Misallocation and Aggregate Productivity

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Overview

- Misallocation and Productivity
  - Basic framework
  - Empirical evidence
  - Applications: specific policies and institutions
  - Applications: broader consequences of misallocation
Survey articles:

- Restuccia and Rogerson (RED 2013)
  http://dx.doi.org/10.1016/j.red.2012.11.003

- Restuccia (Palgrave 2013)
  http://dx.doi.org/10.1057/9780230226203.3908

- Hopenhayn (2014)
  http://dx.doi.org/10.1146/annurev-economics-082912-110223

- Restuccia and Rogerson (2017)
  http://doi.org/10.1257/jep.31.3.151
Resource Allocation with Heterogeneous Production

- Based on Restuccia and Rogerson (2008) “Policy Distortions and Aggregate Productivity with Heterogeneous Establishments”
  http://dx.doi.org/10.1016/j.red.2008.05.002

- Extensive literature on income differences across countries with focus on a stand-in firm and aggregate barriers or distortions

- Micro evidence: allocation of resources across productive uses may be important
  - Baily, Hulten, and Campbell (1992)
Assess the quantitative role of resource allocation across productive uses in development

Consider a version of neoclassical growth model with heterogeneous producers

Consider distortions to the prices faced by different producers *(idiosyncratic distortions)*
Idiosyncratic Distortions

- Credit market imperfections and non-competitive banking systems
- Public enterprises
- Trade restrictions
- Labor market regulations
- Corruption and selective government industrial policy
**Model**

- Production unit is the establishment:
  \[ f(s, k, n) = sk^\alpha n^{\gamma}, \quad 0 < \gamma + \alpha < 1 \]

- Idiosyncratic productivity \( s \) constant over time
- Exogenous probability of exit \( \lambda \)
- Fixed cost of operation \( c_f \) every period
- Entry cost \( c_e \) and productivity of entrants from \( cdf \ H(s) \)
Primer on Resource Allocation

- $M$ producers of a single good with production function
  $$y_i = z_i^{1-\gamma} n_i^\gamma, \quad \gamma < 1.$$  

- Efficient allocation maximizes output subject to aggregate resources
  $$\max \{ n_i \geq 0 \} \quad Y^e = \sum_i y_i = z_i^{1-\gamma} n_i^\gamma \quad \text{s.t.} \quad \sum_i n_i = N.$$  

- Efficient allocation: $n_i^e = \frac{z_i}{\sum_i z_i} N$.

- Key features of efficient allocation:
  - More productive establishments allocated more resources, strong association between establishment productivity and size.
  - Equally productive establishments allocated the same amount of resources, hence of same size.
Aggregate production function in the efficient allocation,

\[ Y^e = AN^\gamma M^{1-\gamma} , \]

where

\[ A = \left( \frac{\sum_i z_i M}{M} \right)^{1-\gamma} = \bar{z}^{1-\gamma} . \]

Any allocation that deviates from the efficient allocation will reduce output (even allocating more resources to the more productive producers), will show up as lower \( A \).

Aggregate production function is CRS despite DRS at the establishment level.
Consumers

- Infinitely-lived representative household:
  \[ \sum_{t=0}^{\infty} \beta^t u(C_t), \quad 0 < \beta < 1 \]

- Endowments: One unit of productive time each period, \( K_0 > 0 \) units of the capital stock, and equal shares of all establishments

- Budget constraint:
  \[ \sum_{t=0}^{\infty} p_t (C_t + K_{t+1} - (1 - \delta)K_t) = \sum_{t=0}^{\infty} p_t (r_t K_t + w_t N_t + \pi_t - T_t) \]
Policy Distortions

Focus on policies that create *idiosyncratic* distortions to establishment-level decisions

Each establishment faces its own output tax/subsidy denoted by $\tau \in (-1, 1)$

Entering establishments face draws of $s$ and $\tau$ (assume finite number of possible $s$ and $\tau$)

Given $cdf H(s)$, policy distortions induce a joint distribution $cdf G(s, \tau)$ (pdf $g$)
Incumbent Establishment’s Problem

- Per-period profit function:

\[
\pi(s, \tau) = \max_{n, k} \left\{ \left(1 - \tau\right)sk^{\alpha}n^{\gamma} - wn - rk - cf \right\}
\]

- \(\bar{k}(s, \tau), \bar{n}(s, \tau)\) optimal decisions

- With constant \((s, \tau)\), present value of incumbent plant:

\[
W(s, \tau) = \frac{\pi(s, \tau)}{1 - \rho}, \quad \rho = \frac{1 - \lambda}{1 + R}
\]
The expected value of a potential entrant:

\[ W_e = \sum (s, \tau) \max [W(s, \tau), 0] g(s, \tau) - c_e \]

\( \bar{x}(s, \tau) \) optimal entry decision
Denote $\mu(s, \tau)$ the distribution of producing establishments this period and $E$ the mass of entrants.

Next period’s distribution:

$$\mu'(s, \tau) = (1 - \lambda)\mu(s, \tau) + \bar{x}(s, \tau)g(s, \tau)E$$

Let $\hat{\mu}$ be the invariant distribution associated with $E = 1$:

$$\hat{\mu}(s, \tau) = \frac{\bar{x}(s, \tau)}{\lambda}g(s, \tau)$$
Labor Market Clearing

- Aggregate labor demand:

\[ N(r, w) = E \sum_{(s, \tau)} \bar{n}(s, \tau) \hat{\mu}(s, \tau) \]

- Labor supply inelastic equal to one, entry \( E \) satisfies:

\[ E = \frac{1}{\sum_{(s, \tau)} \bar{n}(s, \tau) \hat{\mu}(s, \tau)} \]
Definition of Equilibrium

A steady state competitive equilibrium with entry is $w, r, T, \mu(s, \tau), E, W(s, \tau), \pi(s, \tau), W_e, \bar{x}(s, \tau), \bar{k}(s, \tau), \bar{n}(s, \tau), C,$ and $K$ such that:

- Consumer optimization $r = 1/\beta - (1 - \delta)$
- Plant optimization
- Free-entry $W_e = 0$
- Market clearing: labor, capital, output
- Government budget balance

$$T + \sum_{s, \tau} \tau f(s, \bar{k}, \bar{n}) \mu(s, \tau) = 0$$

- Invariant $\mu$

$$\mu(s, \tau) = E\frac{\bar{x}(s, \tau)}{\lambda} g(s, \tau)$$
Calibration

- Calibrate undistorted benchmark economy to U.S. data
- Model period equal to a year

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>0.283</td>
<td>Capital income share</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>0.567</td>
<td>Labor income share</td>
</tr>
<tr>
<td>$\beta$</td>
<td>0.96</td>
<td>Real rate of return</td>
</tr>
<tr>
<td>$\delta$</td>
<td>0.08</td>
<td>Investment to output ratio</td>
</tr>
<tr>
<td>$c_e$</td>
<td>1.0</td>
<td>Normalization</td>
</tr>
<tr>
<td>$c_f$</td>
<td>0.0</td>
<td>Benchmark case</td>
</tr>
<tr>
<td>$\lambda$</td>
<td>0.1</td>
<td>Annual exit rate</td>
</tr>
</tbody>
</table>
Key elements: range of $s$ and $H(s)$

Use mapping from $s$ to $n$ and from $H(s)$ to $\mu(s)$ implied by the model

$$\frac{\bar{n}_i}{\bar{n}_j} = \left( \frac{s_i}{s_j} \right)^{\frac{1}{1-\gamma-\alpha}}$$

$$\mu(s) = \frac{\bar{x}(s)}{\lambda} h(s)$$

Number of workers per establishment in U.S. data implies $s \in [1, 3.98]$
Establishments by Employment Size

Cumulative Distribution of Establishments

- Model
- Data

Number of Employees (log scale)

1 10 100 1,000 10,000

0 0.2 0.4 0.6 0.8 1

Macro Growth and Development

University of Oslo
### Distribution Statistics B.E.

<table>
<thead>
<tr>
<th>Establishment Size</th>
<th>Number of Employees</th>
<th>Share of establishments</th>
<th>Share of output</th>
<th>Share of labor</th>
<th>Share of capital</th>
<th>Average employment</th>
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<tr>
<td></td>
<td>&lt; 5</td>
<td>0.56</td>
<td>0.08</td>
<td>0.08</td>
<td>0.08</td>
<td>2.4</td>
</tr>
<tr>
<td></td>
<td>5 to 49</td>
<td>0.39</td>
<td>0.34</td>
<td>0.34</td>
<td>0.34</td>
<td>15.5</td>
</tr>
<tr>
<td></td>
<td>≥ 50</td>
<td>0.05</td>
<td>0.58</td>
<td>0.58</td>
<td>0.58</td>
<td>183.0</td>
</tr>
</tbody>
</table>
Assume a fraction of plants are taxed and the rest are subsidized.

Output tax/subsidy combinations:
   - Tax packages of 0.1, 0.2, 0.3, 0.4, with subsidies so that the net effect on steady state capital accumulation is zero.
   - Lump-sum redistribution to consumers to balance the government budget.
### Uncorrelated Idiosyncratic Distortions

<table>
<thead>
<tr>
<th>Variable</th>
<th>$\tau_0$</th>
<th>$\tau_1$</th>
<th>$\tau_2$</th>
<th>$\tau_3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_s/Y$</td>
<td>0.72</td>
<td>0.85</td>
<td>0.93</td>
<td>0.97</td>
</tr>
<tr>
<td>$S/Y$</td>
<td>0.05</td>
<td>0.08</td>
<td>0.09</td>
<td>0.10</td>
</tr>
<tr>
<td>$\tau_s$</td>
<td>0.06</td>
<td>0.09</td>
<td>0.10</td>
<td>0.11</td>
</tr>
</tbody>
</table>
## Correlated Idiosyncratic Distortions

<table>
<thead>
<tr>
<th>Variable</th>
<th>( \tau_t )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.1</td>
</tr>
<tr>
<td>Relative Y</td>
<td>0.90</td>
</tr>
<tr>
<td>Relative TFP</td>
<td>0.90</td>
</tr>
<tr>
<td>Relative E</td>
<td>1.00</td>
</tr>
<tr>
<td>( Y_s/Y )</td>
<td>0.42</td>
</tr>
<tr>
<td>( S/Y )</td>
<td>0.17</td>
</tr>
<tr>
<td>( \tau_s )</td>
<td>0.40</td>
</tr>
</tbody>
</table>
## Correlated Idiosyncratic Distortions

<table>
<thead>
<tr>
<th>Fraction of Establishments Taxed (%)</th>
<th>$\tau_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.1</td>
</tr>
<tr>
<td>90</td>
<td>0.81</td>
</tr>
<tr>
<td>80</td>
<td>0.84</td>
</tr>
<tr>
<td>60</td>
<td>0.88</td>
</tr>
<tr>
<td>50</td>
<td>0.90</td>
</tr>
<tr>
<td>40</td>
<td>0.92</td>
</tr>
<tr>
<td>20</td>
<td>0.95</td>
</tr>
<tr>
<td>10</td>
<td>0.97</td>
</tr>
</tbody>
</table>
Restuccia and Rogerson (2008)

- Study misallocation by extending the neoclassical growth model with production heterogeneity
- Focus on misallocation (no selection, fixed cost set to zero)
- Consider *idiosyncratic* policy distortions in the form of effective output taxes/subsidies $\tau_i$

$$ (1 - \tau_i) = \frac{1}{\theta} \epsilon_i $$

where $\theta$ controls the elasticity of distortions with respect to productivity (correlated distortions) and $\epsilon_i$ reflects random idiosyncratic distortions (uncorrelated distortions)

- Assume $\epsilon_i$ log normally distributed with mean zero and standard deviation $\sigma_\epsilon$
Restuccia and Rogerson (2008)

- Calibrate benchmark economy with no distortions ($\theta = 0, \sigma_\varepsilon = 0$) to US data: key are moments of productivity distribution $A_i$ (employment-size distribution or estimates of TFP)

- Study the impact of correlated and/or uncorrelated distortions on aggregate output and TFP

- For each economy ($\theta, \sigma_\varepsilon$), report the ratio of TFP in the efficient allocation (benchmark economy) to the distorted economy

<table>
<thead>
<tr>
<th>$\sigma_\varepsilon$</th>
<th>$\theta$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>1.00</td>
</tr>
<tr>
<td>0.1</td>
<td>1.03</td>
</tr>
<tr>
<td>0.4</td>
<td>1.23</td>
</tr>
</tbody>
</table>
Distorted Allocation \((\theta = 0.9, \sigma_{\epsilon} = 0.4)\)
Land Misallocation in Malawi

Restuccia and Santaeulalia-Llopis (2017): Efficient factor reallocation increases aggregate agricultural productivity by 3.4-fold
Idiosyncratic distortions can lead to substantial reallocation of resources across heterogeneous production units.

The impact of this reallocation on aggregate TFP and output per capita can be large.

Given the pervasiveness of institutions, policies, and regulations that induce resource reallocation across productive units, this channel may prove useful in accounting for some of the patterns in output, capital accumulation, and TFP across countries.
Evidence of Misallocation

- An important insight of basic framework (e.g. \( y_i = A_i h_i^\gamma \)) is that to maximize output, the marginal (or average) product of factors should equalize across producers of the same good

\[
(1 - \tau_i)^\gamma \frac{y_i}{h_i} = w
\]

Value of marginal output

- In this context we can define Revenue Productivity as

\[
\text{TFPR}_i \equiv \frac{y_i}{h_i} \propto \frac{1}{(1 - \tau_i)}
\]

- TFPR_i equalizes across producers in the efficient allocation (more productive establishments are larger) whereas in the distorted economy TFPR_i is higher for producers with higher distortions
Evidence of Misallocation

\[ \text{TFPR}_i \equiv \frac{y_i}{h_i} \propto \frac{1}{(1 - \tau_i)} \]

- Suggests two broad approaches to assess the empirical relevance of misallocation: indirect and direct
- Indirect: measure deviations in \( \text{TFPR}_i \) across producers using data on output and inputs
- Direct: Measure specific policies and institutions that generate \( (1 - \tau_i) \) differences
- Remark: The aggregate productivity cost of misallocation depends not only on dispersion in \( \text{TFPR}_i \) but also on dispersion of \( A_i \) (generally joint distribution)
**Indirect Approach**

- Assess extent of misallocation without identifying underlying cause: *Hsieh and Klenow (2009)*

- Evidence points to substantial misallocation and large TFP loses from misallocation

<table>
<thead>
<tr>
<th></th>
<th>SD (log TFPR&lt;sub&gt;i&lt;/sub&gt;)</th>
<th>TFP gains</th>
</tr>
</thead>
<tbody>
<tr>
<td>China (1998)</td>
<td>0.74</td>
<td>115%</td>
</tr>
<tr>
<td>India (1991)</td>
<td>0.67</td>
<td>102%</td>
</tr>
<tr>
<td>India (1994)</td>
<td>0.67</td>
<td>128%</td>
</tr>
<tr>
<td>United States (1997)</td>
<td>0.49</td>
<td>43%</td>
</tr>
</tbody>
</table>
INDIRECT APPROACH

- Evidence of misallocation from many other contexts/countries
- Recent World Bank study using census data for manufacturing in poor African countries (Cirera, Fattal-Jaef, and Maemir 2017)

<table>
<thead>
<tr>
<th>Country</th>
<th>SD (log TFPR(_i))</th>
<th>(\theta)</th>
<th>TFP gains</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cote d’Ivoire</td>
<td>0.65</td>
<td>0.42</td>
<td>31%</td>
</tr>
<tr>
<td>Kenya</td>
<td>1.52</td>
<td>0.52</td>
<td>67%</td>
</tr>
<tr>
<td>Ghana</td>
<td>0.95</td>
<td>0.44</td>
<td>76%</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>0.78</td>
<td>0.53</td>
<td>163%</td>
</tr>
</tbody>
</table>
Empirical evidence of misallocation

- Drawn from: Hsieh and Klenow (2009)
  http://www.jstor.org/stable/40506263
- Simplified static framework
Production Technology

- One homogeneous good produced each period
- Production unit is an establishment with idiosyncratic productivity $s_i$, labor input ($\ell_i$), and capital ($k_i$)
- Fixed number $M$ of establishments
- Production according to a decreasing returns to scale technology,

$$y_i = s_i^{1-\gamma} \left[ \ell_i^{\alpha} k_i^{1-\alpha} \right]^\gamma$$

where $y_i =$ establishment output and $\gamma =$ span-of-control parameter
Efficient Allocation Problem

Planner maximizes total output $Y^e$ subject to resource constraints, given $K$, $L$, and $M$ establishments with idiosyncratic productivity:

$$Y^e = \max \sum_{\{\ell_i, k_i\}_{i=1}^M} s_i^{1-\gamma} (\ell_i^\alpha k_i^{1-\alpha})^\gamma, \ i = 1, 2, \ldots M;$$

subject to

$$L = \sum_{i=1}^M \ell_i; \quad K = \sum_{i=1}^M k_i$$

$Y^e$ is aggregate output under the efficient allocation
Efficient Allocation

\[ l_i = \frac{s_i}{\sum_{j=1}^{M} s_j} L \]

\[ k_i = \frac{s_i}{\sum_{j=1}^{M} s_j} K \]

- Relatively more productive establishments should command relatively more labor and capital in the efficient allocation.
- Establishments with same productivity should be of same size.

\[ Y^e = \left( \sum_{i=1}^{M} s_i \right)^{1-\gamma} (L^\alpha K^{1-\alpha})^\gamma = (\bar{s}M)^{1-\gamma}(L^\alpha K^{1-\alpha})^\gamma \]
Idiosyncratic Distortions

Rationalize actual allocations as an equilibrium outcome of a competitive economy with distortions:

- \( \tau^l_i \) = establishment-specific labor tax (wedge)
- \( \tau^k_i \) = establishment-specific capital tax (wedge)

- Total tax revenues distributed lump sum across all households
Establishment Problem

- Establishment $i$ maximizes profits,

$$\max_{\ell_i,k_i} \left\{ \pi_i = y_i - \left(1 + \tau_{i}^{k}\right) r k_i - \left(1 + \tau_{i}^{\ell}\right) w \ell_i \right\}$$

- $r =$ capital rental rate
- $w =$ labor wage
Market Clearing Conditions

- Labor market clearing condition:
  \[ \sum_{i=1}^{M} \ell_i = L \]

- Capital market clearing condition:
  \[ \sum_{i=1}^{M} k_i = K \]
Use equilibrium framework to identify establishment-specific wedges \( \{ \tau^k_i, \tau^\ell_i \}_{i=1}^M \).

From determination of labor and capital allocations, i.e. wedges that rationalize actual allocations as an equilibrium outcome.
Identification of Wedges

- Establishment-level labor and capital wedges can be identified up to a scalar from the average product of each factor.

- Farm-level FOCs imply,

\[
\frac{MRPL_i}{\alpha \gamma} = \frac{y_i}{\ell_i} = w \left(1 + \tau_i^{\ell}\right) \propto \left(1 + \tau_i^{\ell}\right)
\]

\[
\frac{MRPK_i}{(1 - \alpha)\gamma} = \frac{y_i}{k_i} = r \left(1 + \tau_i^{k}\right) \propto \left(1 + \tau_i^{k}\right)
\]

- \(MRPX = \) marginal (revenue) product of factor \(X\)
Summary Measure of Distortions

Summary measure of distortions for establishment $i$,

$$TFPR_i = \frac{y_i}{\ell^{\alpha_i} k_i^{1-\alpha_i}} = \left( \frac{MRPL_i}{\alpha \gamma_i} \right)^{\alpha_i} \left( \frac{MRPK_i}{(1 - \alpha_i) \gamma_i} \right)^{1-\alpha_i} =$$

$$= \left( 1 + \tau_i \ell_i \right)^{\alpha_i} \left( 1 + \tau_i k_i \right)^{1-\alpha_i} \left( \frac{w}{\alpha \gamma_i} \right)^{\alpha_i} \left( \frac{r}{(1 - \alpha_i) \gamma_i} \right)^{1-\alpha_i}$$

$TFPR = “revenue productivity”$
Aggregation of Factor Distortions

- Average marginal revenue product of labor
  \[ \frac{\alpha \gamma Y}{L} = \frac{w}{\sum_{i=1}^{M} \frac{y_i}{Y} \frac{1}{1+\tau_i^L}} \equiv MRPL \]

- Average marginal revenue product of capital
  \[ \frac{(1 - \alpha) \gamma Y}{K} = \frac{r}{\sum_{i=1}^{M} \frac{y_i}{Y} \frac{1}{1+\tau_i^K}} \equiv MRPK \]

- \( Y = \sum_{i=1}^{M} y_i \) = aggregate real output

- \( K = \sum_{i=1}^{M} k_i \) = aggregate capital input
Aggregate TFP Distorted Economy

\[ TFP = \left[ \sum_{i=1}^{M} \frac{s_i}{M} \left( \frac{TFPR}{TFPR_i} \right)^{\frac{\gamma}{1-\gamma}} \right]^{1-\gamma} \]

where

\[ TFPR = \left( \frac{MRPL}{\alpha \gamma} \right)^\alpha \left( \frac{MRPK}{(1 - \alpha) \gamma} \right)^{1-\alpha} \]

\[ Y = TFP \cdot M^{1-\gamma} (L^{\alpha} K^{1-\alpha})^\gamma \]

Aggregate output \( Y \) in distorted and actual data coincide
Data

- Manufacturing plants in the U.S., China, and India
- Mapping of model to data non trivial but can be done
- Data on real output $y_i$, capital $k_i$, and labor $\ell_i$
- Need to calibrate elasticity parameters $\alpha$ and $\gamma$
- Use establishment-level production function to measure $s_i$, i.e. $TFPQ_i$
Output (TFP) gain from eliminating misallocation given by,

\[
\frac{Y^e}{Y} = \frac{TFP^e}{TFP}
\]

Relates to dispersion in \(TFPR_i\)
Figure 35: The Distribution of TFPQ in 4-digit Manufacturing Industries

Note: This is the average distribution of TFPQ within 4-digit manufacturing industries for the U.S. in 1997, China in 2005, and India in 1994, computed as described in the text. The means across countries are not meaningful. Source: Hsieh and Klenow (2009); data provided by Chang Hsieh.


<table>
<thead>
<tr>
<th></th>
<th>1998</th>
<th>2001</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>China</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S.D.</td>
<td>1.06</td>
<td>0.99</td>
<td>0.95</td>
</tr>
<tr>
<td>75 – 25</td>
<td>1.41</td>
<td>1.34</td>
<td>1.28</td>
</tr>
<tr>
<td>90 – 10</td>
<td>2.72</td>
<td>2.54</td>
<td>2.44</td>
</tr>
<tr>
<td>N</td>
<td>95,980</td>
<td>108,702</td>
<td>211,304</td>
</tr>
<tr>
<td><strong>India</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S.D.</td>
<td>1.16</td>
<td>1.17</td>
<td>1.23</td>
</tr>
<tr>
<td>75 – 25</td>
<td>1.55</td>
<td>1.53</td>
<td>1.60</td>
</tr>
<tr>
<td>90 – 10</td>
<td>2.97</td>
<td>3.01</td>
<td>3.11</td>
</tr>
<tr>
<td>N</td>
<td>31,602</td>
<td>37,520</td>
<td>41,006</td>
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<tr>
<td><strong>United States</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>S.D.</td>
<td>0.85</td>
<td>0.79</td>
<td>0.84</td>
</tr>
<tr>
<td>75 – 25</td>
<td>1.22</td>
<td>1.09</td>
<td>1.17</td>
</tr>
<tr>
<td>90 – 10</td>
<td>2.22</td>
<td>2.05</td>
<td>2.18</td>
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<tr>
<td>N</td>
<td>164,971</td>
<td>173,651</td>
<td>194,669</td>
</tr>
</tbody>
</table>

*Notes.* For plant $i$ in industry $s$, $\text{TFPQ}_{si} = \frac{Y_{si}}{K_{si}^{\bar{s}}(w_{si}L_{si})^{1-\alpha_s}}$. Statistics are for deviations of log(TFPQ) from industry means. S.D. = standard deviation, 75 – 25 is the difference between the 75th and 25th percentiles, and 90 – 10 the 90th vs. 10th percentiles. Industries are weighted by their value-added share. $N =$ the number of plants.
Figure II
Distribution of TFPR
### Table II

**Dispersion of TFPR**

<table>
<thead>
<tr>
<th></th>
<th>1998</th>
<th>2001</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>China</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S.D.</td>
<td>0.74</td>
<td>0.68</td>
<td>0.63</td>
</tr>
<tr>
<td>75 – 25</td>
<td>0.97</td>
<td>0.88</td>
<td>0.82</td>
</tr>
<tr>
<td>90 – 10</td>
<td>1.87</td>
<td>1.71</td>
<td>1.59</td>
</tr>
<tr>
<td><strong>India</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S.D.</td>
<td>0.69</td>
<td>0.67</td>
<td>0.67</td>
</tr>
<tr>
<td>75 – 25</td>
<td>0.79</td>
<td>0.81</td>
<td>0.81</td>
</tr>
<tr>
<td>90 – 10</td>
<td>1.73</td>
<td>1.64</td>
<td>1.60</td>
</tr>
<tr>
<td><strong>United States</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S.D.</td>
<td>0.45</td>
<td>0.41</td>
<td>0.49</td>
</tr>
<tr>
<td>75 – 25</td>
<td>0.46</td>
<td>0.41</td>
<td>0.53</td>
</tr>
<tr>
<td>90 – 10</td>
<td>1.04</td>
<td>1.01</td>
<td>1.19</td>
</tr>
</tbody>
</table>

*Notes. For plant $i$ in industry $s$, TFPR$_{si} = \frac{P_{si}Y_{si}}{K_{si}^{aS}(w_{si}L_{si})^{1-aS}}$. Statistics are for deviations of log(TFPR) from industry means. S.D. = standard deviation. 75 – 25 is the difference between the 75th and 25th percentiles, and 90 – 10 the 90th vs. 10th percentiles. Industries are weighted by their value-added shares. Number of plants is the same as in Table I.*
### TABLE IV
**TFP GAINS FROM EQUALIZING TFPR WITHIN INDUSTRIES**

<table>
<thead>
<tr>
<th></th>
<th>1998</th>
<th>2001</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>115.1</td>
<td>95.8</td>
<td>86.6</td>
</tr>
<tr>
<td>India</td>
<td>1987</td>
<td>1991</td>
<td>1994</td>
</tr>
<tr>
<td>%</td>
<td>100.4</td>
<td>102.1</td>
<td>127.5</td>
</tr>
<tr>
<td>%</td>
<td>36.1</td>
<td>30.7</td>
<td>42.9</td>
</tr>
</tbody>
</table>

**Notes.** Entries are 100\(Y_{\text{efficient}}/Y - 1\) where \(Y/Y_{\text{efficient}} = \prod_{s=1}^{S} \left[ \sum_{i=1}^{M_s} \left( \frac{A_{si}}{K_{si}^\alpha (w_{si} L_{si})^{1-\alpha}} \right) \right]^{\frac{\text{TFPR}_{si}}{\alpha}} - 1 \right) / (\sigma - 1)\) and

\[
\text{TFPR}_{si} = \frac{P_{si} Y_{si}}{K_{si}^{\alpha s} (w_{si} L_{si})^{1-\alpha_s}}.
\]
TABLE VI
TFP GAINS FROM EQUALIZING TFPR RELATIVE TO 1997 U.S. GAINS

<table>
<thead>
<tr>
<th></th>
<th>1998</th>
<th>2001</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>%</td>
<td>50.5</td>
<td>37.0</td>
<td>30.5</td>
</tr>
<tr>
<td>India</td>
<td>1987</td>
<td>1991</td>
<td>1994</td>
</tr>
<tr>
<td>%</td>
<td>40.2</td>
<td>41.4</td>
<td>59.2</td>
</tr>
</tbody>
</table>

Notes. For each country-year, we calculated \( \frac{Y_{\text{efficient}}}{Y} \) using \( Y / Y_{\text{efficient}} = \prod_{s=1}^{S} \left[ \sum_{i=1}^{M_s} \frac{A_{si}}{A_s} \right]^{\theta_s/(\sigma-1)} \) and \( \frac{TFPR_{s_i}}{TFPR_{s_i}^{U.S.}} \).

We then took the ratio of \( Y_{\text{efficient}} / Y \) to the U.S. ratio in 1997, subtracted 1, and multiplied by 100 to yield the entries above.
Indirect Approach

- Approach useful in identifying relevant patterns (within industry, across industry, across time and space, across occupations, etc.)

- But is silent about the specific sources of misallocation

- Identifying causes of misallocation key for policy analysis

- There are also important limitations related to measurement and specification
  - Demand structure to separate price and output from revenue data (not an issue with plant-specific price deflators or when quantity data is available)
  - Specification of production structure
  - Inputs-outputs may be measured with error (Bils, Klenow, and Ruane 2017)
  - Adjustment costs vs. distortions (David and Venkateswaran 2017)
Direct Approach

- Quantifies role of specific policies/institutions creating misallocation either through quasi-natural experiments or via a structural model

- Some examples:
  - Regulation and discretionary provisions
  - Selective industrial policy
  - Financial frictions
  - Trade restrictions
Regulations

- **Firing costs** *(Hopenhayn and Rogerson 1993)*
  - Adjustment costs created by policy generating misallocation
  - Firing cost equivalent to 1 year’s wages (prevalent in some OECD and developing countries) implies a TFP loss of 2%
  - Firing cost equivalent to 5 year’s wages implies dispersion in TFPR of 0.19, correlation log TFPR and TFPQ of 0.76, and TFP loss of 8% *(Hopenhayn 2014)*

- **Size-dependent policies** *(Guner, Ventura, and Xu 2008)*
  - Distortions related to the size of the establishment (e.g. number of employees)
  - Large effects on number of establishments and average size
  - Relatively small effects on TFP
Financial Frictions

- Large literature, survey in Buera, Kaboski, and Shin (2015)
  - Credit constraints generate dispersion in the marginal product of capital across producers
  - Country-level institution, idiosyncratic effects: credit constraints disproportionally affect productive producers that should operate at larger scale
  - TFP loss from this type of misallocation can be large
Causes of Misallocation

Challenges of direct approach:
- Many specific policies/institutions not easily amenable to direct measurement
- Not a single source generating the bulk of misallocation and productivity differences across countries
- Role of misallocation from specific policies quantitatively limited
- Many different policies/institutions needed to account for the data

Some notable exceptions:
- Land market institutions in agriculture (Adamopoulos and Restuccia 2014)
- Changes in policy over time in specific contexts
Land Market Institutions

- Land institutions in poor countries characterized by:
  - Lack of well-defined property rights over land
  - Land use-rights are distributed in a fairly egalitarian basis...
  - ...coupled with difficulty of adjusting operational scales

- As a result, land not allocated to best uses, leading to small operational scales, preventing the adoption of best practices and investment in farm operations

- Evidence points to substantial land (and factor) misallocation in agriculture in poor and developing countries
Large implied correlated distortions in the agricultural sector

$\sigma(\log(\text{TFPR})) = 0.97$, $\rho(\log(\text{TFPR}), \log(\text{TFP})) = 0.88$
Aggregate Implications

- Productivity impact of distortions:
  - Eliminate distortions in agricultural sector in China
  - Result: TFP gain 1.8-fold (Adamopoulos et al 2017)
  - Take US manufacturing distribution of $A_i$’s from Hsieh-Klenow
  - Apply China distortions in agriculture from Adamopoulos et al (2017)
  - Result: TFP gain 4-fold
  - Instead apply China distortions in manufacturing
  - Result: TFP gain 1.6-fold

- Remarks
  - Much larger distortions (misallocation) in agriculture
  - Differences in productivity distribution important
  - Heavier distortions to more productive units prevalent in poor countries, key for broader implications of misallocation
(1) Land reform in Philippines (Adamopoulos and Restuccia 2015)

- Cap in farm size + gov. intervention in the land market (direct excess land to landless/smallholders, restrict reallocation)
- Reform reduces farm size (34%) and aggregate productivity (17%), gov intervention key as market reallocation of excess land generates only 1/3 of the negative effects

(2) Trade reform in Chile (Pavnick 2002)

- Liberalized trade reform on productivity using plant-level data, exploiting differential exposure to external competitive pressure
- Plants in import competing sectors grew 3-10% more than plants in the non-traded sector
- Reallocation of resources from less to more efficient plants and through plant exit contributed substantially to aggregate productivity growth during the period
What accounts for productivity differences across sectors and countries?

Restuccia and Rogerson (2017): Single good produced by $N$ potential heterogeneous production units indexed by $i$ according to

$$y_i = A_i \cdot f(k_i, h_i)$$

where $A_i$ reflects differences in productivity across producers

Fixed cost of operation $c$ in units of output

Efficient allocation: Given aggregate capital $K$ and labor $H$, there is unique threshold $\bar{A}$ such that producers with $A_i > \bar{A}$ operate; and producers with higher $A_i$ are allocated greater amounts of capital and labor
Stylized Efficient Allocation
Stylized Misallocation
Simple Framework of TFP Differences

- Holding the amount of aggregate resources constant, three channels can account for aggregate TFP differences across countries:
  - Distribution of $A_i$’s differs across countries (technology)
  - Countries choose different set of producers to operate (selection)
  - Countries allocate inputs differently across producers (misallocation)

- All channels seem relevant

- Remark: specific policies/institutions generating misallocation can have larger effects on TFP by affecting technology/selection channels
Broader Consequences of Misallocation

- Early misallocation analysis: given a fixed productivity distribution common across countries, assess quantitative impact of factor misallocation (e.g. Restuccia and Rogerson, 2008)
- Recent work considers dynamic implications of misallocation
- Policies/institutions causing misallocation can generate larger effects on aggregate productivity by altering the productivity distribution via technology and selection channels
Broader Consequences of Misallocation

- Distribution of $A_i$’s differs across countries (technology, selection, sample selection?)
- Consider accounting from simple parametric framework discussed earlier and moments from micro/aggregate data in Hsieh and Klenow (2009)
- TFP gain of eliminating distortions China/India relative to US distortions is 60% (half of actual TFP differences)
- Only half (30%) when China/India relative distortions applied to US productivity distribution
- A rough TFP decomposition in manufacturing: misallocation (1/4) + selection (1/4) + technology (1/2)
- Substantial shifts in the productivity distribution via technology/selection required
Some illustrative examples (misallocation + selection):

- Financial frictions (Buera, Kaboski, and Shin 2011; Midrigan and Xu 2014)
  - Distorts entrepreneur-worker choices in addition to misallocation
  - Generates large negative effects on productivity
  - Can account for 40% of non-agricultural productivity differences across countries
Some illustrative examples (**misallocation + selection**):

- **Trade liberalizations**
  - Selection effects important in all the empirical studies of trade liberalizations (also important productivity effects of incumbents)
    - Pavcnik (2002) for Chile
    - Trefler (2004) for the Canada-US Free Trade Agreement
    - Eslava, Haltiwanger, Kugler, and Kugler (2013) for Colombia
  - **Khandelwal, Schott, and Wei (2013)**: elimination of export quotas on Chinese textile and clothing by US, EU, and Canada in 2005, particularly government allocation of quotas to less productive state-owned enterprises; large TFP gain, 70% due to quota misallocation (selection)
Broader Consequences of Misallocation

Some illustrative examples (misallocation + selection):

- Imperfect land markets (Adamopoulos, Brandt, Leight, and Restuccia 2017)
  - Pattern of implicit distortions affect sector choice of highly productive farmers in addition to misallocation
  - In China a 1.8-fold TFP gain in agriculture from eliminating misallocation translates into a 15-fold gain when accounting for selection
Broader Consequences of Misallocation

Some illustrative examples (misallocation + technology):

- Trade liberalization and technology upgrading (Bustos 2011)
- Technology adoption and diffusion (Ayerst 2016)
- Productivity investment and firm dynamics
PLANT LIFE-CYCLE EMPLOYMENT GROWTH

AVERAGE EMPLOYMENT (AGE<5 = 1, LOG SCALE)

Source: Hsieh and Klenow (2014)
Productivity Elasticity of Distortions

Source: Bento and Restuccia (2017)
**Productivity Investment and Firm Dynamics**

- **Bento and Restuccia (2017)** Standard monopolistic competition framework extended to include: endogenous entry and entry-level and life-cycle productivity investment

<table>
<thead>
<tr>
<th>Prod. elasticity of distortions:</th>
<th>0.09 (US)</th>
<th>0.50 (India)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Establishment Size</td>
<td>22</td>
<td>3</td>
</tr>
<tr>
<td>Entrant Productivity</td>
<td>1.00</td>
<td>0.42</td>
</tr>
<tr>
<td>Life-cycle growth (%)</td>
<td>5.0</td>
<td>2.1</td>
</tr>
<tr>
<td>Prod. investment share (%)</td>
<td>13.5</td>
<td>5.4</td>
</tr>
</tbody>
</table>

**Decomposition of agg. output:**

- (a) Static misallocation 1.00 0.63
- (c) Endogenous life-cycle growth 1.00 0.70
- (d) Entrant investment 1.00 0.47
Conclusions

- Productivity at the core of cross-country differences in aggregate economic outcomes
- Misallocation quantitatively important in accounting for productivity differences but...
- ...there is not a single source of misallocation that can account for the bulk of differences
- Current work shows important link between misallocation and technology/selection channels in accounting for productivity differences
- More work is needed in quantifying the dynamic implications of misallocation