Supply Chain Resilience: Should Policy Promote Diversification or Reshoring?

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The New (Ab)Normal: Supply Chain Disruptions

- Japanese earthquake and tsunami, 2011
- Thai floods, 2011
- Pandemic, e.g., shortages of toilet paper, pork, shipping containers
- Ever Given vessel blocks Suez Canal
- Semi-conductors, plastics, lumber, copper wire
- Texas power outage, Colonial pipeline
- Russia-Ukraine War: wheat, fertilizer

Executive Order on America's Supply Chains

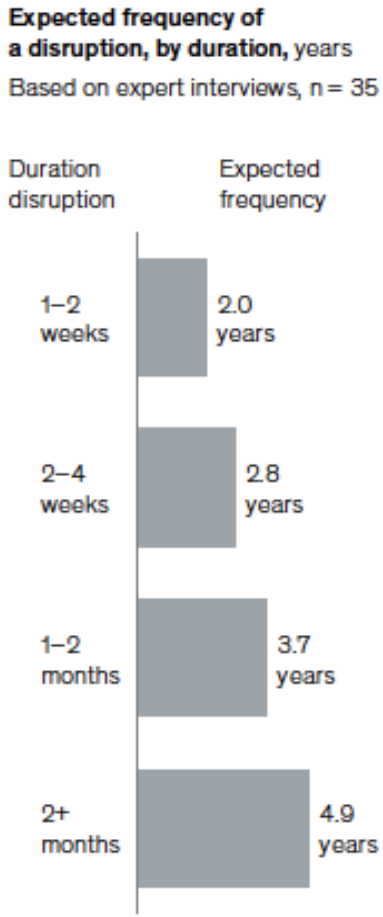
FEBRUARY 24, 2021 • PRESIDENTIAL ACTIONS

By the authority vested in me as President by the Constitution and the laws of the United States of America, it is hereby ordered as follows:

Section 1. Policy. The United States needs resilient, diverse, and secure supply chains to ensure our economic prosperity and national security. Pandemics and other biological threats, cyber-attacks, climate shocks and extreme weather events, terrorist attacks, geopolitical and economic competition, and other conditions can reduce critical manufacturing capacity and the availability and integrity of critical goods, products, and services. Resilient American supply chains will revitalize and rebuild domestic manufacturing capacity, maintain America's competitive edge in research and development, and create well-paying jobs.

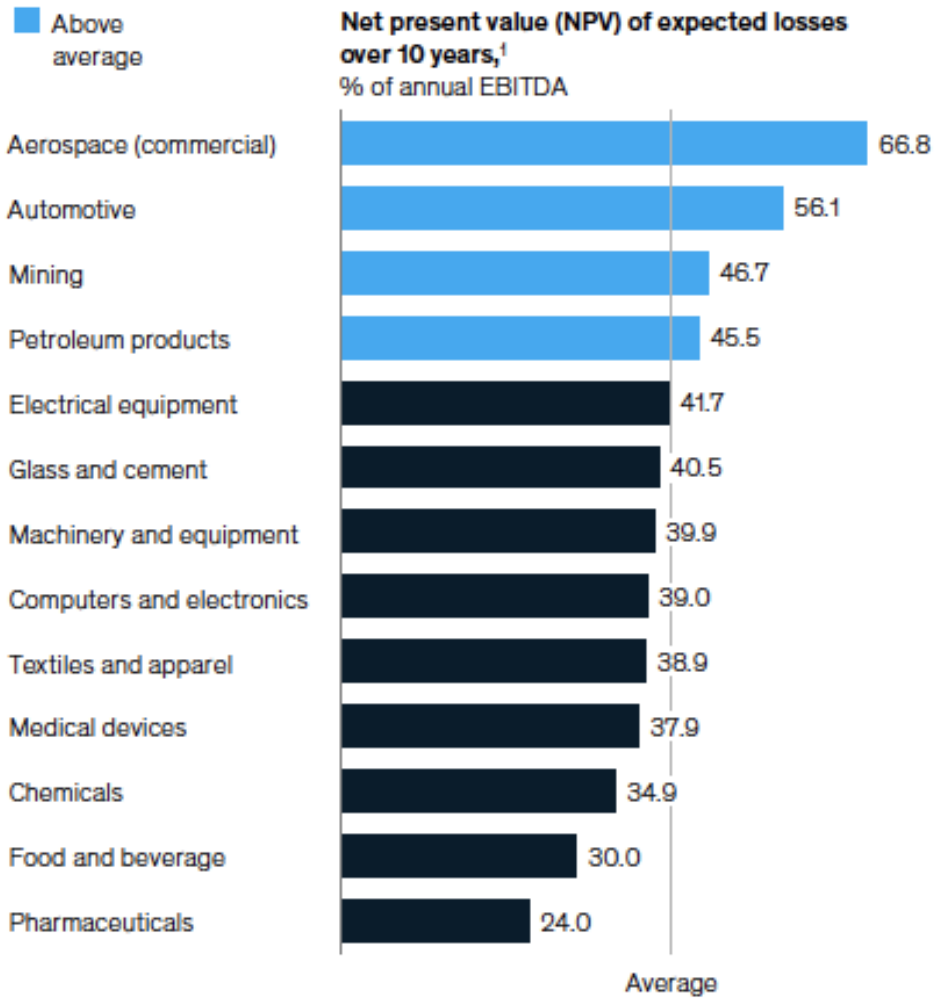
Frequency of Disruptions

Source: McKinsey Global Institute (2020).



Cost of Disruptions

EBITDA: earnings before interest, taxes, depreciation and amortization. Source: McKinsey Global Institute (2020).



This Paper

- Not much known about optimal policy toward supply chains
  - Of course, resilience brings social benefits; but also costly
  - Do private and social incentives for safety and resilience differ?
- Develop simple analytical framework to study optimal policy when there is a risk of supply chain disruption:
  1. Should policy promote diversification of supply chains in multiple countries?

     and/or
  2. Should policy promote reshoring of supply chains when foreign sources are riskier than domestic sources?

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- Continuum of firms of measure one that produce nontraded differentiated products
- Output of each good requires a single, customized critical input

$$x(\omega) = m(\omega)$$

where per unit cost of input from country i is q_i, $q_F \leq q_H$

  - Could allow additional factors and more complex production function
  - Could allow longer or more complex supply chains
  - Could allow multiple periods, inventories, stockpiling

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- Sourcing Options:
  - If a firm invests in a single relationship in country i, it can produce with probability $\gamma_i\rho$ at unit cost q_i and not at all with probability $(1-\gamma_i\rho)$
  - If a firm invests in two relationships, one in each country, it can produce with unit cost q_F with probability $\gamma_F\rho$, with unit cost q_H with probability $\gamma_H\rho\left(1-\gamma_f\rho\right)$, and not at all with probability $\left(1-\gamma_H\rho\right)\left(1-\gamma_F\rho\right)$

Preferences and Demand

- Quasi-linear demand for homogeneous good and consumption index X of differentiated products:
  - $V(X, Y) = Y + U(X)$
  - $U(\cdot)$ has constant elasticity $\varepsilon \geq 1$
  - $X = P^{-\varepsilon}$, where P is the price index of X

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- Use broader class of preferences, following Matsuyama and Ushchev: Homothetic with a Single Aggregator (HSA)
- Consumption index X is a linear homogeneous function of consumption of continuum of varieties, with a linear homogeneous price index P, a function of prices $p(\omega)$, such that there exists a market share function $s(\cdot)$ that satisfies

1. $$\frac{d \log P}{d \log p(\omega)} = s\left[\frac{p(\omega)}{A}\right]$$
2. $$1 = \int_{\omega \in \Omega} s\left[\frac{p(\omega)}{A}\right] d\omega$$

Assumptions and Examples

Assumption 1: The share function $s(z)$ is strictly decreasing for $s(z) > 0$, with $\lim_{z \to 0} s(z) = \infty$ and $\lim_{z \to \bar{z}} s(z) = 0$

- This assumption ensures A is function of prices and that all goods are gross substitutes
- Elasticity of substitution between two goods with equal prices is $\sigma(z) \equiv 1 - \frac{s'(z)z}{s(z)} > 1$

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- Examples:
  - Symmetric CES: $s(z) = z^{1-\sigma}$; Then $\sigma(z) = \sigma$, $P \propto A$
  - Symmetric Translog: $s(z) = -\theta \log z$, $z \in (0,1)$, $\theta > 0$; Then $\sigma(z) = 1 - \frac{1}{\log z}$, $\log A = \frac{1}{n\theta} + \frac{1}{n} \int_{\omega \in \Omega} \log p(\omega) \, d\omega$

Strategies and States

- Firms compare three strategies (plus exit): f: form single partnership in F; h: form single partnership only in H; or b: diversify (i.e., invest in both)
  - Compare expected profits
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- Four macro states: (i) only supply chains in home are active (H) (ii) only supply chains in foreign are active (F); (iii) supply chains in both are active (B); (iv) all supply chains inactive (N)

Equilibrium in Absense of Government Intervention

- Use optimal pricing and resulting profits to solve for operating profits in each state from each strategy, which depends on A^J and thus choices of other firms: $\boldsymbol{\mu} := (\mu_h, \mu_f, \mu_b)$
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- Outcomes depend on (q_H, q_F) and (γ_H, γ_F). For example, with $q_H \approx q_F$ and $\gamma_H > \gamma_F$ we have

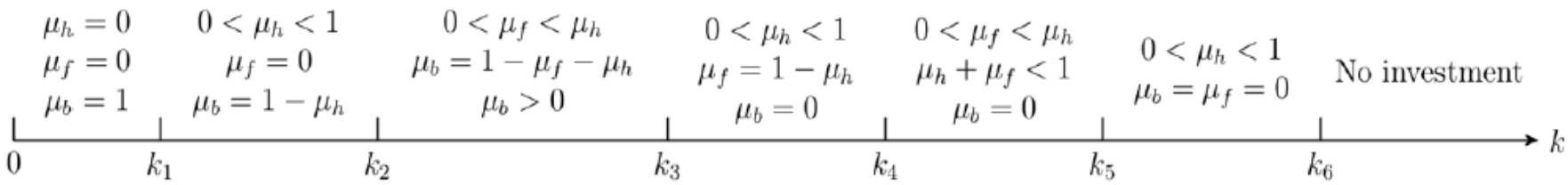

Figure 1:
Supply Chain Outcomes

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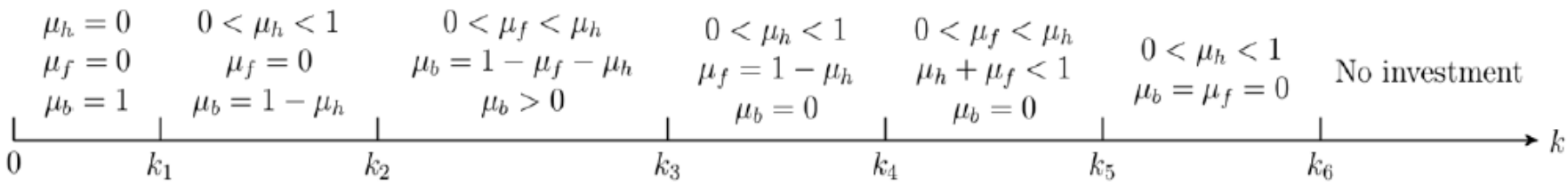

Figure 1:
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- Focus on $k \in (k_2, k_3)$; i.e., all strategies used in equilibrium

Government Policy

- Government can promote (or discourage) diversification, onshoring or offshoring
  - Subsidize or tax formation of second supply chain
  - Subsidize or tax formation of a single supply relationship at home or abroad
- Policies affect product availability in different states of nature
- Equivalence
  - $\Pi_h + s_h$, $\Pi_f + s_f$, $\Pi_b + s_b$
  - In general, one policy is redundant
  - In general, need two policies to achieve constrained optimum.
  - In general, need two policies plus consumption subsidy to achieve first best

Unconstrained Optimum

- Unconstrained optimum uses consumer subsidies to equate consumer prices with marginal costs and supply chain subsidies (or taxes) to achieve socially optimal supply chains
- Such consumer subsidies not practical: must vary with state of nature and source of input supply
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- Government objective is expected indirect utility, the sum of labor income, expected profits, expected tax revenues and expected consumer surplus
- With optimal consumption subsidies, cost of such subsidies exactly offsets operating profits
- Government sets supply chain policies to maximize

$$W_c\left(\mu_h, \mu_f\right) := \frac{1}{\varepsilon - 1} \sum_{J=H,F,B} \delta^J P_c^J\left(\mu_h, \mu_f\right)^{1-\varepsilon} - k\left(2 - \mu_h - \mu_f\right)$$

Observations about the Unconstrained Optimum

1. With $\mu_b = 1 - \mu_f - \mu_h$ and $\mu_b^o = 1 - \mu_f^0 - \mu_h^o$, we need two instruments, beyond optimal consumption subsidy, to achieve optimal $\boldsymbol{\mu} \Rightarrow$ degree of freedom

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3. Under CES: $s_b^o = s_f^o = s_h^o = 0$ achieves first best.
4. Under MSLD, profit-shifting effect of diversification exceeds consumer-surplus effect
    1. Government should encourage single suppliers at home and abroad at expense of diversification: Can achieve first best with $s_f > 0$ and $s_h > 0$, with $s_b = 0$
    2. Whether government wants to encourage onshoring relative to offshoring depends on whether $\psi(z) = \int_z^{\bar{z}} \frac{s(\zeta)}{\zeta} / \frac{s(z)}{\sigma(z)-1}$ is decreasing or increasing in z and comparison of z_o^H vs. z_o^F and $z_o^{B,H}$ vs. $z_o^{B,F}$
    3. As $q_H \searrow q_F$: (i) $z_o^H < z_o^F$ and $z_o^{B,H} = z_o^{B,F}$ (ii) In translog case, $\psi(z)$ is constant

Constrained Optimum with Symmetric Countries

- Diversification policy
  - $\mu_h^{co} = \mu_f^{co}$, so diversification policy alone can achieve second best
  - CES: Optimal to subsidize diversification (due to markup pricing)
  - MSLD: Ambiguous. Excessive diversification due to rising elasticity conflicts with insufficient diversification due to markups
  - Translog: Subsidize diversification of ε large (large consumption distortion) but tax if ε small (small consumption distortion)

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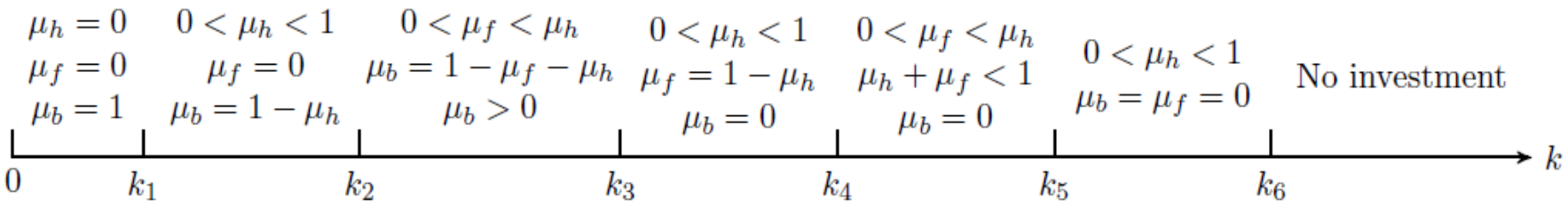
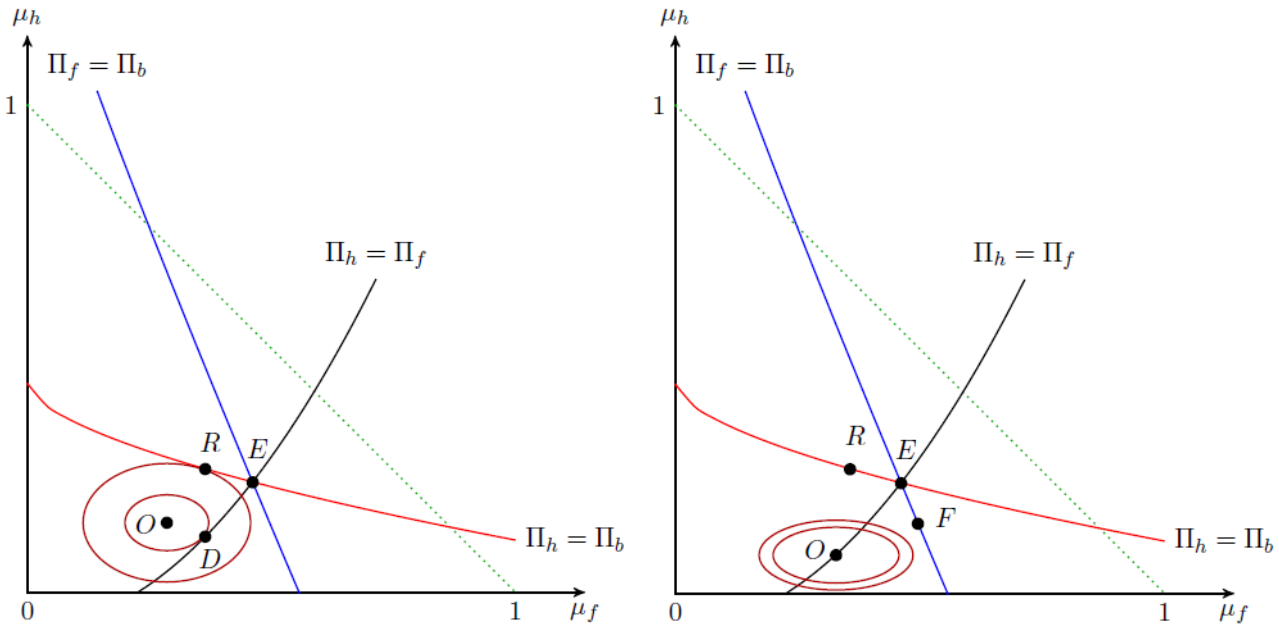
- Reshoring or Offshoring policy
  - Does not achieve constrained optimum
  - Reshoring and offshoring policies offer symmetric potential benefits
  - Reshoring and offshoring tax at equal rates equivalent to diversification subsidy

Asymmetric Countries

- Home is safer but higher cost: $\gamma_F < \gamma_H$, $q_F < q_H$,
- Equilibrium strategies ($q_F \approx q_H$)



Constrained Optimum with Asymmetric Countries



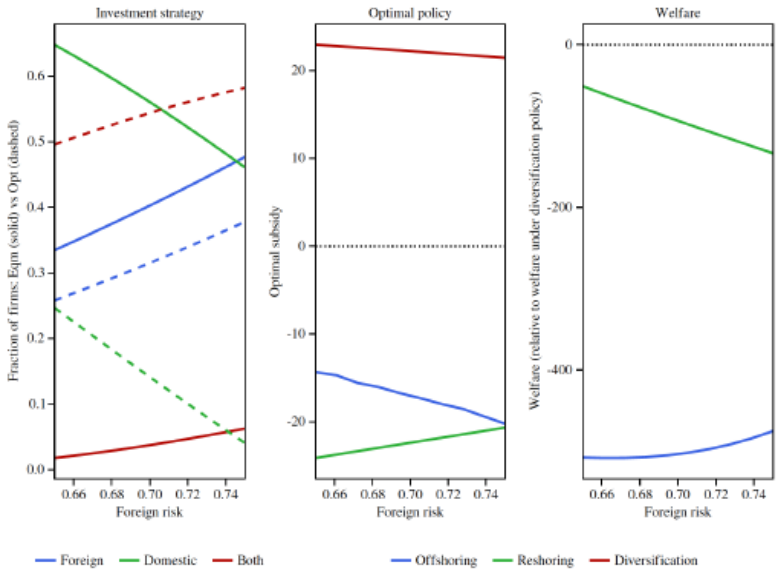
(a) General HSA Preferences

(b) CES Preferences

- Constrained optimum at O
  - Need not fall on any of three equi-profit curves; need two instruments.
  - Subsidy to diversification ($s_b > 0$), shift along $\Pi_f = \Pi_h$. Attains D
  - Tax on offshoring ($s_f > 0$), shift along $\Pi_h = \Pi_b$. Attains R.
- CES: $s_b > 0$ achieves constrained optimum
- Translog: Tend to find optimal to encourage offshoring relative to reshoring, because markups smaller in state H than F

Optimal Policies and Comparative Statics w.r.t. Risk

$\varepsilon = 1.4, \theta = 3.5, 1 - \rho = 0.1, q_H = 0.1, q_F = 0.08$



- LEFT PANEL: Too many firms have single relationships in safe market; too little diversification
- MIDDLE PANEL: Optimal subsidy to diversification; optimal tax on offshoring or reshoring (higher on h)
- RIGHT PANEL: Diversification policy dominates tax on h or f
- Results are typical, except when ε is small

Summary

- Resilience of global supply chains is widely discussed, but there is little analytical work on policies toward them.
- Have developed simple framework that links welfare to the composition of investment strategies in supply chains, allowing for country-level and idiosyncratic disruptions.
- Analyze policies toward supply chains, emphasizing diversification vs. single-country targeting (e.g., reshoring).
- Departures from *CES* are important:
  - Under *CES* a constrained optimum can always be attained with a subsidy to diversification, while with preferences that satisfy Marshall's Second Law of Demand a subsidy or tax can be optimal.
- Subsidies to diversification may or may not dominate single-country targeting
- Subsidies to investment in a more risky but less costly country can be optimal; i.e., governments may want to discourage reshoring