Sabotage as Industrial Policy

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New Policies, Same Old Terms of Trade

> *...[T]echnology export controls can be more than just a preventative tool. If implemented in a way that is robust, durable, and comprehensive, they can be a new strategic asset in the U.S. and allied toolkit to impose costs on adversaries, and even over time degrade their battlefield capabilities.*
>
> — Jake Sullivan

- Sabotage: measures designed to lower foreign productivity
- Non-economic interests (e.g. National Security) are being run through trade policy
- We develop trade tools to understand the **economic consequences** of these actions

Policy Evaluation

- There is a policy debate about whether or not foreign productivity has been disrupted (Crosignani et al., 2024; Hsieh, 2024)
- **This Paper:** For domestic real income, what matters is not whether the program "works" but whether the destruction is comprehensive
  - Classic debate: are foreign productivity *improvements* good (Hicks, 1953; Jones & Ruffin, 2008) or bad (Gomory & Baumol, 2001; Samuelson, 2004)?
  - When targeted at the same goods:
    - Technology transfers: raise global efficiency and lower import price
    - Incomprehensive sabotage: lower global efficiency and raise import price
    - Comprehensive sabotage: relocation of production and ToT gains
  - Contrast with tariffs: for a large open economy, small tariffs better than no tariffs
  - Characterize the benefit from sabotage using a few sufficient statistics

Set-up (Dornbusch et al., 1977)

- **Environment:**
  - 2 countries: Home and Foreign (asterisked)
  - Continuum of goods indexed by i
  - Fixed labor supply, L and L^*, with mobile workers
  - Competitive firms
- **Demand:**
  - Cobb-Douglas with expenditure share: β_i
- **Technology:**
  - Unit labor requirements: a_i
  - Define *comparative advantage schedule* to be $A(i) = a_i^* / a_i$
  - Rank goods so that $A(i)$ is decreasing

Consumers source from the lowest cost producer:

$$m_i = \mathbf{1}\left(w^* a_i^* \leq w a_i\right)$$

- No additional trade costs (relaxed in quantification)
- Specialization is *complete*
  - All adjustments occur on the extensive margin
  - We relax this for quantification
- **Trade Policy:**
  - Planner can engage in targeted sabotage of Foreign TFP, a_i^*
  - Later, add tariffs and other trade instruments

1. Optimal sourcing: there is a cutoff good that determines production,

$$wa_\iota = w^* a_\iota^* \Rightarrow \underbrace{\frac{a_\iota^*}{a_\iota}}_{A(\iota)} = \underbrace{\frac{w}{w^*}}_{\equiv\omega}$$

2. Trade Balance:

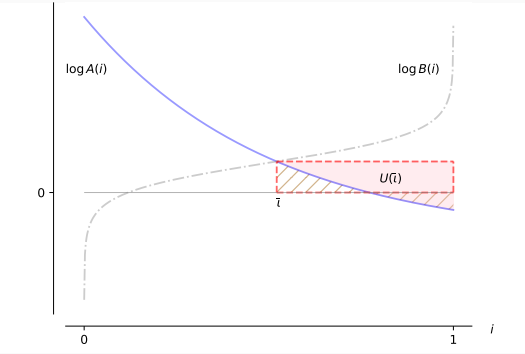
$$wL \times \int_\iota^1 \beta_i di = w^* L^* \times \int_0^\iota \beta_i di \Rightarrow \omega = \underbrace{\frac{L^* \times \int_0^\iota \beta_i di}{L \times \int_\iota^1 \beta_i di}}_{\equiv B(\iota)}$$

$\Rightarrow$ **Equilibrium is when** $A(\iota) = B(\iota)$

Graphical Illustration of Welfare Gains

$$U(\bar{\imath}) = \log A(\bar{\imath})(1 - \bar{\imath}) - \int_{\bar{\imath}}^{1} \log A(i)di$$

Figure 1: Equilibrium and Welfare Gains

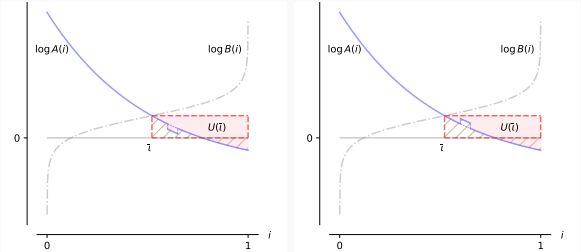


- Equilibrium is where $\log A = \log B$
- Rectangle between 0 and ω is the *Terms of Trade Effect*: change in relative wages
- Area under $\log A$ is the *Price Index Effect*: change in prices due to specialization
- Difference is Home's indirect utility, i.e. the gains from trade

Introducing Sabotage

Figure 2: Technology Transfer v Minor Sabotage

(a) Case I: Improvement **(b)** Case II: Decline



- **Sabotage:** For a small measure of goods, ε, the planner can shift Foreign productivity
- We do *not* consider optimal mass of sabotage, and we only consider "small" sabotage
  - Approximates targeted policies on specific goods—e.g., export controls on chips

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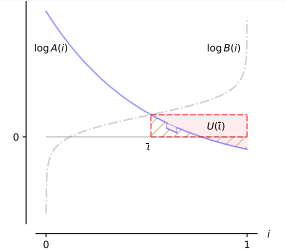
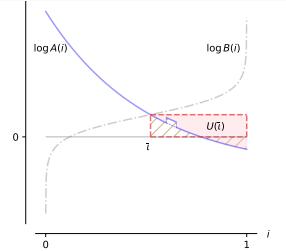


(b) Case II: Decline

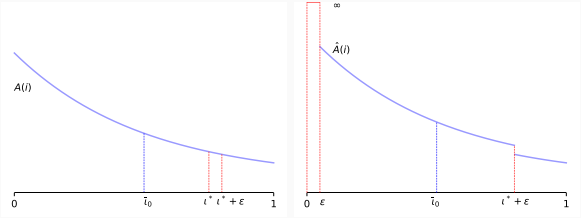


- **Sabotage:** For a small measure of goods, ε, the planner can shift Foreign productivity
- For small changes, sabotage is *bad*
- Compare to increases in productivity—which only lowers prices
- Key: for small changes, production patterns do not change

Comprehensive Sabotage

Figure 3: Comprehensive Sabotage

(a) Baseline **(b)** Sabotage



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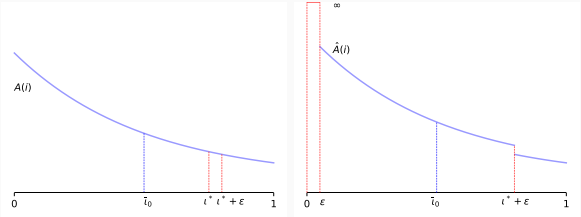

- If the reduction in foreign productivity is sufficiently large (e.g., $a_i^* \to \infty$) then production shifts
- $[\iota^*, \iota^* + \varepsilon)$ moves Home
- But some marginal goods shift to Foreign

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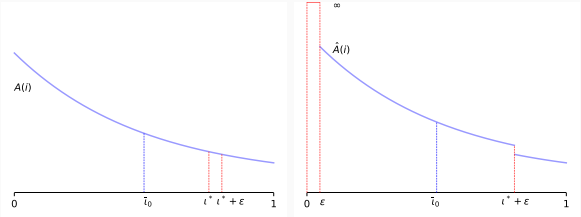
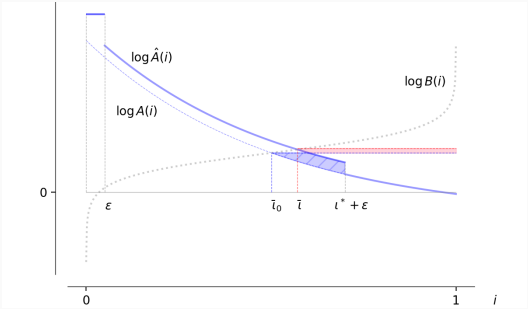


- If the reduction in foreign productivity is sufficiently large (e.g., $a_i^* \to \infty$) then production shifts
- $[\iota^*, \iota^* + \varepsilon)$ moves Home
- But some marginal goods shift to Foreign
- What happens to income?

Welfare Gains of Comprehensive Sabotage

Figure 4: Effects of Comprehensive Sabotage



- *Terms of Trade*: Red trapezoid is the **gain** in relative wage coming from Home's increase in relative TFP
- *Price Effect*: Blue area is the **loss** in efficiency due to reallocating goods out of line with initial comparative advantage

Proposition
To a first order approximation, the change in welfare is given by:

$$\Delta U = \underbrace{\epsilon}_{\text{Extent of Sabotage}} \times \left[\underbrace{\frac{1}{1+\theta}\frac{1}{1-\Phi_H}}_{\text{Sufficient Statistic}} - \underbrace{\log\left(\frac{A(\bar{\iota}-\epsilon)}{A(\iota^*+\epsilon)}\right)}_{\text{Efficiency Cost}} \right].$$

- Larger ι^*, larger efficiency distortion from shifting production
- Higher import share Φ_H, trade is more important, larger ToT gains
- Lower trade elasticity θ, increasing domestic prices is less distortionary

The Welfare Equation Expanded

$$\Delta U^S \approx \beta_{\iota^*}\epsilon \times \left[\underbrace{\Delta \frac{\frac{1-s_H}{s_H}\frac{m^*_{\iota^*}(1-m^*_{\iota^*})}{m_{\iota^*}(1-m_{\iota^*})-\Delta(1-m_{\iota^*}-m^*_{\iota^*})}+1}{1+\theta(1-\Phi_H)+\theta(1-\Phi_H\frac{s_H}{1-s_H})}}_{\text{ToT Gain}} - \underbrace{\frac{1}{\sigma_{\iota^*}-1}\log\left(1+\frac{\Delta}{1-m_{\iota^*}}\right)}_{\text{Efficiency Cost}} \right]$$

- In the paper we expand our formula for three realistic features of the data:
  1. Variable expenditure shares $\Rightarrow$ need expenditure share on sabotaged goods, β_{ι^*}
  2. Trade Costs $\Rightarrow$ need to know Home's share of global output, s_H. A large open economy already enjoys a favorable ToT, so the room for improvement is small.
  3. Incomplete specialization $\Rightarrow$ need EoS, σ_{ι^*}, and good-level trade shares, $m_{\iota^*}, m^*_{\iota^*}$
- $\Delta \equiv [m_{\iota^*+\epsilon}(1) - m_{\iota^*+\epsilon}(z)]$: fraction of production reshored

The Welfare Equation Expanded

$$\Delta U^S \approx \beta_{\iota^*}\epsilon \times \left[\underbrace{\Delta \frac{\frac{1-s_H}{s_H}\frac{m^*_{\iota^*}(1-m^*_{\iota^*})}{m_{\iota^*}(1-m_{\iota^*})-\Delta(1-m_{\iota^*}-m^*_{\iota^*})}+1}{1+\theta(1-\Phi_H)+\theta(1-\Phi_H\frac{s_H}{1-s_H})}}_{\text{ToT Gain}} - \underbrace{\frac{1}{\sigma_{\iota^*}-1}\log\left(1+\frac{\Delta}{1-m_{\iota^*}}\right)}_{\text{Efficiency Cost}} \right]$$

- Intuition for each term:
  - The ToT Gain depends only on aggregate sufficient statistics that describe the shape of A and B near the initial equilibrium $\bar{\iota}_0$
  - The efficiency cost is local to the products subject to sabotage

Corollary (Policy Regions)
Suppose sabotaging the worst product lowers Home's real income and the technology transfer is not too large, i.e. $-\log z < \frac{1}{\bar{\iota}_0 + \frac{\eta(\bar{\iota}_0)}{1-\bar{\iota}_0}} < \log \frac{A(\bar{\iota}_0)}{A(1)}$. *There exist two critical goods,* $\hat{\iota}_1$ *and* $\hat{\iota}_2$*, such that:*

- *For* $\iota^* \in (\bar{\iota}_0, \hat{\iota}_2)$, $\Delta U^S(\iota^*, \epsilon) > \Delta U^T(\iota^*, \epsilon) > 0$ ***(Region I)***.
  Sabotage dominates tech transfer
- *For* $\iota^* \in (\hat{\iota}_2, \hat{\iota}_1)$, $\Delta U^T(\iota^*, \epsilon) > \Delta U^S(\iota^*, \epsilon) > 0$. ***(Region II)***.
  Sabotage dominates doing nothing
- *For* $\iota^* \in (\hat{\iota}_1, 1)$, $\Delta U^T(\iota^*, \epsilon) > 0 > \Delta U^S(\iota^*, \epsilon)$. ***(Region III)***.
  Sabotage is always bad

There always exist products for which comprehensive sabotage is good

Is Sabotage Still Useful When Standard Tools Are Available?

- When policy makers have access to **tariffs**
  - Optimal tariff in classic Ricardian world is uniform (Costinot et al., 2015)
  - Under initial optimal tariff, the planner would still like access to sabotage
- When policy makers have access to **unrestricted trade instruments**
  - Optimal allocation achieved with no tariffs and export taxes that leave Foreign indifferent between buying from Home and themselves (Costinot et al., 2015)
  - With flexible export taxes, sabotage is beneficial if the original tax revenue can be maintained, which is feasible when A is not too steep around the initial cutoff

Implementing Sabotage Through Export Controls

- Production requires a critical input m owned only by Home:

$$y_i = \left(\frac{l_i}{\alpha a_i^j} \right)^{\alpha} \left(\frac{m_i}{1-\alpha} \right)^{1-\alpha}$$

- Utility change from free trade to export controls of m:

$$\underbrace{(1-\iota_S)\frac{d\log\omega_S}{d\epsilon} - \log\frac{A(\iota_0)}{A(\iota^*)}}_{\text{Sabotage}} + \underbrace{(1-\alpha)\log\frac{A(\iota_0)}{A(\iota^*)}}_{\text{Labor Saving}} - \underbrace{(1-\iota_F)\frac{d\log\omega_F}{d\epsilon}}_{\text{Cost of Export Controls}}$$

- Export controls are isomorphic to comprehensive sabotage, scaled by α
  - Returns to export controls are highest for goods like rare earths: inputs with low cost shares but without which downstream production is impossible

Empirics

Two empirical exercises

1. Sabotage across industries
   - Let β reflect a collection of goods that comprise an “industry."
   - For each industry, we can estimate the costs and benefit of “completely sabotaging" a product, $\Delta = m_{\iota^*}$
   - $\beta\epsilon$ is share of products fully reshored

2. CHIPS Act
   - We focus on one very narrow set of goods, semiconductors (NAICS 334413)
   - Treat $\beta\epsilon$ as the full industry, and vary Δ as the fraction of chips production reshored

Calibration

Variable	Description	Value	Source
s_H	US Share of Global Output	.23	WIOD
Φ_H	US Share of Imports in Gross Output	.08	WIOD
m_{ι^*}	Foreign Share in US Consumption	Various	WIOD
$m^*_{\iota^*}$	US Share in Foreign Consumption	Various	WIOD
θ	Trade Elasticity	2/4	Boehm et al. (2023)
			Simonovska & Waugh (2014)
σ_{ι^*}	Goods level EoS	Various	BEA using
			Gervais and Jensen (2019)

Table 1: Effects of Sabotage at $\theta = 2.0$

Industry	ToT Gain	Efficiency Cost	Net
Other non-metallic mineral products	0.73	0.07	0.66
Fabricated metal products	0.72	0.06	0.66
Paper and paper products	0.71	0.06	0.65
Wood, and products of wood and cork	0.72	0.09	0.64
Food products, beverages, and tobacco products	0.71	0.06	0.64
Rubber and plastic products	0.73	0.09	0.63
Furniture; other manufacturing	0.73	0.13	0.61
Other transport equipment	0.65	0.04	0.61
Basic metals	0.75	0.16	0.59
Electrical equipment	0.79	0.21	0.58
Computer, electronic, and optical products	0.78	0.22	0.56
Motor vehicles, trailers, and semi-trailers	0.75	0.22	0.53
Textiles, wearing apparel, and leather products	0.83	0.33	0.50
Chemicals and chemical products	0.72	0.25	0.47
Mining and quarrying	0.75	0.29	0.46
Coke and refined petroleum products	0.69	0.32	0.37
Pharmaceutical products	0.72	0.35	0.37

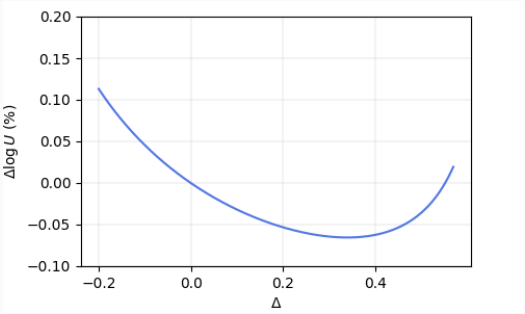
- Net = elasticity of reshoring 1% of goods
- Little variation in ToT, which is predominantly a function of aggregate characteristics
- Cost variation driven by EoS and revealed relative cost

CHIPS Data + Brief Policy Discussion

- CHIPS Act and related actions have at least two flavors of sabotage:
  1. US convinced allies to ban critical imports to China (similar tactics have been used by other countries for other reasons)
  2. US barred Americans from working for Chinese companies producing certain products
- Semiconductors (NAICS 334413) is too disaggregated for WIOD
  - BEA and Grossman, Blevins and Sutter (2023): total share of semiconductors in consumption is 0.5%; US imports 57% of chips from abroad; RoW imports 9% from the US
  - EoS from Jones et al. (2023)

Gains from Sabotaging Foreign Chips

Figure 5: Gains From Sabotaging Foreign Chips



- Negative Δ is technology transfer—raises welfare
- Most sabotage *lowers* real income
- Comprehensive sabotage *raises* real income
  - Is this realistic? RoW is much larger than just China and includes many allies
- A partially effective program is worse than none at all

Conclusion

1. Sabotage needs to be comprehensive to be beneficial
2. There always exist products for which comprehensive sabotage is good
3. Sabotage is useful when tariff is available, and can be useful when unrestricted instruments is available
4. The DFS framework with trade costs, variable demands, and intra-industry trade is tractable: the benefit of sabotage can be calculated using readily available data
5. Plenty of room for the future: modeling the exact mechanisms of sabotage, adding “allied" trading partners, dynamics and economies of scale

References

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