Misallocation, Economic Growth, and Input-Output Economics

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Introduction

Important theme of recent growth literature:

- Enhanced appreciation of the role that misallocation plays in explaining cross country income differences

Examples:

- Restuccia and Rogerson (2008), Banerjee and Duflo (2005), Hsieh and Klenow (2009)
- Parente and Prescott (1999), Caselli and Gennaioli (2005), Lagos (2006), Alfaro et al (2008), Buera and Shin (2008), Guner-Ventura-Xu (2008), Bartelsman et al (2009), Syverson (2010)

Three Points

- **Misallocation:** Overview of misallocation
- **Theory:** The input-output structure of the economy can amplify effects of misallocation
- **Empirics:** Quantifying the input-output multiplier

Asks more questions than it answers...

I. Misallocation

1. Misallocation and TFP: A Simple Example

Production: $X_{steel} = L_{steel}, \quad X_{latte} = L_{latte}$

Resource constraint: $L_{steel} + L_{latte} = \bar{L}$

GDP (aggregation): $Y = X_{steel}^{1/2} X_{latte}^{1/2}$

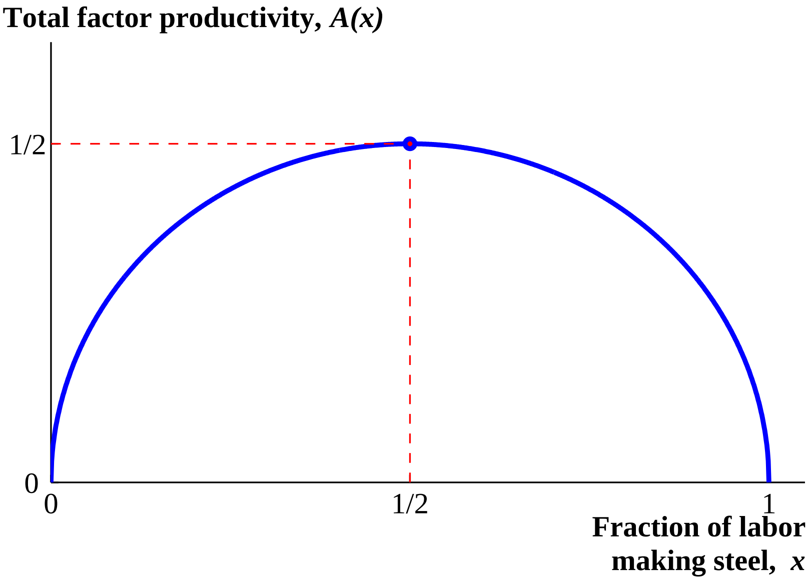
$x \equiv L_{steel}/\bar{L}$ denotes the allocation
(markets, distortions, central planner, etc).

Then GDP and TFP are

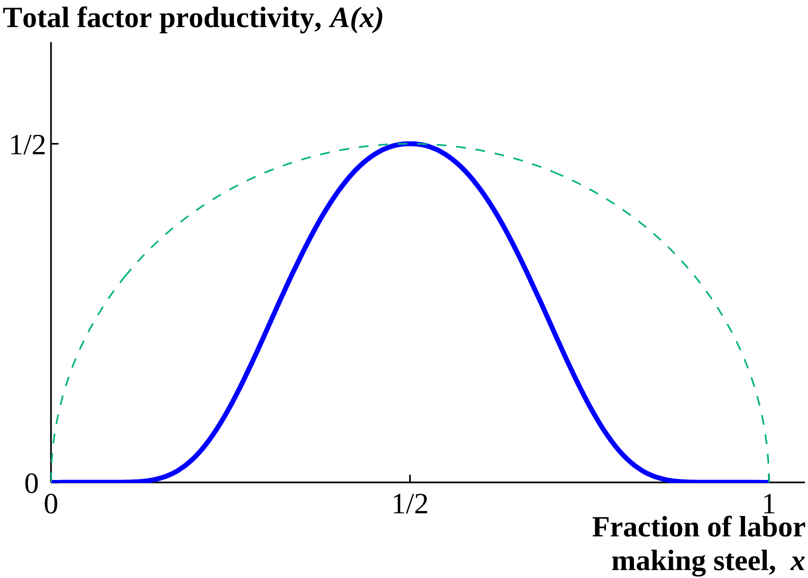
$$Y = A(x)\bar{L}$$

$$A(x) = \sqrt{x\,(1-x)}$$

Misallocation Reduces TFP



An Alternative View of Misallocation



Remarks

Advantages of "Alternative View"

- Intermediate degrees of misallocation can have large effects
- In a poor country, small improvements in the allocation may have small effects: growth miracles are hard.

What models deliver this "alternative view"?

- O-ring complementarity of Kremer (1993)?
- Others?

Simple example misleads on one key point

- Misallocation may not only be across sectors
- *Within* sector?
- *Within* firms and plants?

2. Misallocation of Ideas?

Romer (1990) variety framework

- Romer (1994) suggests effects can be large
- But not so when goods are highly substitutable
- Broda and Weinstein (2006): Gains from new varieties imported into the U.S. between 1972 and 2001 only 2.6% of GDP.

Is a different approach needed?

- Quality ladders, a la Aghion-Howitt?

3. Key Questions

What is the nature of misallocation?

- Within sector? Between sectors? Within firms?
- Ideas?

Why is there misallocation?

- Active literature on political economy and growth
- Acemoglu, Johnson, and Robinson (2005)
- "Alternative view" of misallocation may help...

How does misallocation lead to 50-fold income differences?

- Amplification question.
- Significant in business cycle models; much more needed in growth!

II. Input-Output Economics: Overview

A Brief History of the Growth Literature

Capital multiplier: more $K \rightarrow$ more $Y \rightarrow$ more K, etc.

- Multiplier is $1 + \alpha + \alpha^2 + ... = \frac{1}{1-\alpha} = 3/2$ if $\alpha = 1/3$.
- Mankiw, Romer, and Weil (1992): This is too small...

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Broaden capital: Need $\alpha = 2/3 \Rightarrow$ multiplier = 3

human capital	Mankiw, Romer, and Weil (1992)
organizational capital	Chari, Kehoe, and McGrattan (1997)
ideas	Howitt (2000), Klenow/Rodriguez (2005)
human capital	Manuelli/Seshadri (05), Erosa et al (06)

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Intermediate goods are another possibility!

- Very similar to capital, only depreciate fully in production
- Easily measured, share of gross output is large
- Ciccone (2002), Yi (2003)

A Simple Example

- Gross output and intermediate goods

$$Q_t = \bar{A}\left(K_t^{\alpha} L_t^{1-\alpha}\right)^{1-\sigma} X_t^{\sigma}$$

$$X_{t+1} = \bar{x} Q_t$$

- GDP is $Y_t \equiv (1 - \bar{x}) Q_t$. In steady state:

$$Y = \text{TFP} \cdot K^{\alpha} L^{1-\alpha}$$

$$\text{TFP} \equiv \left(\bar{A} \bar{x}^{\sigma} (1 - \bar{x})^{1-\sigma}\right)^{\frac{1}{1-\sigma}}$$

With capital accumulation...

- A constant fraction $\bar{s}$ of GDP is invested:

$$K_{t+1} = \bar{s}Y_t + (1 - \delta)K_t$$

- GDP per worker in steady state is

$$y^* \equiv \frac{Y}{L} = \left(\bar{A}\bar{x}^{\sigma}(1 - \bar{x})^{1-\sigma} \left(\frac{\bar{s}}{\delta}\right)^{\alpha(1-\sigma)}\right)^{\frac{1}{(1-\alpha)(1-\sigma)}}$$

Remarks

The effects of misallocation and differences in $\bar{A}$ are multiplied:

- A 1% increase in $\bar{A}$ raises output by more than 1% because of the multiplier $\frac{1}{(1-\alpha)(1-\sigma)}$
- With no intermediate goods, just the standard $\frac{1}{1-\alpha} = 1 + \alpha + \alpha^2 + ...$
- With intermediate goods, an additional effect from the induced production of intermediates, so multiplier is larger.
- Can be written as $\frac{1}{1-\beta}$, where $\beta \equiv \sigma + \alpha(1-\sigma)$ is the total factor share of produced goods

Quantitatively significant

- Standard values: $\alpha = 1/3$, $\sigma = 1/2$
- Share of produced goods: $\beta = \sigma + \alpha(1-\sigma) = 2/3$
- Total multiplier: $\frac{1}{(1-\alpha)(1-\sigma)} = 3$

Input-Output Economics: Model

Is the multiplier effect diluted by a realistic I-O structure?

Economic Environment: N sectors

$$Q_i = A \cdot A_i \left(K_i^{\alpha_i} H_i^{1-\alpha_i} \right)^{1-\sigma_i-\lambda_i} \underbrace{d_{i1}^{\sigma_{i1}} d_{i2}^{\sigma_{i2}} \cdot \ldots \cdot d_{iN}^{\sigma_{iN}}}_{\text{domestic IG}} \underbrace{m_{i1}^{\lambda_{i1}} m_{i2}^{\lambda_{i2}} \cdot \ldots \cdot m_{iN}^{\lambda_{iN}}}_{\text{imported IG}}$$

Resource constraint (j): $c_j + \sum_{i=1}^N d_{ij} = Q_j$

Aggregation: $Y = c_1^{\beta_1} \cdot \ldots \cdot c_N^{\beta_N}$

Resource constraint: $C + X = Y$

Physical capital: $\sum_{i=1}^N K_i = K$ given

Human capital: $\sum_{i=1}^N H_i = H$ given

Balanced trade: $\bar{P}X = \sum_{i=1}^N \sum_{j=1}^N \bar{p}_j m_{ij}$

Equilibrium with Misallocation

Allocation of Resources: A standard competitive equilibrium, where some heterogeneous fraction τ_i of firm i's output is expropriated.

- Could be a tax.
- Could also be theft, regulations, special relationships, etc.
- A more general model could allow input-specific distortions at the firm level as well.
- To keep presentation short, I omit a formal definition of equilibrium (see paper).

Proposition 1 (Solution for Y and C)

In the competitive equilibrium with misallocation, the solution for total production of the aggregate final good is

$$Y = A^{\tilde{\mu}} K^{\tilde{\alpha}} H^{1-\tilde{\alpha}} \epsilon$$

where

$$\mu' \equiv \frac{\beta'(I-B)^{-1}}{1-\beta'(I-B)^{-1}\lambda} \quad \text{(}N \times 1 \text{ vector of multipliers)}$$

$$\tilde{\mu} \equiv \mu' \mathbf{1}$$

$$\log \epsilon \equiv \omega + \mu' \tilde{A}, \quad \text{where } \tilde{A}_i \equiv A_i(1-\tau_i).$$

Understanding the Key Multiplier, $\tilde{\mu}$

$$\mu' \equiv \frac{\beta'(I-B)^{-1}}{1-\beta'(I-B)^{-1}\lambda}$$

The matrix $L \equiv (I-B)^{-1}$ is known as the Leontief inverse.

- I is the $N \times N$ identity matrix
- B is the $N \times N$ input-output matrix, with typical element σ_{ij}
- Let ℓ_{ij} denote the typical element of L
- Then a 1% increase in A_j raises output in sector i by $\ell_{ij}\%$

Then $\beta'(I-B)^{-1}$ just adds up these effects across all sectors

- Weight by value-added
- Typical element reveals the effect of sector j on GDP.

Finally $\tilde{\mu} \equiv \mu'\mathbf{1}$

- This reveals the effect on GDP if economy-wide productivity rises by 1%.

Proposition 2 (Multiplier in a special case)

- Assume each sector has the same total exponent on intermediate goods (though composition can vary):

$$\sigma_i \equiv \sum_{j=1}^{N} \sigma_{ij} = \hat{\sigma} \text{ and } \lambda_i \equiv \sum_{j=1}^{N} \lambda_{ij} = \hat{\lambda} \text{ for all } i.$$

- Define $\bar{\sigma} \equiv \hat{\sigma} + \hat{\lambda} < 1$ to be the total intermediate goods share.

- Then,

$$\frac{\partial \log Y}{\partial \log A} = \mu' \mathbf{1} = \frac{\beta' (I-B)^{-1} \mathbf{1}}{1 - \beta' (I-B)^{-1} \lambda} = \frac{1}{1-\bar{\sigma}}.$$

Proposition 3 (Symmetry and Distortions)

- Suppose all parameters are identical across sectors:

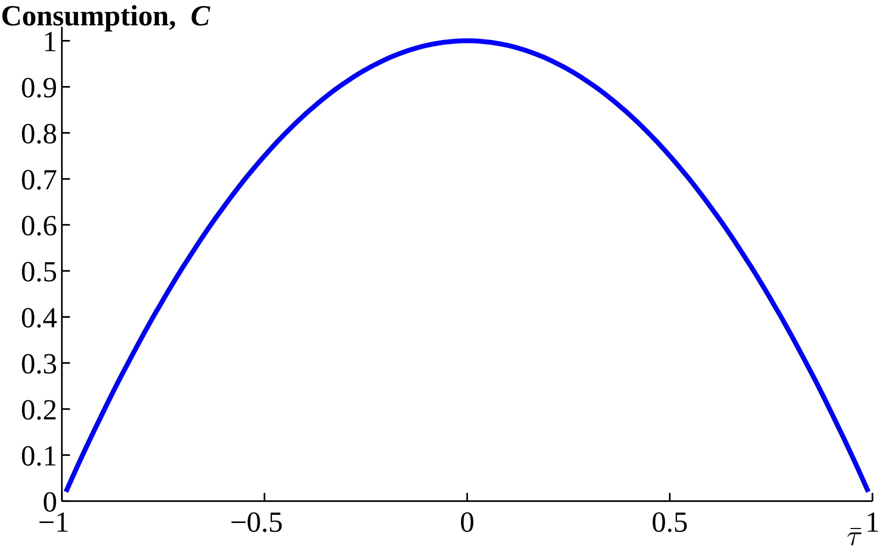
$$\sigma_{ij} = \hat{\sigma}/N,\ \lambda_{ij} = \hat{\lambda}/N,\ \beta_i = 1/N, \text{ and } \tau_i = \bar{\tau}$$

- Define $\bar{\sigma} \equiv \hat{\sigma} + \hat{\lambda} < 1$ to be the total intermediate goods share.

- Then,

$$\log C = \text{Constant} + \tfrac{\bar{\sigma}}{1-\bar{\sigma}} \log(1 - \bar{\tau}) + \log\left(1 - \bar{\sigma}(1 - \bar{\tau})\right)$$

Consumption vs. $\bar{\tau}$ with $\bar{\sigma} = 1/2$



Proposition 4 (Symmetry with Random Distortions)

- Suppose all parameters are identical across sectors:

$$\sigma_{ij} = \hat{\sigma}/N,\ \lambda_{ij} = \hat{\lambda}/N, \text{ and } \beta_i = 1/N$$

- Define $\bar{\sigma} \equiv \hat{\sigma} + \hat{\lambda} < 1$ to be the total intermediate goods share.
- Assume $\log(1-\tau_i) \sim N(\theta, v^2)$ and let $1-\bar{\tau} \equiv e^{\theta+\frac{1}{2}v^2}$ reflect the average distortion.
- Then,

$$\operatorname{plim} \log C = \frac{\bar{\sigma}}{1-\bar{\sigma}} \cdot (1-\bar{\tau}) + \log\left(1-\bar{\sigma}(1-\bar{\tau})\right) - \frac{1}{1-\bar{\sigma}} \cdot \frac{1}{2} \cdot v^2$$

Summary

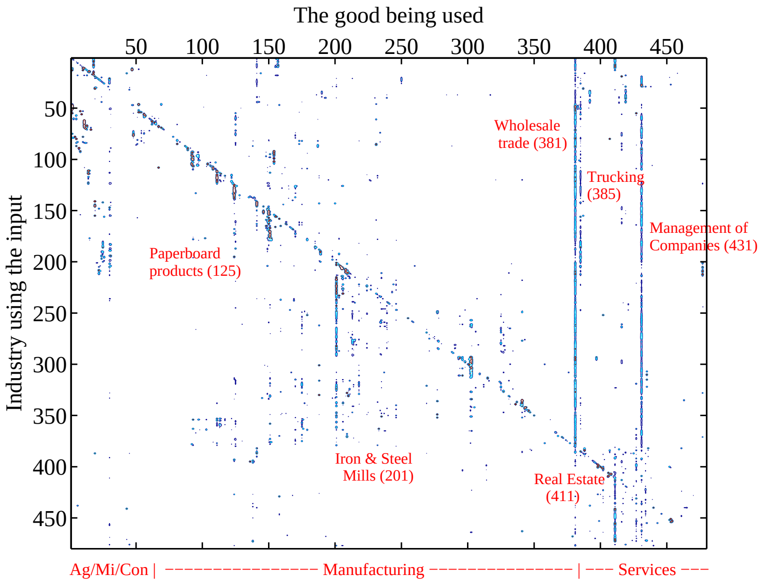
Key Result: The input-output structure of the economy multiplies the effects of distortions.

- Closely related to the Diamond-Mirrlees result about not taxing intermediate goods.
- It would be nice to derive a result for log-normal distortions in the general input-output model, but I have not been able to do so thusfar.
- The multiplier $\tilde{\mu}$ surely plays a key role.

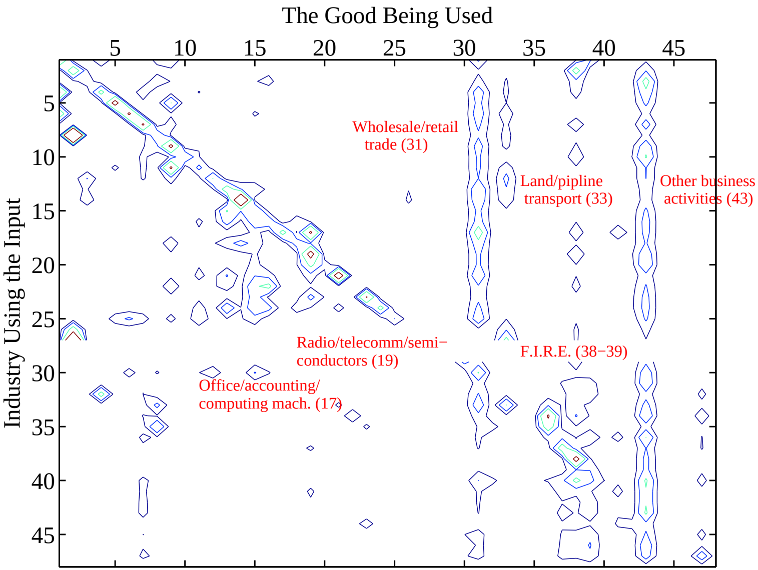
III. Input-Output Economics: Data

The empirical version of the point that $\tilde{\mu} \approx \frac{1}{1-\bar{\sigma}}$

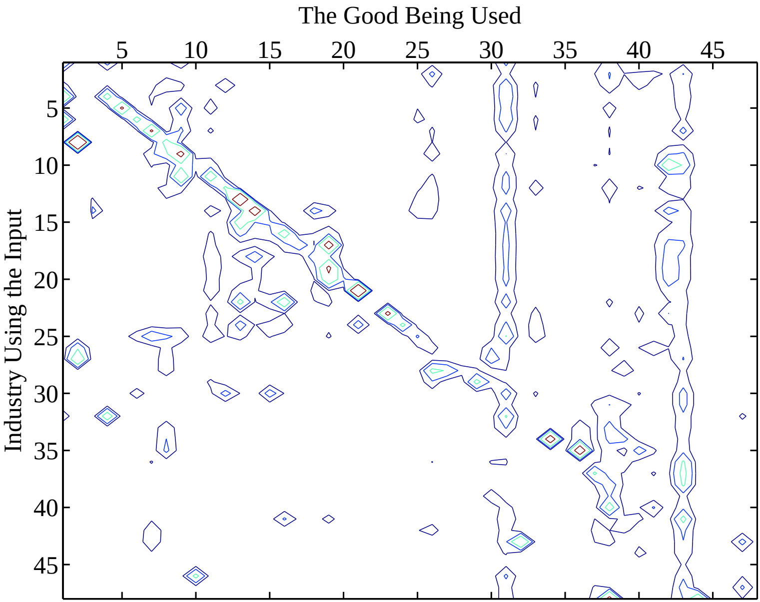
The U.S. Input-Output Matrix, 480 Industries



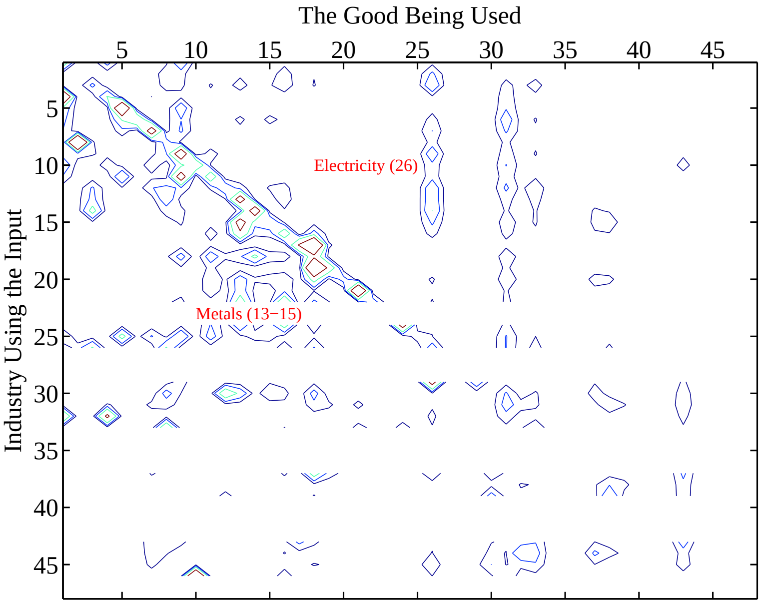
The U.S. Input-Output Matrix, 48 Industries



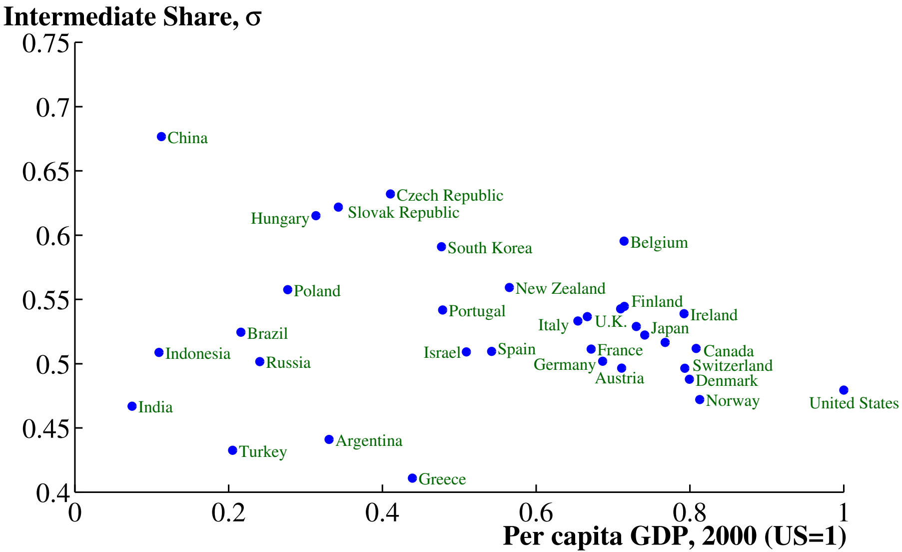
Japan’s Input-Output Matrix, 48 Industries



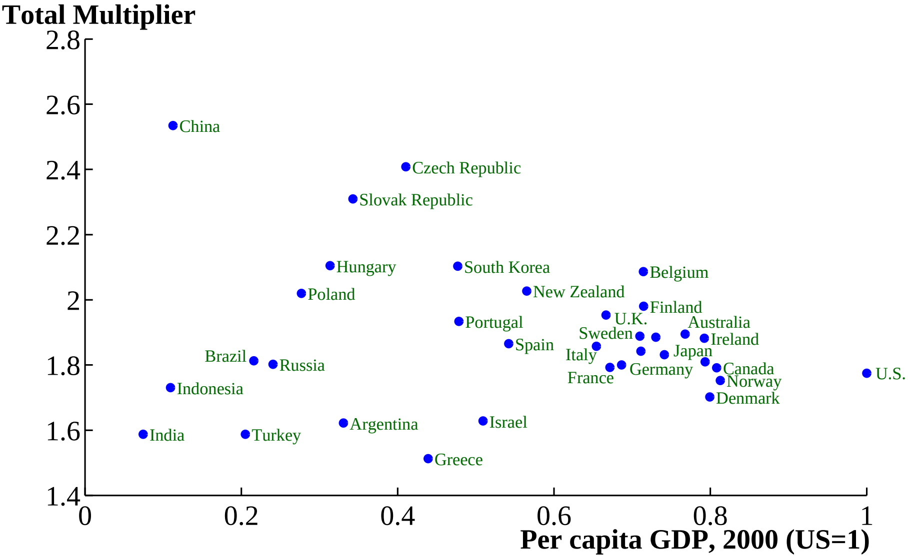
China’s Input-Output Matrix, 48 Industries



The Intermediate Goods Share across Countries



The Multiplier, $\tilde{\mu}$, from 48 Industries



Conclusions

Input-Output Data

- The simple $1/1 - \sigma$ formula works remarkably well.
- Input-output matrices are surprisingly similar across countries.

Input-Output Models

- The input-output structure of an economy has the potential to substantially amplify the effect of distortions.
- If 1/2 of output gets stolen at each stage of production, then the effect on final GDP is much larger: 1/2 of the steel is lost, 1/2 of the cars are lost, and 1/2 of the pizzas are lost — so the steel is essentially stolen three times!

Misallocation

- Intermediate goods are misallocated, just like capital and labor.
- Would be valuable to redo the Hsieh-Klenow (2009) exercise taking this into account.