# Mapping U.S.-China Technology Decoupling: Policies, Innovation, and Firm Performance

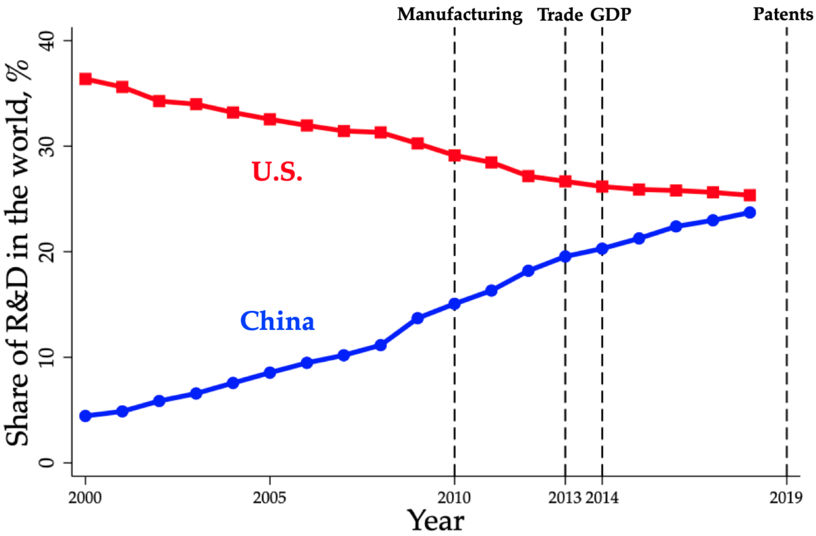
Pengfei Han
Guanghua School of Management, Peking University

Wei Jiang
Emory University, Goizueta Business School, NBER, and ECGI

Danqing Mei
Cheung Kong Graduate School of Business

August 23, 2022

# Reigning & Rising Powers in the 21st Century



# The Emerging Question: U.S.-China Technology Decoupling

- China’s technology benefited from integration, especially with the U.S.
- Technological trajectories have been closely aligned for a long time
- Recently, mutual distrust led to actions to unwind tech interdependence
- Decoupling: A process toward an increasing degree of separation

# Outline

- Tech Decoupling and Dependence: Measurement
- Tech Decoupling and Firm Performance
- Roles of Chinese Industrial Policies
- Roles of U.S. Sanctions Against China

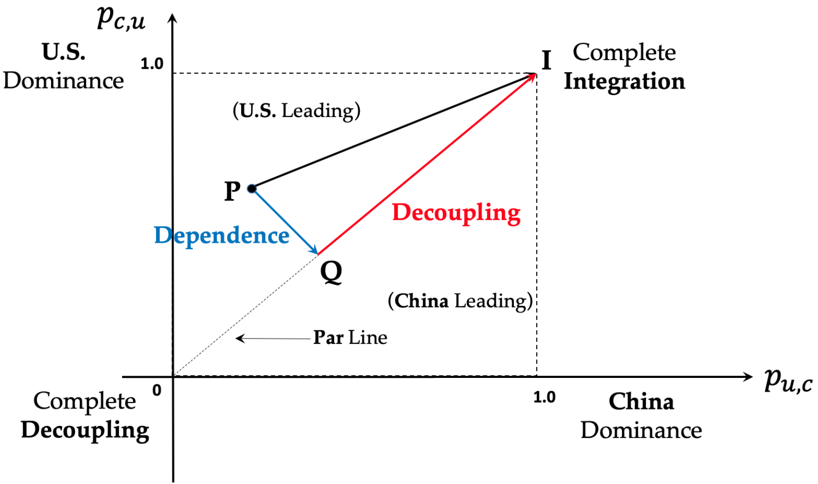
# Decoupling and Dependence:

## Measurement and Stylized Facts

# Patenting Processes in the U.S. and China

- Combine patent data from the patent offices in the U.S. and China
- Comparable three phases: Filing, examination, and granting
- Required to cite the prior art: Both domestic and foreign patents

# Measure of Technology Decoupling



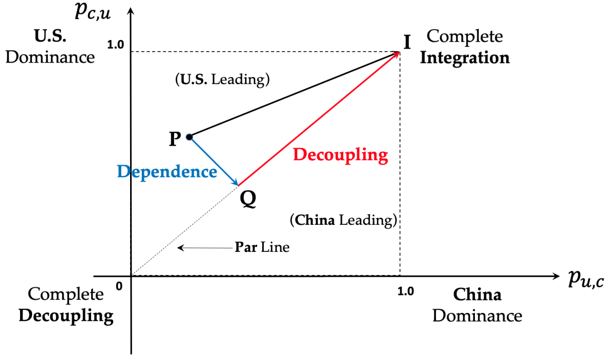

$p_{i,j}$: Propensity for country $i$ patents to cite $j$ patents relative to citing $i$ patents

# Technology Decoupling

$$\textbf{\textit{Decoupling}}(US \,\&\, CN) = 1 - \sqrt{(p_{u,c})^2 + (p_{c,u})^2} \times \cos\left(\theta - \frac{\pi}{4}\right) \times \frac{\sqrt{2}}{2}$$

$$\text{where } \theta = \begin{cases} \arctan\left(\frac{p_{c,u}}{p_{u,c}}\right) & \text{if } p_{u,c} \neq 0 \\ \frac{\pi}{2} & \text{if } p_{u,c} = 0 \end{cases}$$

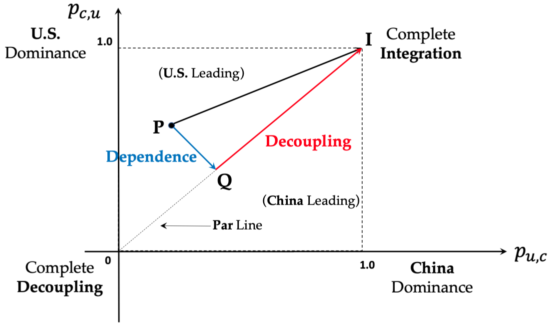
- Correspond to $||QI||$
- *Symmetric* between US and CN
- [0 (Integration), 1 (Decoupling)]



$$\textbf{\textit{Dependence}}(CN\text{-}US) = -\textbf{\textit{Dependence}}(US\text{-}CN) = \sqrt{(p_{u,c})^2 + (p_{c,u})^2} \times \sin\left(\theta - \frac{\pi}{4}\right) \times \sqrt{2}$$

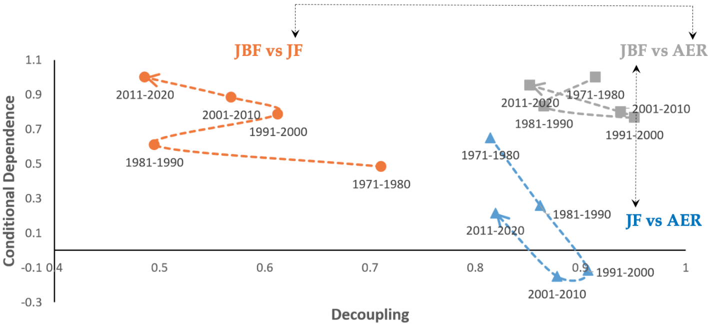
$$\text{where } \theta = \begin{cases} \arctan\left(\frac{p_{c,u}}{p_{u,c}}\right) & \text{if } p_{u,c} \neq 0 \\ \frac{\pi}{2} & \text{if } p_{u,c} = 0 \end{cases}$$

- Correspond to $\overrightarrow{QP}$
- *Asymmetric* between US and CN
- $+$ $(-)$ if US (CN)-leading
- [-1 (CN dominant), 1 (US dominant)]

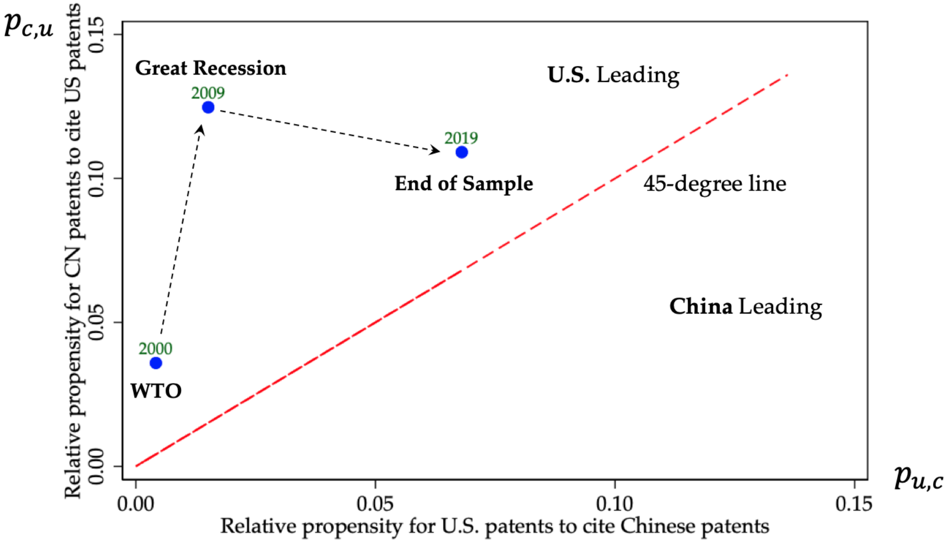


# A Digression: Validating the Measures with Academic Journals

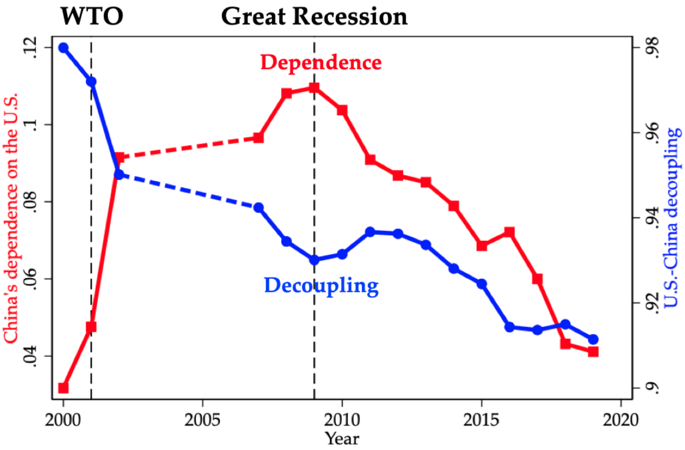
- *Journal of Finance (JF), Journal of Banking and Finance (JBF), American Economic Review (AER)*
- JBF is more integrated with JF than AER
- JBF depends more on AER than JF



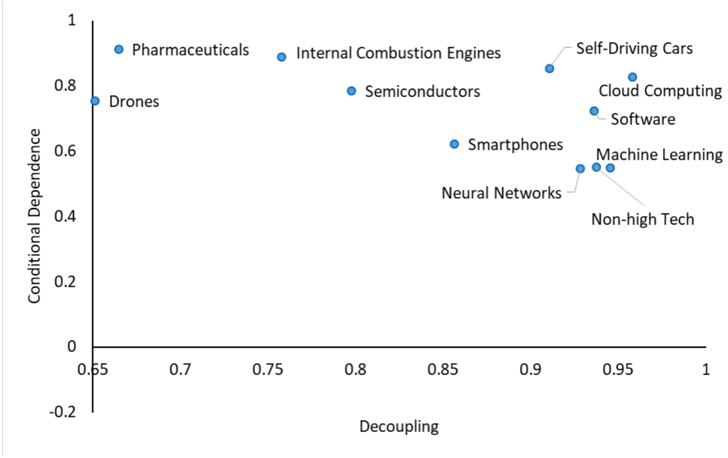
# History by Key Turning Points



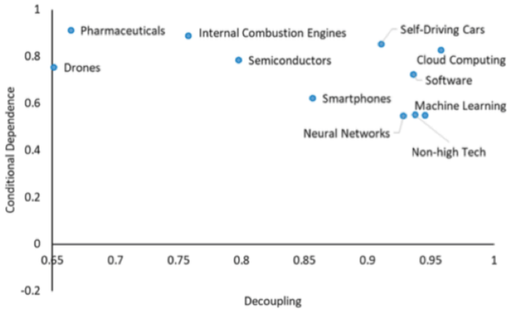
# Full History of Decoupling and Dependence



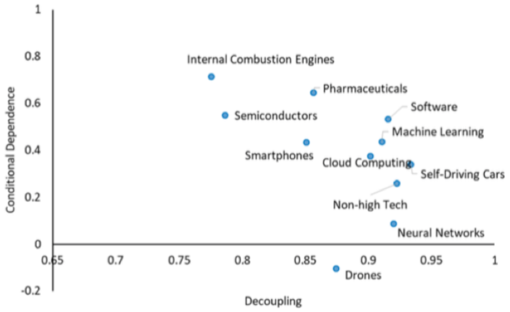
# Heterogeneity Across High-Tech Fields: 2015



# Heterogeneity Across High-Tech Fields: 2015 vs 2019




2015




2019

# Tech Decoupling and Firm Performance

# Tech Decoupling and Firm Innovation: Hypotheses

- Foreign technology: Complement for domestic innovation
  - Decoupling $\uparrow \rightarrow$ knowledge dissemination $\downarrow \rightarrow$ domestic innovation $\downarrow$
  - Complementarity effect
- Foreign technology: Substitute for domestic innovation
  - Decoupling $\uparrow \rightarrow$ reinvent the wheel $\rightarrow$ domestic innovation $\uparrow$
  - Substitution effect
- Impact more profound in the "follower" country

# Tech Decoupling and Performance of Chinese Firms

| | *Innovation Output* | *Innovation Quality* | *TFP* | *ROIC* | *Tobin's Q* |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| *Decoupling*, $t-1$ | 1.815*** | 0.568 | 0.122 | -0.0804* | -0.439** |
| | (0.586) | (0.679) | (0.141) | (0.0429) | (0.207) |
| *Decoupling*, $t-2/3$ | 0.811 | 0.733 | -0.330* | -0.00601 | 0.150 |
| | (0.726) | (0.799) | (0.188) | (0.0541) | (0.280) |
| Observations | 14,739 | 14,739 | 14,739 | 14,739 | 14,739 |
| Adjusted R-squared | 0.607 | 0.186 | 0.657 | 0.445 | 0.793 |
| Controls | Yes | Yes | Yes | Yes | Yes |
| Firm fixed effect | Yes | Yes | Yes | Yes | Yes |
| Year fixed effect | Yes | Yes | Yes | Yes | Yes |

- *Innovation Output*: $ln$(1+ # of patents)
- *Innovation Quality*: # of normalized citations
- *TFP*: $ln$(total factor productivity) (Ackerberg, Caves, and Frazer, 2015)
- *ROIC*: return on invested capital

# Tech Decoupling and Performance of Chinese Firms

- Decoupling $\uparrow \longleftrightarrow$ Patenting output $\uparrow$
  - Substitution effect > Complementarity effect
- Decoupling $\uparrow \longleftrightarrow$ Firm productivity, profitability, and valuation $\downarrow$
  - Efficiency loss due to ”reinventing the wheels”
- Hypothetically, decoupling $\uparrow$ by the actual change: 2000–2019 (7.4% of sample mean)
  - Patenting $\uparrow$ 12.4% one year later
  - ROIC $\downarrow$ 0.6 percentage points (7.6% of sample average) one year later
  - Tobin’s Q $\downarrow$ 3.0% one year later
  - TFP $\downarrow$ 2.3% over a horizon of two to three years

# Tech Decoupling and Performance of U.S. Firms

| | *Innovation Output* | *Innovation Quality* | *TFP* | *ROIC* | *Tobin's Q* |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| $Decoupling, t-1$ | 0.285 | -0.741 | -0.321 | 0.052 | 0.328 |
| | (0.593) | (0.755) | (0.237) | (0.189) | (0.205) |
| $Decoupling, t-2/3$ | -0.085 | -0.470 | -0.141 | -0.148 | -0.179 |
| | (0.344) | (0.504) | (0.124) | (0.095) | (0.121) |
| Observations | 13,884 | 13,884 | 13,884 | 13,884 | 13,884 |
| Adjusted R-squared | 0.85 | 0.34 | 0.79 | 0.60 | 0.71 |
| Controls | Yes | Yes | Yes | Yes | Yes |
| Firm fixed effect | Yes | Yes | Yes | Yes | Yes |
| Year fixed effect | Yes | Yes | Yes | Yes | Yes |

- Impact of tech decoupling on U.S. firms: No significant damage

# Role of Chinese Industrial Policies

# Have China's Industrial Policies Encouraged Decoupling?

- China's "Strategic Emerging Industries (SEI)" initiative of 2012
  - Seven high-tech sectors as strategic emerging industries
  - Front row of government support (e.g., R&D grant, talent recruiting)
  - Center stage of the ongoing debate on decoupling
- Narratives by the Obama and Trump administrations
  - "Self-sufficiency" by "domestic substitution of foreign technologies"

# SEI-Promotion Policy and Tech Decoupling/Dependence

- SEI-promotion policy: More tech integration with the U.S.
  - China's State Council (2010):

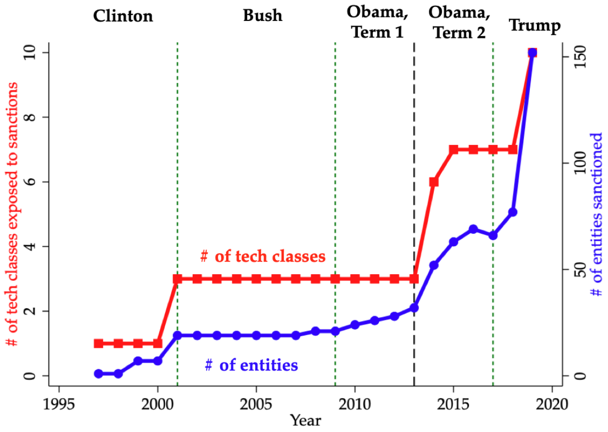
    *China "will vigorously enhance integrated innovation and actively participate in the international division of labor, and will strengthen the adoption, digestion, and absorption of foreign technologies, making full use of global innovation resources."*
- SEI-promotion policy: China's stronger tech independence
  - Consistent with the U.S. "self-sufficiency" narrative
  - Achieved by integration instead of decoupling

# Role of U.S. Sanctions Against China

# U.S. Sanctions Against China Imposed via the Entity List

- Issued by U.S. Department of Commerce's Bureau of Industry and Security
  - First entity list: Issued in 1997
  - Restrictions on the export, reexport and/or transfer (in-country) of specified items
- Technology classes exposed to U.S. sanctions
  - Chinese entities on the list are merged with the Chinese patent data
  - Each merged entity is associated with a unique technology class
  - A tech class is exposed to sanctions if some entities in this class are sanctioned

# Number of Entities and Tech Classes Exposed to U.S. Sanctions




- Nuclear technology
- Aerospace
- Supercomputers
- Communications technology
- Semiconductors
- Artificial intelligence

# U.S. Sanctions and Tech Decoupling/Dependence

- U.S. Sanctions
  - Did not lead to U.S.-China technology decoupling
    - U.S.-China trade: Soared by 4.6 times after China joined the WTO
    - Talent flows: 373,000 Chinese students (35% of all foreign students) in the US in 2019;
    - 4.9 million Chinese students completed studies overseas and 4.2 million returned
  - Spurred more independent technological development in China
- Government intervention
  - Integration-oriented intervention (China's SEI policy): Accelerated integration
  - Decoupling-oriented intervention (U.S. sanctions): Failed to reverse integration

# U.S. Sanctions: Network Spillovers

- Innovation network: Patent-citation-based input-output table
- U.S. Sanctions: Network spillovers and upstream-downstream asymmetries
- Sanctioning upstream: Tech integration in downstream and firm performance $\downarrow$
  - Innovation output, productivity, profitability, valuation $\downarrow$
  - Innovation input, efficiency, breakthrough, explorativeness, generality $\downarrow$
- Sanctioning downstream: Tech decoupling in upstream and firm performance $\uparrow$
  - Innovation output, productivity, profitability, valuation $\uparrow$
  - Innovation input $\uparrow$, breakthrough, explorativeness, generality $\uparrow$

# Policy Objectives of U.S. Sanctions: Non-Congruence

- Two policy objectives of U.S. sanctions
  - Decouple from China + Contain the Chinese firms
  - But an intrinsic **conflict**
- Sanctioning upstream: Firm performance $\downarrow$ in downstream but tech integration
- Sanctioning downstream: Tech decoupling in upstream but firm performance $\uparrow$

# Conclusion

- U.S.-China tech decoupling: Fierce debates $\leftrightarrow$ A paucity of empirical evidence
    - Combine patent data from the U.S. and China
    - Create novel measures of technology decoupling and dependence
    - Map out the current state and dynamics of tech competition and decoupling
- Impact of tech decoupling on Chinese firms vs. U.S. firms
- China's industrial policies and U.S. sanctions: Motives and consequences