Industrial Policies in Production Networks

Ernest Liu
Motivation

- Industrial policies: *selective* intervention into key economic sectors

- Widely adopted today and in the past
  - examples: Japan, Korea, Taiwan, China
  - tax incentives, subsidized credit, direct state involvement
  - despite many arguments against industrial policies
    - how can we trust the bureaucrats?

- How to conduct industrial policies *if we must*? Not well understood
  - important to consider linkages across sectors (Hirschman 1958)

- This paper:
  - analyze policy interventions in production networks
  - use the framework to evaluate industrial policies
Korea’s Heavy-Chemical Industry Drive (1973-1979) promoted six broad “strategic” sectors:

- steel, non-ferrous metals, shipbuilding, machinery, electronics, petrochemicals
Korea’s input-output table in 1970 — transformed
Korea’s input-output table in 1970 — transformed

The input-using industry was targeted by HCI drive
All others

- The input-using industry was targeted by HCI drive
- All others
Model and stylized example

- Rep. consumer, exogenous factor supply $L$, a unique consumption good
- $S$ intermediate sectors, CRTS production with input-output linkages
Model and stylized example

- Rep. consumer, exogenous factor supply $L$, a unique consumption good
- $S$ intermediate sectors, CRTS production with input-output linkages
- Example: three intermediate sectors:
  - upstream (sector 1): $Q_1 = z_1 L_1$
  - midstream (sector 2): $Q_2 = z_2 F_2 (L_2, M_{21})$
  - downstream (sector 3): $Q_3 = z_3 F_3 (L_3, M_{32})$
  - final good is produced linearly from good 3
Model and stylized example

- Rep. consumer, exogenous factor supply \( L \), a unique consumption good
- \( S \) intermediate sectors, CRTS production with input-output linkages
- Example: three intermediate sectors:
  - upstream (sector 1): \( Q_1 = z_1 L_1 \)
  - midstream (sector 2): \( Q_2 = z_2 F_2 (L_2, M_{21}) \)
  - downstream (sector 3): \( Q_3 = z_3 F_3 (L_3, M_{32}) \)
  - final good is produced linearly from good 3

- Analyze how policies can improve efficient under market imperfections
  - example: intermediate inputs are subject to credit constraints

\[
P_i = \min_{\ell_i, m_{i,i-1}, k_i} \left( P_{i-1} m_{i,i-1} + W \ell_i + r k_i \right)
\]

s.t. \( z_i F_i (\ell_i, m_{i,i-1}) \geq 1 \), \( \delta_i P_{i-1} m_{i,i-1} \leq k_i \).
Sectoral allocations in decentralized economy

- Start with the *decentralized economy*: no intervention

- Let \( \sigma_i \left( \equiv \frac{\partial \ln F_i(L_i, M_{i,i-1})}{\partial \ln M_{i,i-1}} \right) \) denote equilibrium elasticity on intermediate inputs

- Imperfections distort sectoral expenditure shares:

  \[
  P_i M_{i,i-1} = \frac{\sigma_i}{1 + \chi_{i,i-1}} P_i Q_i;
  \]

  in the example, distortion wedge is \( \chi_{i,i-1} = r \delta_i \)

- Assume the distortion payments are deadweight losses
  - interest payments are "quasi-rent"
Influence, sales, and distortion centrality

Sectoral influence \( \mu_i \equiv \frac{d \ln Y}{d \ln z_i} \): an elasticity measure of sectoral importance

\[
\mu' \propto \left( \begin{array}{ccc}
\sigma_2 \sigma_3 & \frac{1}{\sigma_3} & \\
\text{upstream sector 1} & \text{midstream sector 2} & \text{downstream sector 3}
\end{array} \right)
\]

Definition. Distortion centrality is influence over sales \( \xi_i \equiv \frac{\mu_i}{\gamma_i} \).
Influence, sales, and distortion centrality

▶ Sectoral influence $\mu_i \equiv \frac{d \ln Y}{d \ln z_i}$: an elasticity measure of sectoral importance

$$
\mu' \propto \left( \frac{\sigma_2 \sigma_3 \text{ upstream sector 1}}{1 + r \delta_2}, \frac{\sigma_3 \text{ midstream sector 2}}{1 + r \delta_3}, \frac{1 \text{ downstream sector 3}}{} \right)
$$

▶ Sectoral sales share $\gamma_i = \frac{p_i Q_i}{Y}$: a measure of equilibrium sector size

$$
\gamma' \propto \left( \frac{\sigma_2 \text{ upstream sector 1}}{1 + r \delta_2}, \frac{\sigma_3 \text{ midstream sector 2}}{1 + r \delta_3}, \frac{1 \text{ downstream sector 3}}{} \right)
$$
Influence, sales, and distortion centrality

▶ Sectoral influence \( \mu_i \equiv \frac{d \ln Y}{d \ln z_i} \): an elasticity measure of sectoral importance

\[
\mu' \propto \left( \frac{\sigma_2 \sigma_3}{1 + r \delta_2}, \quad \frac{\sigma_3}{1 + r \delta_3}, \quad \frac{1}{\text{downstream sector 3}} \right)
\]

▶ Sectoral sales share \( \gamma_i = \frac{p_i Q_i}{Y} \): a measure of equilibrium sector size

\[
\gamma' \propto \left( \frac{\sigma_2}{1 + r \delta_2} \cdot \frac{\sigma_3}{1 + r \delta_3}, \quad \frac{\sigma_3}{1 + r \delta_3}, \quad \frac{1}{\text{downstream sector 3}} \right)
\]

**Definition.** *Distortion centrality* is influence over sales

\[ \xi_i \equiv \frac{\mu_i}{\gamma_i}. \]

▶ In efficient economies, \( \xi_i = 1 \)

▶ Upstream has the highest distortion centrality
Introducing a government

- Consider sector-specific input subsidies $\tau_{ij}$, for $j = 1, \ldots, S, L$
  - subsidies expand sectoral expenditures, but cost government resources

\[
(1 - \tau_{ij} + \chi_{ij}) P_i M_{ij} = \sigma_{ij} P_i Q_i
\]
Introducing a government

- Consider sector-specific input subsidies $\tau_{ij}$, for $j = 1, \ldots, S, L$
  - subsidies expand sectoral expenditures, but cost government resources

  \[
  (1 - \tau_{ij} + \chi_{ij}) \ P_i M_{ij} = \sigma_{ij} P_i Q_i
  \]

- Government budget constraint:

\[
\underbrace{G}_{\text{public consumption}} + \underbrace{B}_{\text{subsidies}} = \underbrace{T}_{\text{lump-sum tax}}
\]

- $B$ is the total subsidy payments: $B \equiv \sum_{i=1}^{S} \left( \sum_{j=1}^{S} \tau_{ij} P_j M_{ij} + \tau_i^L W_L \right)$

- Aggregate output is $Y = C + G$
Introducing a government

- Consider sector-specific input subsidies $\tau_{ij}$, for $j = 1, \ldots, S, L$
  - subsidies expand sectoral expenditures, but cost government resources

\[
(1 - \tau_{ij} + \chi_{ij}) P_i M_{ij} = \sigma_{ij} P_i Q_i
\]

- Government budget constraint:

\[
G + B = T
\]
- $B$ is the total subsidy payments: $B \equiv \sum_{i=1}^{S} \left( \sum_{j=1}^{S} \tau_{ij} P_j M_{ij} + \tau^L_i W L_i \right)$

- Aggregate output is $Y = C + G$

**Lemma.** The elasticity of aggregate output w.r.t. subsidy $\tau_{ij}$ is

\[
\left. \frac{d \ln Y}{d \tau_{ij}} \right|_{\tau=0} = \frac{\sigma_{ij}}{1 + \chi_{ij}} \left( \begin{array}{c}
\mu_i \\
\text{expenditure share influence}
\end{array} - \begin{array}{c}
\gamma_i \\
\text{sales}
\end{array} \right) \quad \text{for } j = 1, \ldots, S, L.
\]

- A reduced-form formula for non-parametric and ex-ante counterfactuals!
Decomposing changes in aggregate consumption: \( dY = dC + dG \)

**Definition:** the *social value of policy expenditure* on input subsidy \( \tau_{ij} \) is

\[
SV_{ij} \equiv -\frac{dC/d\tau_{ij}}{dG/d\tau_{ij}} \quad \text{hold} \ T \ \text{constant,} \ \tau = 0
\]

- a general equilibrium spending multiplier; “bang for the buck”
Decomposing changes in aggregate consumption:  \( dY = dC + dG \)

**Definition:** the *social value of policy expenditure* on input subsidy \( \tau_{ij} \) is

\[
SV_{ij} \equiv -\left. \frac{dC/d\tau_{ij}}{dG/d\tau_{ij}} \right|_{\text{hold } T \text{ constant, } \tau=0}
\]

- a general equilibrium spending multiplier; “bang for the buck”

**Theorem.** Sectoral distortion centrality \( \xi_i \) is a sufficient statistic for the social value of marginal policy spending into the sector:

\[
SV_{ij} = \xi_i \quad \text{for all } j = 1, \ldots, S, L.
\]
Social value of policy expenditure

- Interpretation: subsidize upstream!

\[ \xi' \propto \left( \frac{(1 + r\delta_2)(1 + r\delta_3)}{1 + r\delta_3}, \frac{1}{downstream} \right) \]

- two intuitions: subsidizing upstream 1) indirectly relaxes constraints downstream; 2) pushes resources towards efficient allocations

- Policy should not target the most important / large / distorted sectors

- ranking by \( \xi \) is reversed to the ranking by influence or sales
Social value of policy expenditure

- Interpretation: subsidize upstream!
  \[ \xi' \propto \left( \frac{(1 + r\delta_2)(1 + r\delta_3)}{1 + r\delta_3} \right) \]
  - two intuitions: subsidizing upstream 1) indirectly relaxes constraints downstream; 2) pushes resources towards efficient allocations

- Policy *should not* target the most important / large / distorted sectors
  - ranking by \( \xi \) is reversed to the ranking by influence or sales

- Result applies to other policy instruments
  - example: subsidies to credit \( u_i \) and to intermediates are isomorphic
    \[ (1 + (r - u_i)\delta_i) P_i M_{i,i-1} = \sigma_i P_i Q_i \]
  - always better to channel credit to more upstream firms!
  - cross-sector dispersion in interest rate \( \neq \) misallocation
Proposition. Distortion centrality averages to one:

\[ \mathbb{E}[\xi] \equiv \sum_{i \in S} \xi_i \cdot \omega_i^L = 1, \quad \text{with} \quad \omega_i^L \equiv \frac{L_i}{L}. \]

The aggregate gain from selective sectoral intervention is

\[ \frac{\Delta Y}{Y} = \text{Cov}(\xi_i, s_i) + O\left(\max_i s_i^2\right); \]

where \( s_i \) is government spending per value-added in sector \( i \).
Welfare evaluation and counterfactual

Let
- \( sd \) be the standard deviation of \( \xi_i \)
- \( \bar{\xi}_i \equiv \xi_i / sd \): distortion centrality standardized to unit variance

**Corollary.** Consider the bivariate regression

\[
s_i = \alpha + \beta \cdot \bar{\xi}_i + \epsilon_i,
\]

each observation is a sector and is weighted by sectoral value-added. Then

\[
\frac{\Delta Y}{Y} \approx sd \cdot \beta.
\]

Intuitively,
- high \( sd \): more dispersion in \( \xi \), more scope for welfare-enhancing policies
- high \( \beta \): spendings are better targeted to high-\( \xi \) sectors
Constrained-optimal subsidies

- Earlier results are non-parametric and local

- Global, constrained-optimal results depend on parametric assumptions

- Given the set of policy instruments $\mathcal{P}$ available to the planner:

\[
\frac{dY}{d\tau_{ij}} = \frac{d(WL - B)}{d\tau_{ij}} = 0 \quad \text{for } \tau_{ij} \in \mathcal{P}.
\]

**Proposition.** Under Cobb-Douglas, the optimal value-added subsidies follow

\[
\frac{1}{1 - \tau^L_i} \propto \xi_i.
\]
Let $\omega_{ij}$ be the fraction of good $j$ that is sold to sector $i$: $\omega_{ij} \equiv \frac{M_{ij}}{Q_j}$
- captures the importance of $i$ as a buyer of good $j$; define $\omega^F_j$ similarly

**Proposition.** (Distortion Centrality). For scalar $\delta = \frac{WL}{Y}$,

$$\xi_j = \delta \cdot \omega^F_j + \sum_{i \in S} \xi_i \cdot (1 + \chi_{ij}) \cdot \omega_{ij}$$

or in matrix form ($D \equiv [1 + \chi_{ij}]$),

$$\xi' \propto (\omega^F)' (I - D \circ \Omega)^{-1},$$

with Leontief inverse $(I - D \circ \Omega)^{-1} = I + D \circ \Omega + (D \circ \Omega)^2 + \cdots$

**Empirical applications:** evaluate policies and compute welfare gains
- challenge: computing $\xi$ requires knowledge of distortions $D$
Hierarchical networks

**Definition.** A network $\Omega$ has the *hierarchical* property if sectors can be ordered as $1, 2, \ldots, S$ such that it has non-increasing partial column sums:

$$\sum_{k=1}^{K} \omega_{ik} \geq \sum_{k=1}^{K} \omega_{jk} \quad \text{for all } i < j \text{ and } K \leq S.$$ 

In hierarchical networks, sector $i$ is said to be *upstream* to sector $j$ whenever $i < j$.

**Proposition.** Consider a hierarchical network $\Omega$.

Case 1 (Stochastic). If for all $i \neq j$, $\chi_{ij}$’s are i.i.d. conditional on $\{\chi_{ii}\}_{i=1}^{S}$, and $\chi_{ij} \geq \chi_{ii}$ almost surely, then

$$\mathbb{E}[\xi_i] \geq \mathbb{E}[\xi_j] \quad \text{for all } i < j.$$ 

Case 2 (Deterministic). If $D \circ \Omega$ also satisfies the hierarchical property, then

$$\xi_i \geq \xi_j \quad \text{for all } i < j.$$
A hierarchical network

vertical chain

Input-Using Sector
Input-Supplying Sector

hierarchical network

Input-Using Sector
Input-Supplying Sector
Korea’s input-output table in 1970
Korea’s input-output table in 1970 — sectors ordered by $\xi^{10\%}$

Testing for hierarchical property: among >1 million unique inequalities,
- 84% holds true (90% if small violations <0.01 are tolerated)
South Korea in the 1970s promoted sectors with high distortion centrality

“Heavy-Chemical Industry Drive” (1973-1979): promoted six broad “strategic” sectors:

▶ steel, non-ferrous metals, shipbuilding, machinery, electronics, petrochemicals
Input-output table of China in 2007

- Testing for hierarchical property: among >1 million unique inequalities,
  - 85% holds true (90% if small violations <0.01 are tolerated)
$\xi_i^{10\%}: \text{distortion centrality with constant distortion } \chi_{ij} = 0.1$
$\xi_i^{10\%}$: distortion centrality with constant distortion $\chi_{ij} = 0.1$

<table>
<thead>
<tr>
<th>Panel A: Simulated $\chi_{ij}$’s</th>
<th>South Korea in 1970</th>
<th>China in 2007</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pearson’s $r$</td>
<td>Spearman’s $\rho$</td>
</tr>
<tr>
<td>$N(0.1, 0.1)$</td>
<td>0.95</td>
<td>0.93</td>
</tr>
<tr>
<td>$U[0, 0.1]$</td>
<td>0.98</td>
<td>0.97</td>
</tr>
<tr>
<td>$\text{Exp}(0.1)$</td>
<td>0.95</td>
<td>0.94</td>
</tr>
</tbody>
</table>

Panel B: Estimated Distortions

<table>
<thead>
<tr>
<th></th>
<th>South Korea in 1970</th>
<th>China in 2007</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pearson’s $r$</td>
<td>Spearman’s $\rho$</td>
</tr>
<tr>
<td>De Loecker and Warzynski</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Foreign firms as controls</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Rajan and Zingales</td>
<td>0.98</td>
<td>0.97</td>
</tr>
<tr>
<td>Self-reported financial costs</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sectoral profit share</td>
<td>0.91</td>
<td>0.91</td>
</tr>
</tbody>
</table>

$\xi^{10\%}$ with open-economy adjustments

<table>
<thead>
<tr>
<th></th>
<th>South Korea in 1970</th>
<th>China in 2007</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pearson’s $r$</td>
<td>Spearman’s $\rho$</td>
</tr>
<tr>
<td></td>
<td>0.95</td>
<td>0.93</td>
</tr>
<tr>
<td></td>
<td>-0.20</td>
<td>-0.32</td>
</tr>
<tr>
<td>“Upstreamness” by Antras et al. (2012)</td>
<td>0.96</td>
<td>0.96</td>
</tr>
</tbody>
</table>
Korea’s HCI industries

HCI industries have higher simulated distortion centralities!

<table>
<thead>
<tr>
<th>ξ Specification</th>
<th>sd (ξ)</th>
<th>Average ξ of HCI sectors</th>
<th>% sectors with ξ &gt; 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benchmark</td>
<td>0.09</td>
<td>1.16</td>
<td>100% 47.8%</td>
</tr>
<tr>
<td>B3 Rajan and Zingales</td>
<td>0.06</td>
<td>1.12</td>
<td>100% 47.0%</td>
</tr>
<tr>
<td>B5 Sectoral profit share</td>
<td>0.16</td>
<td>1.28</td>
<td>100% 45.1%</td>
</tr>
<tr>
<td>A3 N (0.1, 0.1)</td>
<td>0.09</td>
<td>1.17</td>
<td>100% 47.7%</td>
</tr>
<tr>
<td>A7 U [0, 0.2]</td>
<td>0.09</td>
<td>1.16</td>
<td>100% 47.7%</td>
</tr>
<tr>
<td>A8 Exp (0.1)</td>
<td>0.10</td>
<td>1.17</td>
<td>100% 47.7%</td>
</tr>
</tbody>
</table>
### Which Chinese industries have high / low distortion centralities?

<table>
<thead>
<tr>
<th>Top 10</th>
<th>( \xi )</th>
<th>Bottom 10</th>
<th>( \xi )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coke making</td>
<td>1.36</td>
<td>Canned food products</td>
<td>0.62</td>
</tr>
<tr>
<td>Nonferrous metals and alloys</td>
<td>1.35</td>
<td>Dairy products</td>
<td>0.65</td>
</tr>
<tr>
<td>Ironmaking</td>
<td>1.35</td>
<td>Other miscellaneous food products</td>
<td>0.68</td>
</tr>
<tr>
<td>Ferrous alloy</td>
<td>1.33</td>
<td>Condiments</td>
<td>0.69</td>
</tr>
<tr>
<td>Steelmaking</td>
<td>1.33</td>
<td>Drugs</td>
<td>0.77</td>
</tr>
<tr>
<td>Metal cutting machinery</td>
<td>1.32</td>
<td>Meat products</td>
<td>0.77</td>
</tr>
<tr>
<td>Chemical fibers</td>
<td>1.31</td>
<td>Grain mill products</td>
<td>0.78</td>
</tr>
<tr>
<td>Electronic components</td>
<td>1.30</td>
<td>Liquor and alcoholic drinks</td>
<td>0.81</td>
</tr>
<tr>
<td>Specialized industrial equipments</td>
<td>1.30</td>
<td>Vegetable oil products</td>
<td>0.82</td>
</tr>
<tr>
<td>Basic chemicals</td>
<td>1.29</td>
<td>Tobacco</td>
<td>0.83</td>
</tr>
</tbody>
</table>
\( \xi_i \) predicts availability of credit and low taxes

<table>
<thead>
<tr>
<th></th>
<th>Interest Rate</th>
<th>Debt Ratio</th>
<th>Tax Break</th>
<th>Effec. Tax Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \xi_i^{10%} )</td>
<td>-0.987***</td>
<td>2.726***</td>
<td>2.911**</td>
<td>-1.589***</td>
</tr>
<tr>
<td></td>
<td>(0.223)</td>
<td>(0.622)</td>
<td>(1.412)</td>
<td>(0.431)</td>
</tr>
<tr>
<td>Capital intensity</td>
<td>-0.425**</td>
<td>-0.390</td>
<td>0.759</td>
<td>-0.253</td>
</tr>
<tr>
<td></td>
<td>(0.199)</td>
<td>(0.556)</td>
<td>(1.263)</td>
<td>(0.385)</td>
</tr>
<tr>
<td>Lerner index</td>
<td>-0.0247</td>
<td>0.146</td>
<td>-0.559</td>
<td>0.0958</td>
</tr>
<tr>
<td></td>
<td>(0.173)</td>
<td>(0.481)</td>
<td>(1.092)</td>
<td>(0.333)</td>
</tr>
<tr>
<td>Fixed cost of entry</td>
<td>-0.0273</td>
<td>0.511</td>
<td>-0.559</td>
<td>-0.643</td>
</tr>
<tr>
<td></td>
<td>(0.204)</td>
<td>(0.568)</td>
<td>(1.290)</td>
<td>(0.394)</td>
</tr>
<tr>
<td>Export intensity</td>
<td>-0.682***</td>
<td>0.284</td>
<td>2.824**</td>
<td>-0.375</td>
</tr>
<tr>
<td></td>
<td>(0.172)</td>
<td>(0.487)</td>
<td>(1.105)</td>
<td>(0.337)</td>
</tr>
<tr>
<td>adj. ( R^2 )</td>
<td>0.301</td>
<td>0.231</td>
<td>0.097</td>
<td>0.176</td>
</tr>
<tr>
<td># Obs.</td>
<td>79</td>
<td>79</td>
<td>79</td>
<td>79</td>
</tr>
</tbody>
</table>
More SOEs in high-\(\xi\) sectors
### More SOEs in high-\( \xi \) sectors

#### Outcome variable: SOEs' Share of Sectoral Value-Added in 2007

<table>
<thead>
<tr>
<th></th>
<th>All SOEs in 2007</th>
<th>SOEs established after year ( T )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>( \xi_i^{10%} )</td>
<td>7.577***</td>
<td>7.808***</td>
</tr>
<tr>
<td></td>
<td>(2.963)</td>
<td>(2.834)</td>
</tr>
<tr>
<td>Capital intensity</td>
<td>0.914</td>
<td>0.774</td>
</tr>
<tr>
<td></td>
<td>(2.535)</td>
<td>(0.947)</td>
</tr>
<tr>
<td>Lerner index</td>
<td>-4.622**</td>
<td>-2.191***</td>
</tr>
<tr>
<td></td>
<td>(2.193)</td>
<td>(0.820)</td>
</tr>
<tr>
<td>Fixed cost of entry</td>
<td>6.974***</td>
<td>2.042**</td>
</tr>
<tr>
<td></td>
<td>(2.590)</td>
<td>(0.968)</td>
</tr>
<tr>
<td>Export intensity</td>
<td>-5.660**</td>
<td>-2.013**</td>
</tr>
<tr>
<td></td>
<td>(2.218)</td>
<td>(0.829)</td>
</tr>
<tr>
<td>adj. ( R^2 )</td>
<td>0.066</td>
<td>0.290</td>
</tr>
<tr>
<td># Obs.</td>
<td>79</td>
<td>79</td>
</tr>
</tbody>
</table>
## Policy Evaluation: Aggregate Gains ($\Delta Y/Y$)

<table>
<thead>
<tr>
<th>Distortion centrality specification</th>
<th>$sd(\xi)$</th>
<th>Credit</th>
<th>Taxes</th>
<th>SOEs</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benchmark ($\xi^{10%}$)</td>
<td>0.22</td>
<td>1.69</td>
<td>0.64</td>
<td>1.27</td>
<td>3.60</td>
</tr>
<tr>
<td>De Loecker and Warzynski</td>
<td>0.42</td>
<td>3.07</td>
<td>1.19</td>
<td>2.39</td>
<td>6.65</td>
</tr>
<tr>
<td>Foreign firms as controls</td>
<td>0.25</td>
<td>1.69</td>
<td>0.67</td>
<td>1.16</td>
<td>3.51</td>
</tr>
<tr>
<td>Rajan and Zingales</td>
<td>0.11</td>
<td>1.01</td>
<td>0.36</td>
<td>0.65</td>
<td>2.02</td>
</tr>
<tr>
<td>Sectoral profit share</td>
<td>0.17</td>
<td>1.20</td>
<td>0.47</td>
<td>0.95</td>
<td>2.62</td>
</tr>
</tbody>
</table>
Consider alternative policy target $\tilde{\gamma}$, with counterfactual policy interventions $\tilde{s}_i$:

$$\tilde{s}_i = \alpha + \beta \cdot \tilde{\gamma}_i + u_i, \quad u \perp \xi, \gamma.$$
Consider alternative policy target $\tilde{\gamma}$, with counterfactual policy interventions $\tilde{s}_i$:

$$\tilde{s}_i = \alpha + \beta \cdot \tilde{\gamma}_i + u_i, \quad u \perp \xi, \gamma.$$  

Then aggregate gains under the counterfactual can be capture by $\lambda$:

$$\tilde{\gamma}_i = c + \lambda \cdot \xi_i + \nu_i, \quad \nu \perp \gamma.$$
# Counterfactual Gains

Consider alternative policy target $\tilde{\gamma}$, with counterfactual policy interventions $\tilde{s}_i$:

$$\tilde{s}_i = \alpha + \beta \cdot \tilde{\gamma}_i + u_i, \quad u \perp \xi, \gamma.$$ 

Then aggregate gains under the counterfactual can be capture by $\lambda$:

$$\tilde{\gamma}_i = c + \lambda \cdot \tilde{\xi}_i + \nu_i, \quad \nu \perp \gamma.$$ 

<table>
<thead>
<tr>
<th>Specification for $\xi$</th>
<th>Gains relative to real-world interventions ($\lambda$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\xi^{10%}$</td>
</tr>
<tr>
<td>Real-world interventions</td>
<td>100%</td>
</tr>
<tr>
<td>Counterfactual policy target</td>
<td></td>
</tr>
<tr>
<td>Sales $\gamma$</td>
<td>-39.5%</td>
</tr>
<tr>
<td>Consumption share $\beta$</td>
<td>-71.1%</td>
</tr>
<tr>
<td>Export intensity</td>
<td>31.4%</td>
</tr>
<tr>
<td>Sectoral value-added</td>
<td>-36.2%</td>
</tr>
<tr>
<td>Interm. exp. share</td>
<td>37.2%</td>
</tr>
<tr>
<td>Optimal assignment</td>
<td>148.1%</td>
</tr>
</tbody>
</table>
Hierarchical property survives with coarse IO tables:
figures show 25 sectors for South Korea and 28 for China
<table>
<thead>
<tr>
<th>Number of sectors (S)</th>
<th>Average correlation with benchmark $\xi^{10%}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>$S_{SK} = 54, S_{CN} = 57$</td>
<td></td>
</tr>
<tr>
<td>$S_{SK} = 25, S_{CN} = 28$</td>
<td></td>
</tr>
<tr>
<td>$S_{SK} = 16, S_{CN} = 17$</td>
<td></td>
</tr>
</tbody>
</table>
**Conclusion**

- **Distortion centrality**: the ratio between sectoral influence and sales share
  - a sufficient statistic for social value of sectoral spending
  - can be used to assess welfare impact of sectoral intervention

- Distortions accumulate upstream through backward demand linkages
  - distortion centrality is stable in hierarchical networks

- Many arguments against industrial policies:
  - theory abstracts away from practical aspects of policy implementation and political economy factors

- Yet, evidence suggests that certain aspects of Korean and Chinese industrial strategy might be motivated by a desire to subsidize sectors that create positive network effects
Relation to Hulten (1978)

- Income accounting identity in a decentralized equilibrium:
  \[ Y^G - \Pi = Y = WL - B \]

- Hulten’s theorem: In efficient economies,
  \[ \frac{d \ln Y^G}{d \ln z_i} = \frac{d \ln Y}{d \ln z_i} = \gamma_i. \]
  - generically,
  \[ \frac{d \ln Y^G}{d \ln z_i} \neq \frac{d \ln Y}{d \ln z_i} \neq \frac{d \ln WL}{d \ln z_i} = \mu_i \neq \gamma_i. \]

- Thus Hulten’s theorem fails for two reasons:
  - influence does not equal to sales (well-known in the literature)
  - elasticity of distortion and subsidy payments does not move proportionally with factor payments
Non-equivalence to iceberg costs

- Distortions are not equivalent to iceberg costs
  - similar effect on aggregate output, different efficiency implications
  - quantity of output losses depend on relative prices $\Rightarrow$ room for intervention
Non-equivalence to iceberg costs

- Distortions are not equivalent to iceberg costs
  - similar effect on aggregate output, different efficiency implications
  - quantity of output losses depend on relative prices $\Rightarrow$ room for intervention

- Compare efficient, distortion, and iceberg economies:

\[ Y^* > Y^G > Y = Y^{IB} \]

\[
\frac{dWL}{d \ln (1 + \chi_{ij})} = \frac{dQ^F}{d \ln (1 + \chi_{ij})} - \frac{d\Pi}{d \ln (1 + \chi_{ij})}
\]

- iceberg costs: only deadweight losses $(Y^* - Y^{IB})$, no allocative inefficiency
- distortions: allocative inefficiency $(Y^* - Y^G > 0)$

- Policy instruments can improve allocative efficiency
Non-equivalence to iceberg costs

Example: two intermediate sectors, vertical network

\[ Q_1 = L_1, \quad Q_2 = L_2^\alpha M_21^{1-\alpha}, \quad Q^F = Q_2 \]

Sector 2 faces a wedge \((1 + \chi)\) when purchasing good 1

Under iceberg formulation,

- market clearing condition:

\[ M_21 = \frac{Q_1}{1 + \chi}, \quad C = Q^F \]

- equilibrium factor allocations and aggregate consumption:

\[ L_1 = \alpha L, \quad L_2 = (1 - \alpha) L, \quad C = L\alpha^\alpha (1 - \alpha)^{1-\alpha} \left( \frac{1}{1 + \chi} \right)^{1-\alpha} \]

- productivity loss \(\left( \frac{1}{1 + \chi} \right)^{1-\alpha}\) is entirely due to deadweight losses
- labor input is allocated efficiently
Non-equivalence to iceberg costs

Under distortion formulation,

- market clearing condition:

\[ M_{21} = Q_1, \quad C = Q^F - \chi P_1 M_{21} \]

- equilibrium factor allocations and aggregate consumption:

\[
L_1 = \frac{\alpha}{\alpha + \frac{1-\alpha}{1+\chi}} L, \quad L_2 = \frac{\frac{1-\alpha}{1+\chi}}{\alpha + \frac{1-\alpha}{1+\chi}} L
\]

\[
C = L \left( \frac{\alpha}{\alpha + \frac{1-\alpha}{1+\chi}} \right)^\alpha \left( \frac{\frac{1-\alpha}{1+\chi}}{\alpha + \frac{1-\alpha}{1+\chi}} \right)^{1-\alpha} \left( 1 - \frac{\chi}{1+\chi} (1 - \alpha) \right)
\]

- total productivity loss is the same as under iceberg costs
- but labor input is allocated efficiently \( \implies \) room for policy!
Non-equivalence to iceberg costs

Optimal labor subsidies should be

\[
\frac{1}{1 - \tau_1} = \frac{\alpha}{\alpha + \frac{1 - \alpha}{1 + \chi}}, \quad \frac{1}{1 - \tau_2} = \frac{1 - \alpha}{\left(\frac{1 - \alpha}{1 + \chi}\right) / (\alpha + \frac{1 - \alpha}{1 + \chi})}
\]

– elasticities over equilibrium expenditure shares on labor!
Microfoundations

▶ Marshallian externality:

\[ Q_i = \int_{0}^{N_i} q_i(\nu) \, d\nu, \quad q_i(\nu) = z_i \left( \frac{Q_i}{N_i} \right)^{1-\alpha_i} F_i(\ell_i, \{m_{ij}\})^{\alpha_i} \]

▶ Negative production externality:

\[ Q_i = \left( \int_{0}^{N_i} q_i(\nu) \frac{\sigma-1}{\sigma} \, d\nu \right)^{\frac{\sigma}{\sigma-1}}, \quad q_i(\nu) = z_i N_i^{\frac{1}{\sigma-1}} F_i(\ell_i, \{m_{ij}\})^{\alpha_i} \]