Misallocation and Aggregate Productivity across Time and Space

Diego Restuccia
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and NBER

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## GDP per Capita Across Countries and Time

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<tbody>
<tr>
<td>Botswana</td>
<td>2.3</td>
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<td>21.5</td>
<td>29.1</td>
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<tr>
<td>Ethiopia</td>
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<td>Malawi</td>
<td>4.7</td>
<td>4.3</td>
<td>2.1</td>
<td>1.9</td>
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<tr>
<td>Indonesia</td>
<td>5.3</td>
<td>7.1</td>
<td>9.0</td>
<td>19.8</td>
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<td>China</td>
<td>5.6</td>
<td>5.7</td>
<td>9.5</td>
<td>24.6</td>
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<tr>
<td>India</td>
<td>5.9</td>
<td>4.0</td>
<td>4.4</td>
<td>10.5</td>
</tr>
<tr>
<td>Korea</td>
<td>6.2</td>
<td>18.3</td>
<td>50.5</td>
<td>68.2</td>
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<tr>
<td>Zimbabwe</td>
<td>11.3</td>
<td>10.0</td>
<td>6.1</td>
<td>3.1</td>
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<tr>
<td>Singapore</td>
<td>14.3</td>
<td>41.7</td>
<td>83.3</td>
<td>149.7</td>
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<tr>
<td>Japan</td>
<td>30.8</td>
<td>63.2</td>
<td>73.9</td>
<td>68.2</td>
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<tr>
<td>Mexico</td>
<td>32.0</td>
<td>38.1</td>
<td>25.4</td>
<td>31.1</td>
</tr>
<tr>
<td>Austria</td>
<td>53.4</td>
<td>62.9</td>
<td>77.8</td>
<td>92.7</td>
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<tr>
<td>France</td>
<td>59.4</td>
<td>75.4</td>
<td>68.3</td>
<td>76.5</td>
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<tr>
<td>United Kingdom</td>
<td>68.0</td>
<td>64.7</td>
<td>74.9</td>
<td>75.3</td>
</tr>
<tr>
<td>New Zealand</td>
<td>81.2</td>
<td>60.2</td>
<td>59.4</td>
<td>66.0</td>
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</tbody>
</table>
Overview

(1) Differences in income per capita across countries mostly accounted for by total factor productivity (TFP)
   - What accounts for these productivity differences?

(2) Simple framework to discuss/assess potential channels:
   - technology
   - selection
   - misallocation

(3) Evidence of misallocation, causes, and aggregate effects

(4) Broader consequences of misallocation via effects on selection and technology
(1) **TFP and Income Differences**

- Cross-country income differences mostly accounted for by TFP (e.g. Klenow and Rodriguez-Clare 1997; Jones 2016)

- Similar conclusion when accounting for human capital quality differences (e.g. Erosa, Koreshkova, and Restuccia 2010; Manuelli and Seshadri 2014)
### Basic Development Accounting 2010

<table>
<thead>
<tr>
<th></th>
<th>Y/E</th>
<th>((K/Y)^{(1-\alpha)})</th>
<th>(h)</th>
<th>TFP</th>
<th>Contrib. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>—</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>0.85</td>
<td>1.09</td>
<td>0.83</td>
<td>0.94</td>
<td>48.8</td>
</tr>
<tr>
<td>Germany</td>
<td>0.74</td>
<td>1.08</td>
<td>0.92</td>
<td>0.75</td>
<td>57.0</td>
</tr>
<tr>
<td>Japan</td>
<td>0.68</td>
<td>1.22</td>
<td>0.90</td>
<td>0.62</td>
<td>63.9</td>
</tr>
<tr>
<td>South Korea</td>
<td>0.60</td>
<td>1.15</td>
<td>0.93</td>
<td>0.56</td>
<td>65.3</td>
</tr>
<tr>
<td>Argentina</td>
<td>0.38</td>
<td>1.11</td>
<td>0.78</td>
<td>0.44</td>
<td>66.5</td>
</tr>
<tr>
<td>Mexico</td>
<td>0.34</td>
<td>0.93</td>
<td>0.76</td>
<td>0.48</td>
<td>59.7</td>
</tr>
<tr>
<td>China</td>
<td>0.14</td>
<td>1.14</td>
<td>0.71</td>
<td>0.17</td>
<td>82.9</td>
</tr>
<tr>
<td>India</td>
<td>0.10</td>
<td>0.82</td>
<td>0.53</td>
<td>0.22</td>
<td>67.0</td>
</tr>
<tr>
<td>Malawi</td>
<td>0.02</td>
<td>1.11</td>
<td>0.51</td>
<td>0.04</td>
<td>93.6</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>0.21</td>
<td>0.98</td>
<td>0.71</td>
<td>0.31</td>
<td>63.8</td>
</tr>
</tbody>
</table>

Source: Jones (2016)
(2) **Simple Framework of TFP Differences**

- What accounts for productivity differences across countries?
- One explanation is that poor countries are slow in adopting advanced technologies and best practices.
- Another distinct but complementary explanation is that resources are not allocated to best uses among heterogeneous producers in poor countries causing misallocation.
- Draws from Restuccia and Rogerson (2017)
(2) **Simple Framework of TFP Differences**

- In each period, a single good produced by $M$ potential heterogeneous production units indexed by $i$

- Output $y_i$ is produced according to

$$y_i = A_i \cdot h_i^\gamma, \quad \gamma \in (0, 1)$$

where $A_i$ reflects productivity differences across producers, $h_i$ is labor input, and $\gamma$ measures the extent of decreasing returns to scale at the establishment level

- Fixed cost of operation $c$ in units of output
Efficient allocation:

- Consider the efficient allocation of labor across producers that maximizes aggregate output net of operation costs.

- Given aggregate labor $H$, there is a unique threshold $\bar{A}$ such that producers with $A_i \geq \bar{A}$ operate, producers with $A_i < \bar{A}$ do not operate.

- Among operating producers, those with higher $A_i$ are allocated greater amount of labor, producers with the same productivity operate at the same scale.
Stylized Efficient Allocation

\[ \log h_i = \log A_i \]

Restuccia

Aggregate Productivity

CEA Meeting 2017
Stylized Misallocation

The graph shows a linear relationship between \( \log A_i \) and \( \log h_i \) with data points and a line representing efficient data. The x-axis represents \( \log A_i \) ranging from 0 to 1, and the y-axis represents \( \log h_i \) ranging from 0 to 0.7. The line and data points indicate a direct proportionality between the two variables.
(2) 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
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 $\tau_i$

\[
(1 - \tau_i) = \frac{1}{A_i^\theta} \epsilon_i
\]

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 $\sigma_\epsilon$
Calibrate benchmark economy with no distortions ($\theta = 0, \sigma_\epsilon = 0$) 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 ($\theta, \sigma_\epsilon$), report the ratio of TFP in the efficient allocation (benchmark economy) to the distorted economy

<table>
<thead>
<tr>
<th>$\sigma_\epsilon$</th>
<th>0</th>
<th>0.5</th>
<th>0.9</th>
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<tr>
<td>0</td>
<td>1.00</td>
<td>1.10</td>
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<td>0.1</td>
<td>1.03</td>
<td>1.12</td>
<td>2.07</td>
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<tr>
<td>0.4</td>
<td>1.23</td>
<td>1.43</td>
<td>2.72</td>
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</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
(3) **Evidence of Misallocation**

- An important insight of basic framework is that to maximize output, the marginal (or average) product of factors should equalize across producers of the same good

$$
(1 - \tau_i) \gamma \frac{y_i}{h_i} \gamma \frac{1}{h_i} = w \\
\text{Value of marginal output}
$$

- 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**


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

<table>
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<tr>
<th></th>
<th>SD (log TFPR(_i))</th>
<th>TFP gains</th>
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<tbody>
<tr>
<td>China (1998)</td>
<td>0.74</td>
<td>115%</td>
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<td>India (1991)</td>
<td>0.67</td>
<td>102%</td>
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<tr>
<td>India (1994)</td>
<td>0.67</td>
<td>128%</td>
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<tr>
<td>United States (1997)</td>
<td>0.49</td>
<td>43%</td>
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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.
**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 TFPRᵢ)</th>
<th>θ</th>
<th>TFP gains</th>
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<tr>
<td>Cote d’Ivoire</td>
<td>0.65</td>
<td>0.42</td>
<td>31%</td>
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<tr>
<td>Kenya</td>
<td>1.52</td>
<td>0.52</td>
<td>67%</td>
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<tr>
<td>Ghana</td>
<td>0.95</td>
<td>0.44</td>
<td>76%</td>
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<tr>
<td>Ethiopia</td>
<td>0.78</td>
<td>0.53</td>
<td>163%</td>
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**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
Land Misallocation in China

Large implied correlated distortions in the agricultural sector

\[ \sigma(\log(TFPR)) = 0.97, \quad \rho(\log(TFPR), \log(TFP)) = 0.88 \]
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
Changes in Policy in Specific Contexts

(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
(4) 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
(4) **Broader Consequences of Misallocation**

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)
(4) 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
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

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

Source: Bento and Restuccia (2017)
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>Productivity Investment and Firm Dynamics</th>
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<tbody>
<tr>
<td><strong>Bento and Restuccia (2017)</strong> Standard monopolistic competition framework extended to include: endogenous entry and entry-level and life-cycle productivity investment</td>
</tr>
</tbody>
</table>

<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>
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</tbody>
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<table>
<thead>
<tr>
<th>Decomposition of agg. output:</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Static misallocation</td>
</tr>
<tr>
<td>(c) Endogenous life-cycle growth</td>
</tr>
<tr>
<td>(d) Entrant investment</td>
</tr>
</tbody>
</table>
CONCLUSION

- 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