Resource Reallocation and Aggregate Productivity: Firm dynamics in Korean Manufacturing

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Motivation

• Sources of aggregate productivity growth

1. Allocative efficiency gains associated with shifting labor and capital out of small, less-productive firms into large, more-productive firms

2. Technical efficiency gains associated with innovation, better management, etc

• Estimate the aggregate productivity growth in the Korean manufacturing industry in recent two decades

• Investigate the role of each source in the aggregate productivity growth
In 2012, compared to the manufacturing industry, the data represent:

<table>
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<tr>
<th>Number of plants</th>
<th>Employees</th>
<th>Gross output</th>
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<tr>
<td>17%</td>
<td>72%</td>
<td>87%</td>
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Source: 1) Gross output: Input-Output table from the Bank of Korea
2) Number of plants and employees: Bank of Korea
1991~2014 Manufacturing Employment and value added growth

Source: Statistics Korea "Korean Mining and Manufacturing Survey"
Methodology

- Estimate manufacturing plant’s contribution to the change in aggregate final demand

- Use Petrin and Levinsohn (2012)’s definition of APG (aggregate productivity growth) and quantify the contribution of resource reallocation and technical efficiency to the APG.

  - Decompose at any level of aggregation (age, size, industry)

- Petrin, White, Reiter (2011) find that APG in U.S. manufacturing between 1976 and 1996 was 2.2% on average and the contribution of resource reallocation was larger than the contribution of technical efficiency growth.

- Kwon, Narita, Narita (2015) find that the contribution of resource reallocation declined during 1990s and was negative when a financial crisis occurred in the late 1990s.
Methodology: Decomposing aggregate productivity growth

- Aggregate productivity growth (APG): the change in final demand minus the change in the aggregate expenditures on labor and capital.

\[ APG \equiv \sum_i P_i dY_i - \sum_i \sum_f W_{if} dX_{if} \]

where \( Y_i \): final demand, \( X_{if} \): inputs, \( W_{if} \): input costs

Using the national accounting identity, \( \sum_i P_i Y_i = \sum_i VA_i \),

\[ APG = \sum_i dVA_i - \sum_i \sum_f W_{if} dX_{if} \]
Methodology: Decomposing aggregate productivity growth

\[ APG = (1) \text{ productivity gains from technical efficiency (TE)} + (2) \text{ resource reallocation across plants (RE)} + (3) \text{ net entry of plants (NE)} \]

\[ APG_t = TE_t + RE_t + NE_t \]

\[ TE_t = \sum_{i \in C_t} \bar{D}_{it} \Delta \ln A_{it} \]

where \( A_{it} \): TFP

\[ D_{it} = \text{gross output/aggregate value added: Domar weight} \]

\[ \bar{x}_{it} = \frac{x_{i,t-1} + x_{it}}{2} \]

TE is the sum of weighted plant-level changes in TFP using the ratio of plant-level revenue to aggregate final demand as the weight.
Methodology: Decomposing aggregate productivity growth

\[ APG_t = TE_t + RE_t + NE_t \]

\[ RE_t = \sum_f RE_{ft} = \sum_f \sum_{i \in C_t} \bar{D}_{it} (\varepsilon_{if} - \bar{s}_{ift}) \Delta \ln X_{ift} \]

where

\[ D_{it} = \text{gross output/aggregate value added: Domar weight} \]

\[ \varepsilon_{if} := \frac{\partial Y_i / Y_i}{\partial X_{if} / X_{if}} : \text{elasticity of output to input, } X_{if} \]

\[ f \in \{ \text{labor}(L), \text{capital}(K), \text{materials}(M) \} \]

\[ s_{ift} := W_{ift} X_{ift} / Y_{it}: \text{ratio of costs to gross output} \]

- RE is the weighted sum of the change in input.
  - The weight \((\varepsilon_{if} - \bar{s}_{ift})\) is the gap between the marginal product and the unit cost of input.
  - RE increases when inputs are reallocated to plants with larger gap from plants with smaller gap.
Methodology: Decomposing aggregate productivity growth

\[ APG_t = TE_t + RE_t + NE_t \]

\[ NE_t = \sum_{i \in \epsilon_t} D_{it} \left[ 1 - \sum_f S_{ift} \right] - \sum_{i \in \chi_{t-1}} D_{i,t-1} \left[ 1 - \sum_f S_{if,t-1} \right] \]

where

\[ D_{it} = \text{gross output/aggregate value added: Domar weight} \]

\[ s_{ift} := W_{ift} X_{ift} / Y_{it} : \text{ratio of costs to gross output} \]

NE is output (net of input use) added by the net entry of plants
Productivity Estimation

Estimation of Productivity

\[ \ln Y_{it} = \ln A_{it} + \alpha_K \ln K_{it} + \alpha_L \ln L_{it} + \alpha_M \ln M_{it} \]

- Estimate \( \alpha_K, \alpha_L \) and \( \alpha_M \), the elasticity parameters of capital, labor and materials, for each 3 digit industries (82 industries)
  - apply Wooldridge, Levinsohn and Petrin (2009) method to control simultaneity issue and selection bias
  - Estimated parameters are the elasticity of output to input, \( \varepsilon_{if} = \alpha_f \).
1995~2013 Manufacturing
Aggregate productivity growth decomposition

[Graph showing aggregate productivity growth from 1996 to 2013 with data points for each year, including TE, RE, NE, and APG categories.]
Results

1995~2013 Manufacturing
Aggregate productivity growth decomposition

[Graph showing productivity growth over the years from 1996 to 2013, with different color lines representing different factors.]
Baily, Hulten, Campbell (1992) is commonly used to compute aggregate productivity growth.

\[ BHC_t = \sum_{i \in \mathcal{C}_t} D_{it} \ln A_{it} - \sum_{i} D_{it-1} \ln A_{it-1} \]

\[ BHC_t = TE_t + BHC_RE_t + BHC_NE_t \]

\[ TE_t = \sum_{i \in \mathcal{C}_t} \bar{D}_{it} \Delta \ln A_{it} \]

\[ BHC_RE_t = \sum_{i \in \mathcal{C}_t} \bar{A}_{it} \Delta D_{it} \]

\[ BHC_NE_t = \sum_{i \in \mathcal{C}_t} D_{it} \ln A_{it} - \sum_{\chi_{t-1}} D_{it-1} \ln A_{it-1} \]

- BHC reallocation is the weighted change in shares with the weight of plant-level TFP.
Results: APG VS BHC

Aggregate productivity growth
APG VS BHC

[Graph showing productivity growth comparison between APG and BHC from 1996 to 2013]
Reallocation effects
APG VS BHC

![Graph showing reallocation effects between APG and BHC from 1996 to 2013. The graph compares the differences over time, with two lines representing RE and BHC_RE.]
Results: APG VS BHC

Net entry effects
APG VS BHC


NE BHC_NE
Results: Reallocation during crisis


[Graph showing APG decomposition for various industries during the Asian Financial Crisis]
Results: Reallocation during crisis

APG decomposition during

Global Financial Crisis (2008~2009)
Results: Role of young plants

Aggregate productivity growth
Young (up to 5 years old) VS Old
Results: Role of small plants

Aggregate productivity growth
Small (up to 300 employees) VS Big

[Graph showing productivity growth over years for Small (APG_S300) and Big (APG_B300) categories, with APG as a reference.]
Results: Productivity by size

Productivity by plant’s size (number of employee)

Labor productivity

Total factor productivity
Results: Productivity by size

Productivity by plant’s size

Domar weighted sum

Total factor productivity
Proportion of number of plants by plant’s size
Results: Productivity by size

Proportion of number of employees by plant’s size
Results: Productivity by size

Proportion of value added by plant’s size
Results: Productivity by age

Productivity by plant’s age

Labor productivity

Total factor productivity
Results: Productivity by age

Productivity by plant’s age

Domar weighted sum

Total factor productivity
Results: Productivity by age

Proportion of number of plants by plant’s age

![Graph showing proportion of number of plants by plant's age](image-url)
Results: Productivity by age

Proportion of number of employees by plant’s age
Results: Productivity by age

Proportion of value added by plant’s age

![Graph showing proportion of value added by plant’s age over time.](image-url)
Misallocation and Manufacturing TFP in Korea 1982-2007

by Kim, Oh, Shin (2017)


- We find an improvement in allocative efficiency during the first decade and a reversal after 1992.
Misallocation and Manufacturing TFP in Korea
1982-2007

- Firm faces firm specific wedges that affect marginal product of inputs

\[
\max_{L_{si}, K_{si}} = (1 - \tau_{Ysi})P_{si}Y_{si} - \omega L_{si} - (1 + \tau_{Ksi})RK_{si}
\]

- Revenue productivity (TFPR) is proportional to the geometric average of marginal products of capital and labor.

\[
TFPR_{si} \equiv P_{si}A_{si} \frac{\sigma}{1 - \sigma} \left(\frac{R}{\alpha_s}\right)^{\alpha} \left(\frac{\omega}{1 - \alpha_s}\right)^{1 - \alpha_s} \frac{(1 + \tau_{Ksi})^{\alpha_s}}{1 - \tau_{Ysi}}
\]

\[
TFP_s = \frac{Y_s}{K_s^{\alpha_s}L_s^{1-\alpha_s}} \left(\sum_{i=1}^{M_s} \left(\frac{A_{si}}{TFPR_s} \frac{TFPR_{si}}{TFPR_{si}}\right)^{\frac{1}{\sigma-1}}\right)^{\frac{1}{\sigma-1}}
\]
Misallocation and Manufacturing TFP in Korea 1982-2007

- Industry-level TFP is

\[ TFP_s = \frac{Y_s}{K_s^{\alpha_s} L_s^{1-\alpha_s}} \left( \sum_{i=1}^{M_s} \left( A_{si} \frac{TFPR_s}{TFPR_{si}} \right)^{\sigma-1} \right)^{\frac{1}{\sigma-1}} \]

- Without distortions, \( TFPR_s = TFPR_{si} \ \forall \ i \)

\[ TFP_s = \bar{A}_s \equiv \left( \sum_{i=1}^{M_s} A_{si}^{\sigma-1} \right)^{\frac{1}{\sigma-1}} \]

- Ratio between the final goods produced with and without distortions

\[ \frac{Y}{Y_{eff}} = \prod_{s=1}^{S} \left( \frac{TFP_s}{\bar{A}_s} \right)^{\theta_s} = \prod_{s=1}^{S} \left( \sum_{i=1}^{M_s} \left( \frac{A_{si}}{\bar{A}_s} \frac{TFPR_s}{TFPR_{si}} \right)^{\sigma-1} \right)^{\frac{\theta_s}{\sigma-1}} \]
### Table 1: Evolution of Allocative Efficiency, 1982—2007

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<tbody>
<tr>
<td>$Y/Y_{eff}$</td>
<td>0.55</td>
<td>0.61</td>
<td>0.62</td>
<td>0.59</td>
<td>0.57</td>
<td>0.54</td>
</tr>
<tr>
<td>Implied TFP gains (%)</td>
<td>81.8</td>
<td>63.9</td>
<td>61.3</td>
<td>69.5</td>
<td>75.4</td>
<td>85.2</td>
</tr>
<tr>
<td>Std. dev. log TFPR</td>
<td>0.68</td>
<td>0.63</td>
<td>0.61</td>
<td>0.66</td>
<td>0.67</td>
<td>0.71</td>
</tr>
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Fig. 1: Excess Production by Establishment Age: 1982, 1992 and 2007
Fig. 2: Excess Production by Establishment Size: 1982, 1992 and 2007