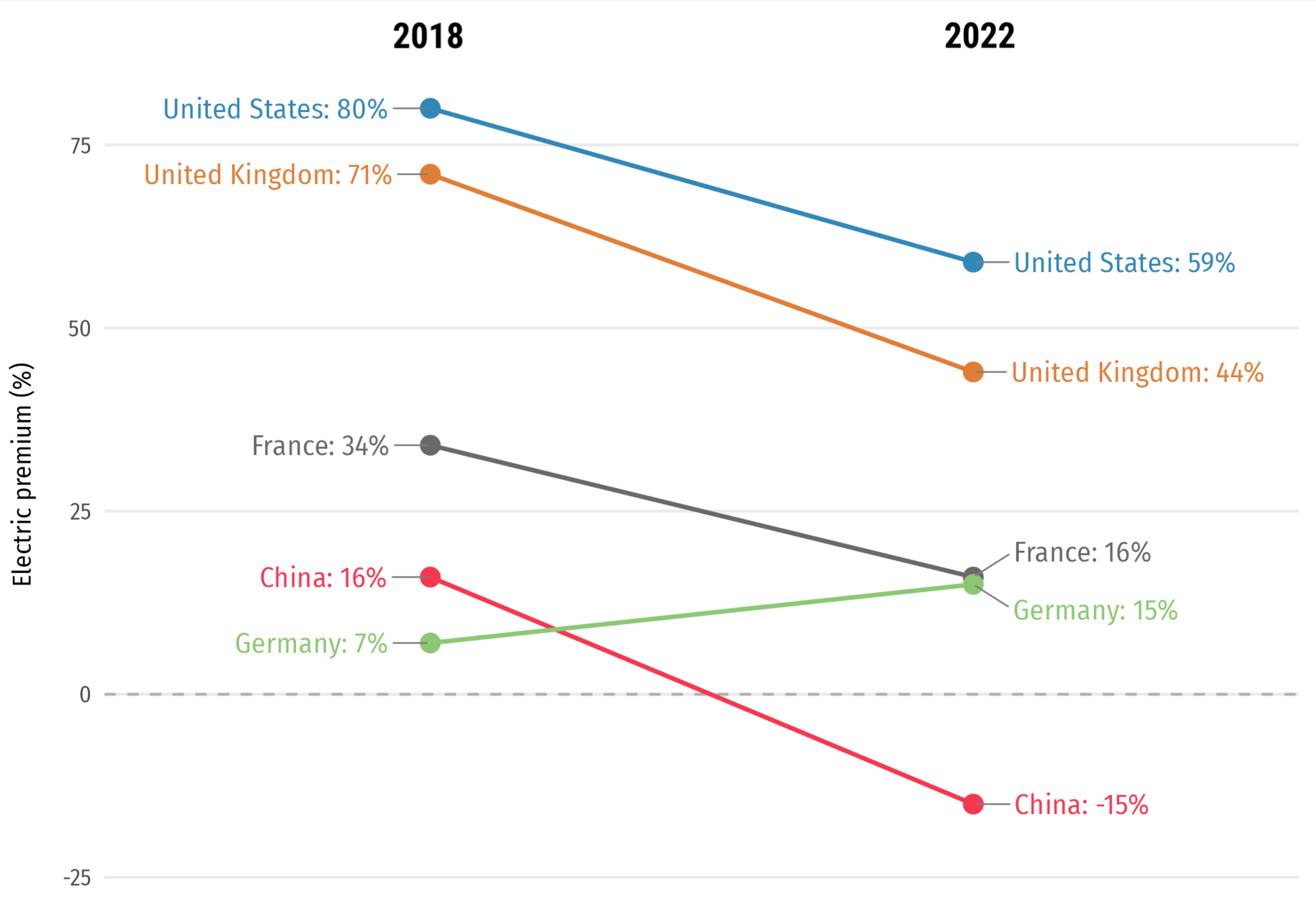
Data sources: OICA, marklines.com

EV sales in US reaching ~10% of sales



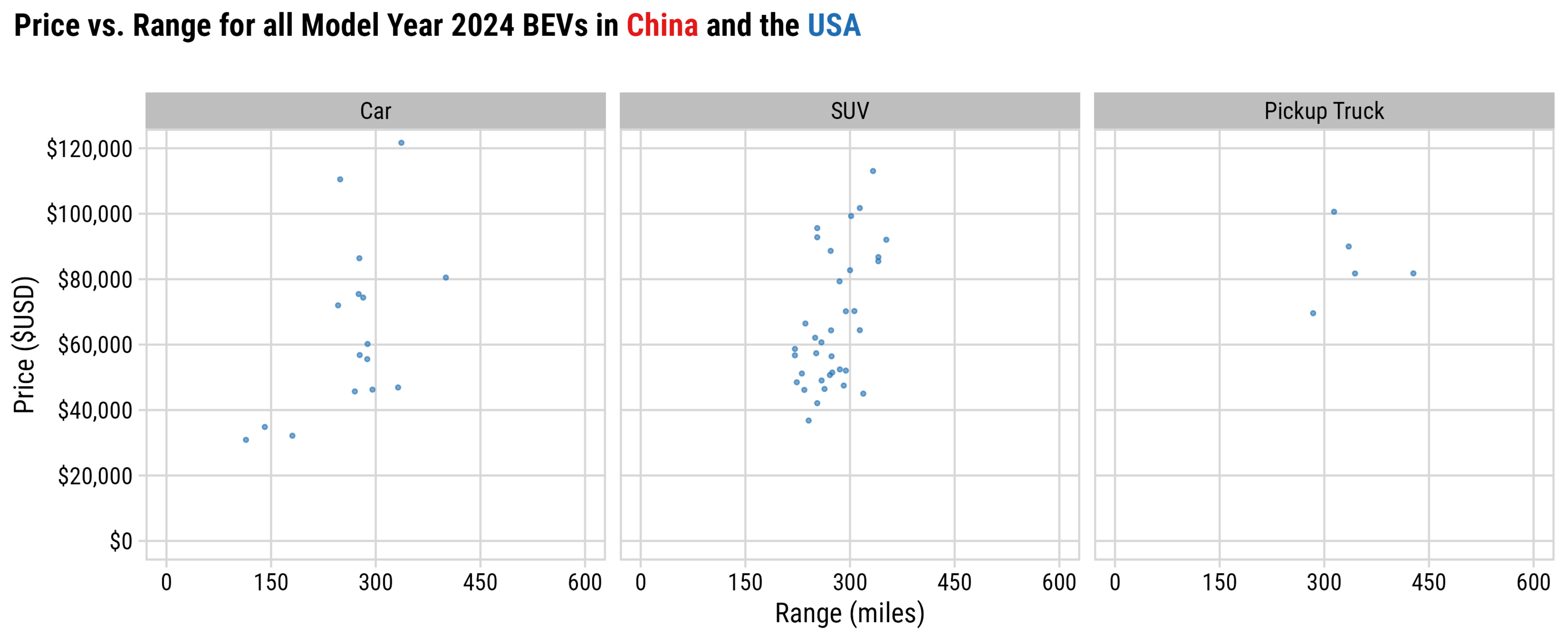
Source: Argonne National Lab, https://www.anl.gov/ev-facts/model-sales

The EV sector has an affordability problem (except in China)



Source: https://www.iea.org/reports/global-ev-outlook-2024/executive-summary

China offers more affordable BEVs across all range categories



Data scraped from autocango.com (China) and carsheet.io (USA)

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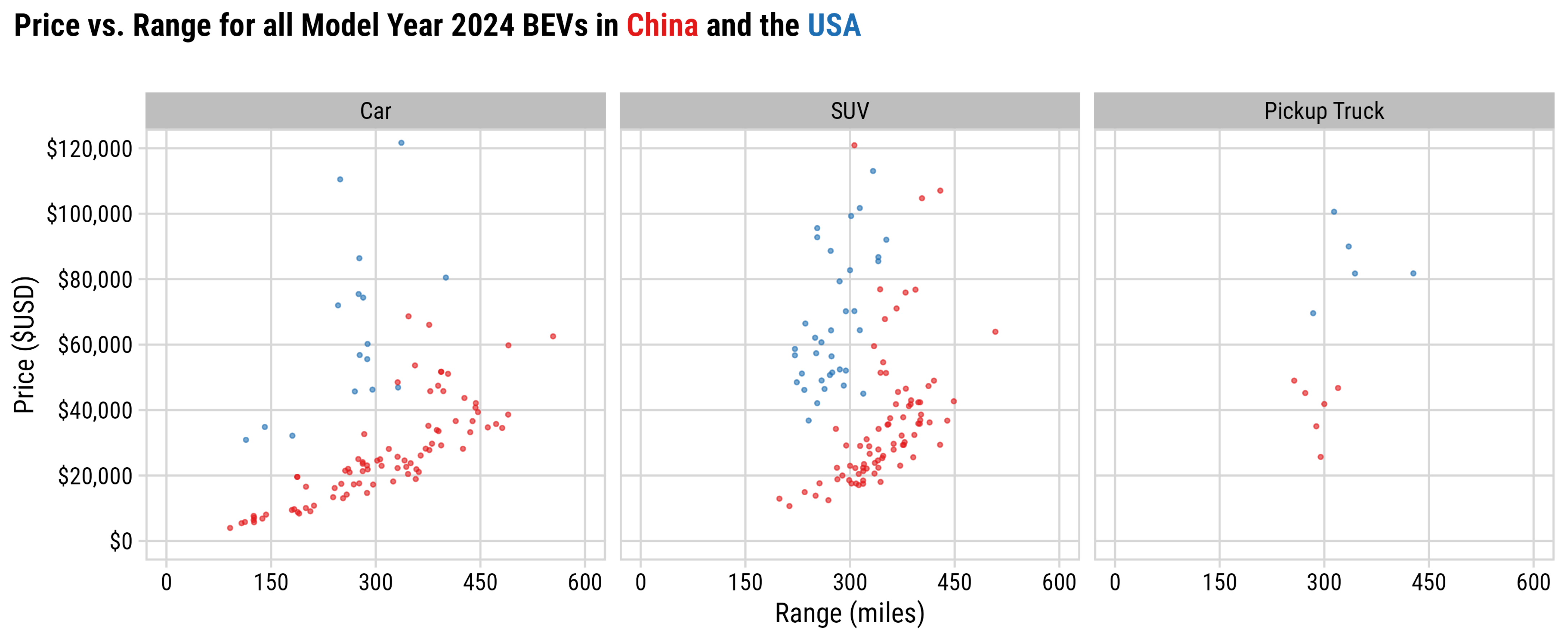

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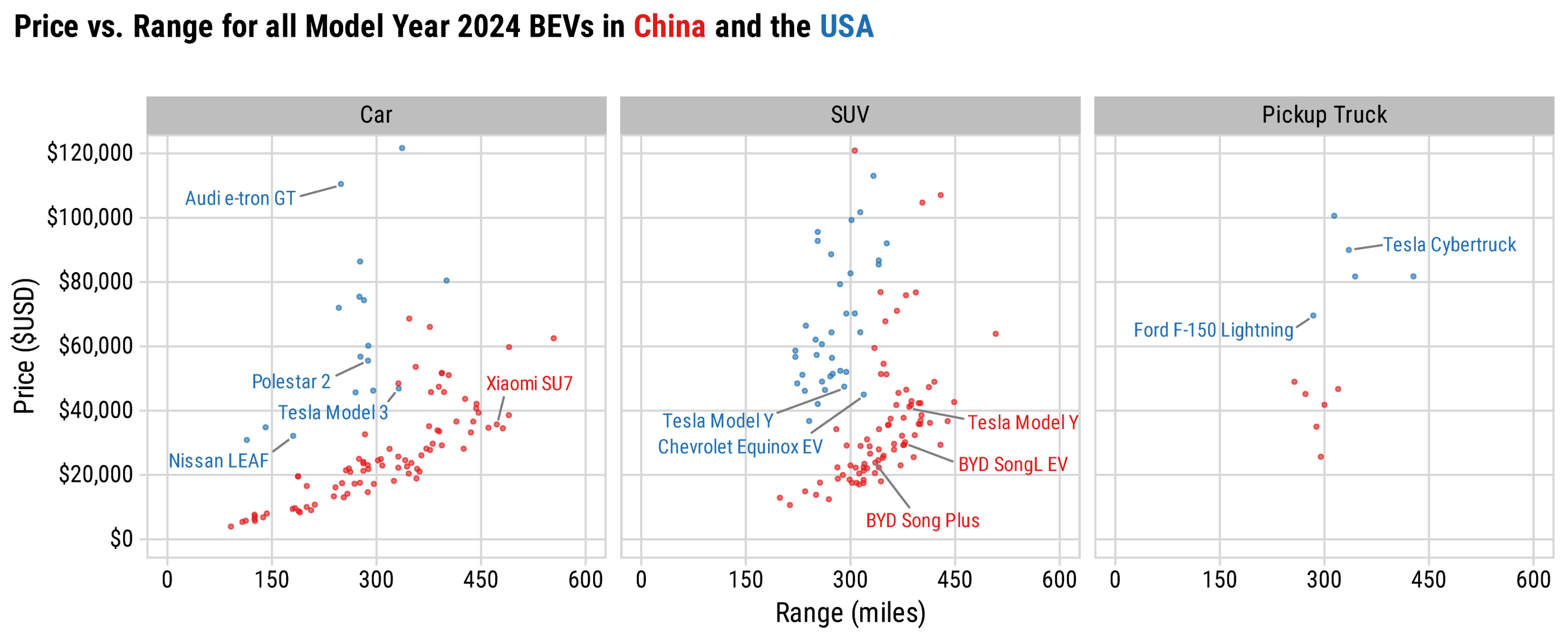

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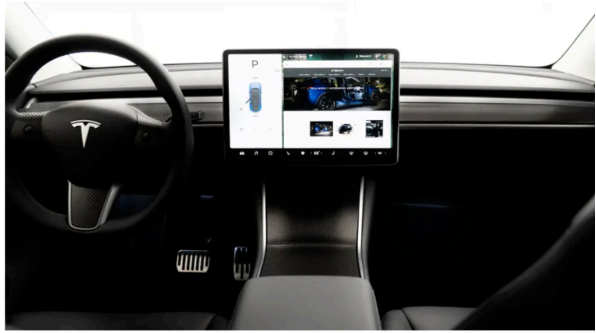
Top 4 Selling Vehicles in **China**

Xiaomi SU7
$30,171 - $41,909

BYD Song
$24,721 - $38,555

Geely Xingyuan
$ 9,615 - $13,667

Tesla Model Y
$36,822 - $43,809



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Top 4 Selling Vehicles in **USA**

Toyota RAV4
$29,250 - $38,955

Honda CRV
$30,100 - $41,100

Ford F-150
$44,095 - $79,005

Chevrolet Silverado
$42,700 - $70,000

Opportunities

Chinese FDI into U.S.

Gotion batteries: Multi-billion dollar investments in Illinois and Michigan

Challenge: Uncertainty around Foreign Entities of Concern (FEOC) status

Technology Licensing Agreements

Ford-CATL: Licensing battery technology in a Michigan plant

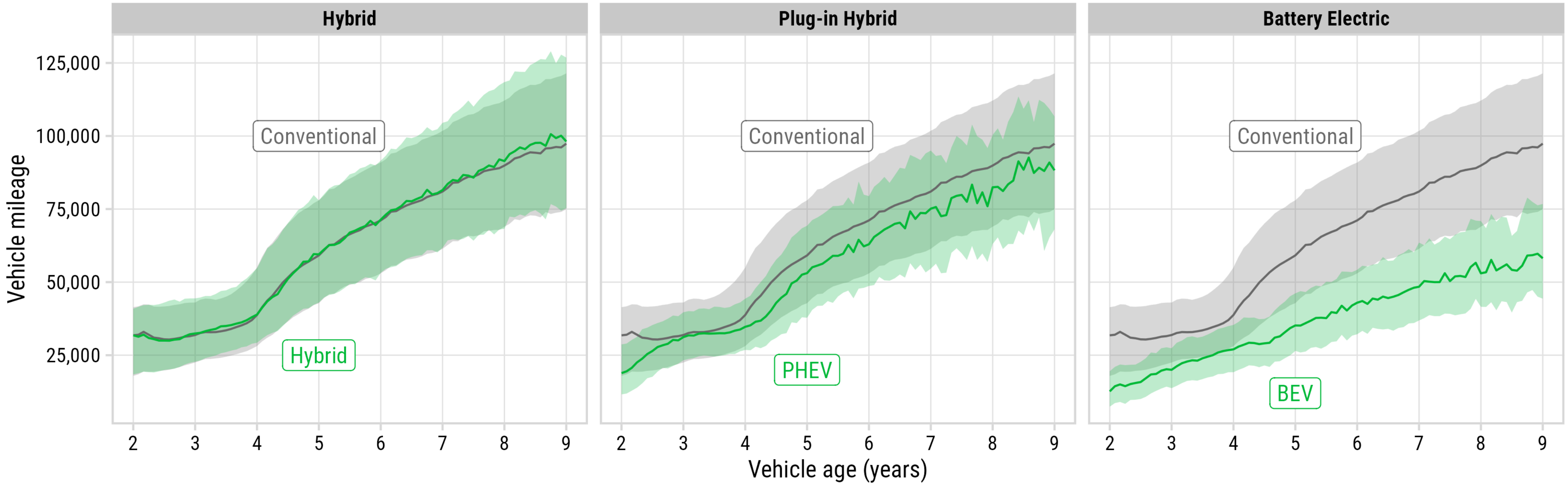
Challenge: CATL was recently added to DOD's list of “Chinese military companies”

Using vehicle listings to quantify EV market development

	Conventional	Hybrid	PHEV	BEV (Non-Tesla)	BEV (Tesla)*
NEW MARKET					
Cars					
Num. of Listings	14,420,855	915,753	135,909	376,838	–
Num. of Models	43	24	7	24	–
Num. of Dealerships	35,989	14,829	6,899	12,680	–
Mean price ($USD)**	$28,728	$34,540	$34,288	$56,920	–
SUVs					
Num. of Listings	29,336,054	1,178,677	199,081	970,210	–
Num. of Models	56	30	11	36	–
Num. of Dealerships	37,742	18,896	8,565	22,463	–
Mean price ($USD)	$37,363	$51,892	$59,286	$57,992	–
USED MARKET					
Cars					
Num. of Listings	28,375,192	1,445,274	219,472	288,909	312,840
Num. of Models	33	24	9	19	2
Num. of Dealerships	110,284	73,238	32,521	29,586	24,562
Mean age (years)	5	5.5	4.3	3.7	3.5
Mean price ($USD)	$17,274	$16,694	$21,322	$24,042	$38,937
SUVs					
Num. of Listings	30,453,021	466,813	22,526	137,053	141,277
Num. of Models	43	31	11	24	2
Num. of Dealerships	109,305	47,937	7,888	17,262	16,063
Mean age (years)	4.8	4.1	1.2	1.7	2.7
Mean price ($USD)	$22,616	$34,103	$44,667	$40,486	$49,380

*Since Tesla does not use a dealership model, we have no observations of new Tesla listings.
**Dollars are inflation-adjusted to 2019 U.S. dollars across all years.

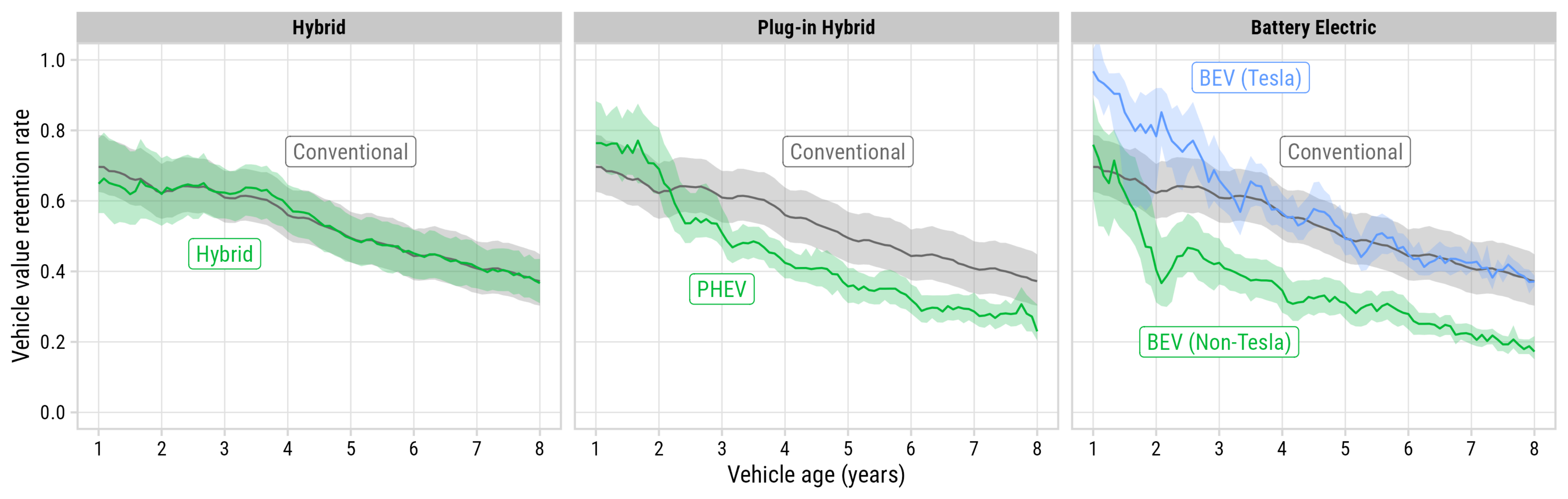
BEVs are driven significantly less than other powertrains



Roberson, Laura A., Pantha, S., & Helveston, J.P. (2024) "Battery-Powered Bargains? Assessing Electric Vehicle Resale Value in the United States" *Environmental Research Letters* DOI: 10.1088/1748-9326/ad3fce

BEVs & PHEVs are depreciating worse than CVs and HEVs

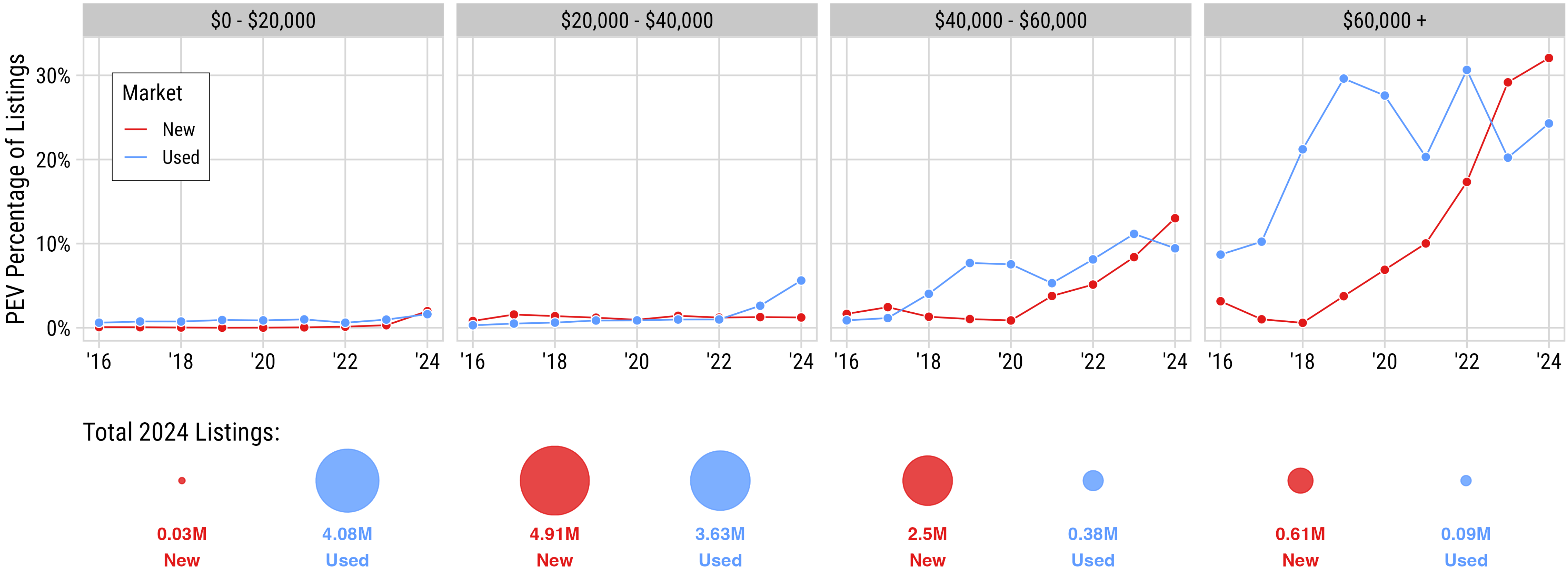
(Except Tesla)



Zhao, L., Ottinger, E., Yip, A., & Helveston, J.P. (2023) "Quantifying electric vehicle mileage in the United States" *Joule.* 7, 1–15. DOI: 10.1016/j.joule.2023.09.015

BEVs Concentrated in High-Price Segments in US

Only 1.2% of new and 3.5% of used listings under $40,000 were BEVs in 2024



The EV Deserts of America (2024)

Thanks!

https://jhelvy.com/slides

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Extra Slides

A Changing Political Reality

2000s Globalization

- Free flow of capital, talent, innovation
- Technology spillovers across borders

2010s Push Back Against Globalization

- Economic security concerns (manufacturing job loss)
- Competition with China

2020s Post-COVID Fragmentation

- Supply chain *resilience* becomes central
- Industrial policy competition
- Defense concerns ("Dual Use")

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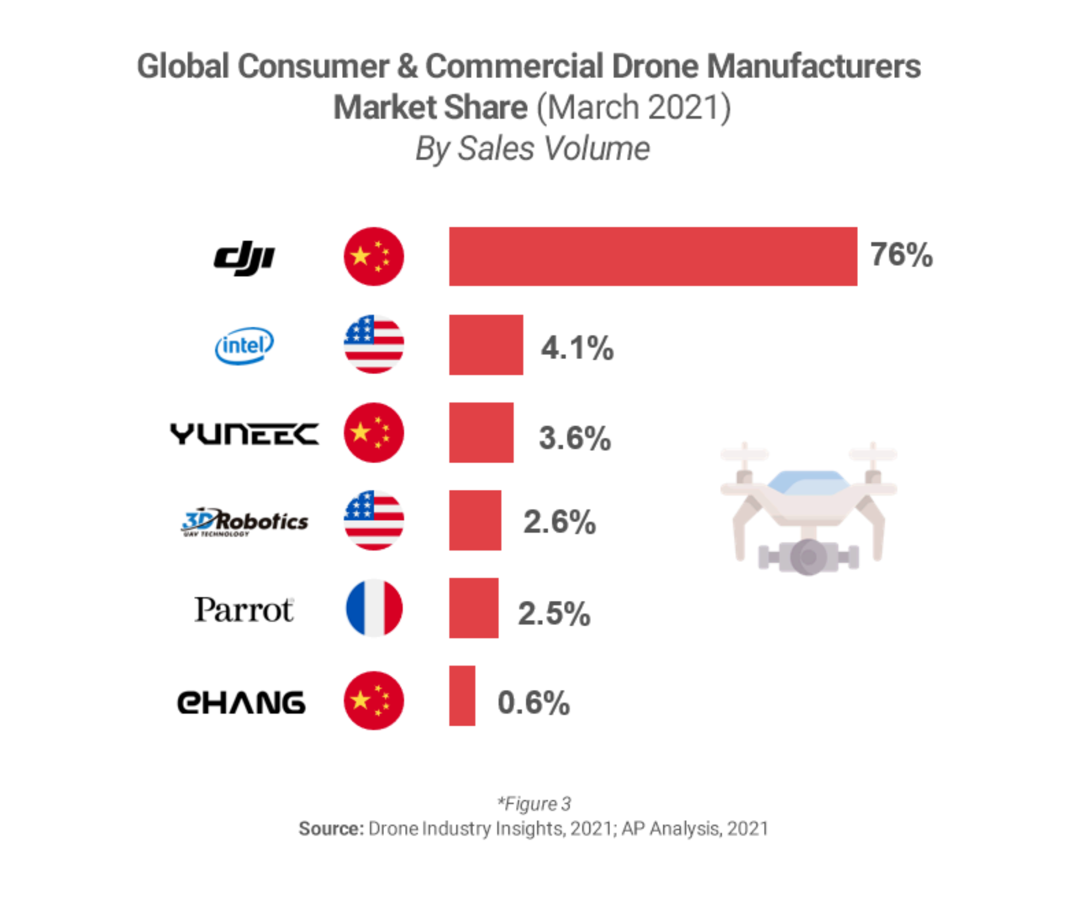
War in Ukraine

- Drones now a clear tactical advantage
- Reliance on Chinese supply now a defense issue

https://www.bbc.com/news/articles/ckgn47e5qyno



https://arc-group.com/china-thriving-drone-industry/

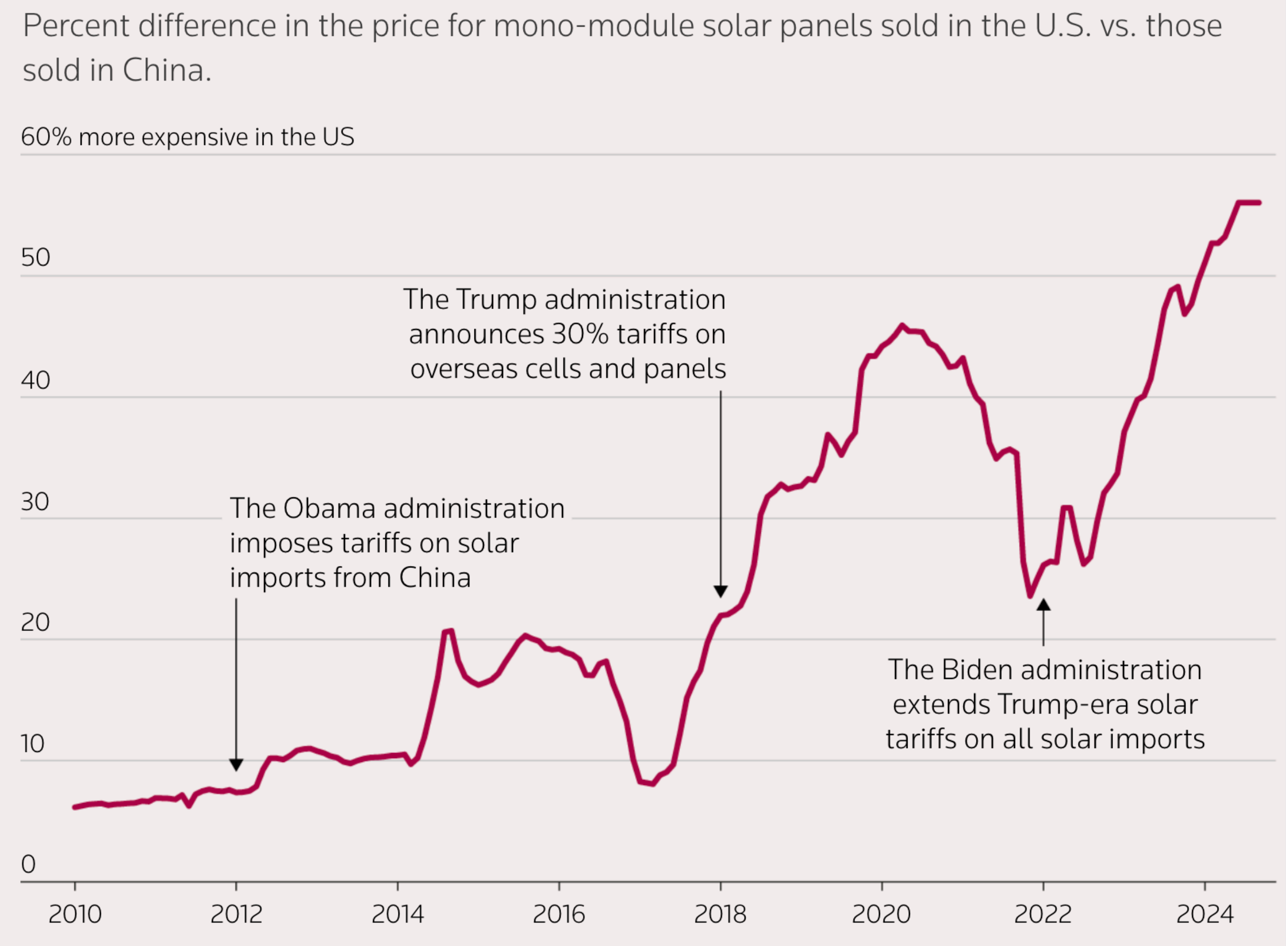
Shift from China to SE Asia (Transhipment)

Chinese firms still leading producers, but manufacturing shifts to SE Asia to skirt US tariffs

Source:
https://www.reuters.com/graphics/USA-CHINA/SOLAR-HISTORY/gdpzkdeqlvw/

Shift from China to SE Asia (Transhipment)

Solar prices in US are much higher than in China



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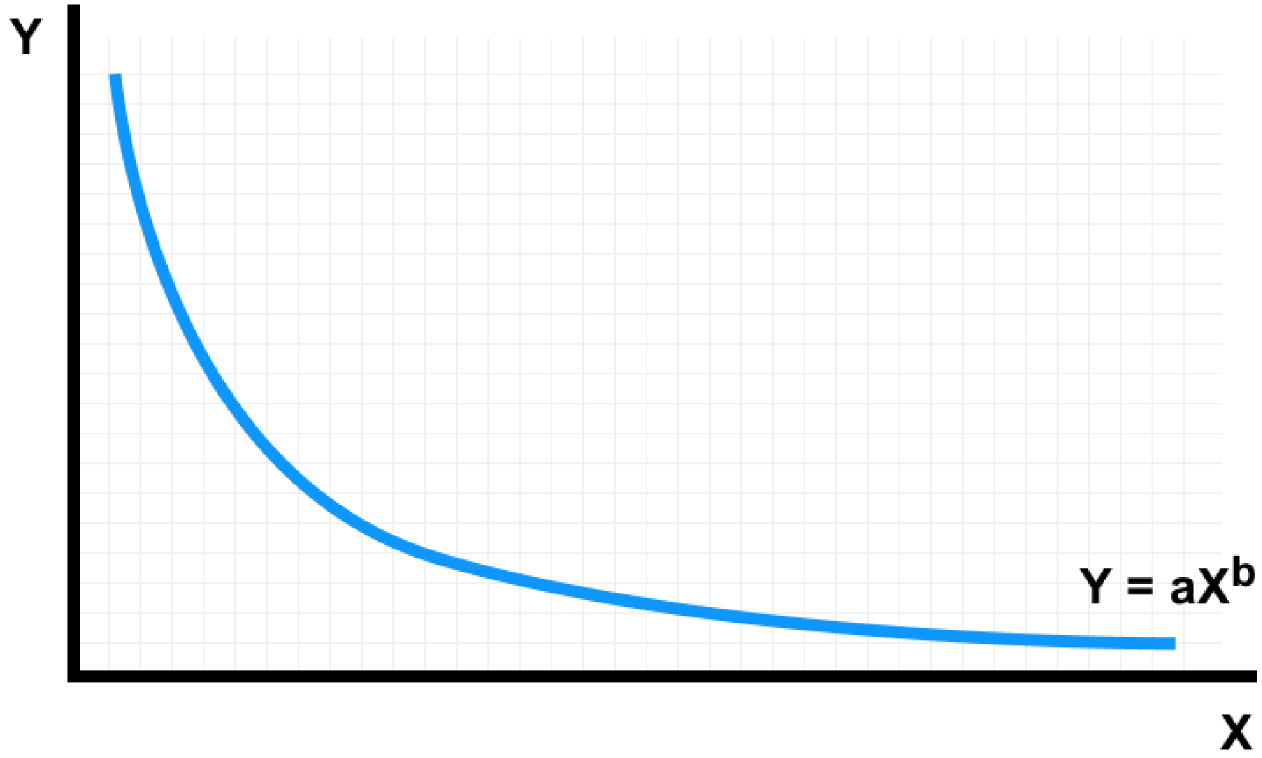
Learning curve model



In context of solar PV:

- X: Cumulative installed cap.
- Y: = Price per kW

Log transformation:

$$\ln Y = \ln a + b \ln X$$

Two-factor learning curve model:

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

price ($ / kW) = intercept + installed capacity + silicon price

for country *i* and year *t*

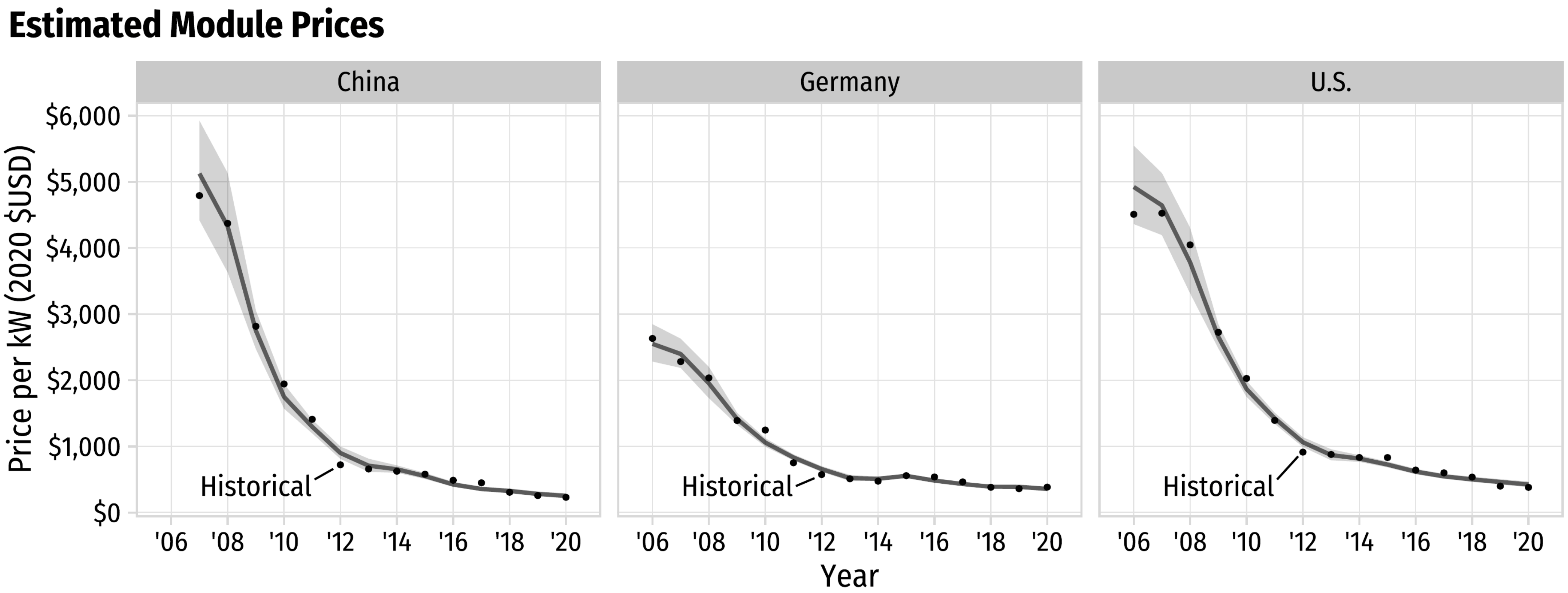
Two-factor learning curve model:

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

Learning rate:

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

U.S.: 26%; China: 33%; Germany: 20%



"National Markets" Counterfactual Scenario

Assumption: learning-related price decreases in country *i* in year *t* are derived from incrementally more nationally-installed PV capacity

$$q_t - q_{t-1} = (q_{it} - q_{it-1}) + (1 - \lambda_t)(q_{jt} - q_{jt-1})$$

$(q_{it} - q_{it-1})$: Amount installed in country *i*

$(q_{jt} - q_{jt-1})$: Amount installed in all other countries

$$q_t - q_{t-1} = (q_{it} - q_{it-1}) + (1 - \lambda_t)(q_{jt} - q_{jt-1})$$

Global markets

$$\lambda_t = 0$$

Capacity from all countries

$$(q_{it} - q_{it-1}) + (q_{jt} - q_{jt-1})$$

National markets

$$\lambda_t = 1$$

Capacity only from country *i*

$$(q_{it} - q_{it-1})$$

λ_t → 1 over 10-year period