From Firm Productivity Dynamics to Aggregate Efficiency

Bernabe Lopez-Martin
Banco de México

ABCD Conference “Productivity, Growth, and the Law”
Mexico City, June 15-16 2015
Disclaimer

The views expressed in this presentation are exclusively those of the author and do not necessarily represent those of Banco de Mexico.
Productivity Growth of Firms over their Life Cycle

- USA
- MEXICO

Productivity (TFPQ in log base 2) vs Age of Firm

Age of Firm:
- 1-5
- 10-15
- 20-25
- 30-35

Productivity Levels:
- USA: Increasing trend
- MEXICO: Initial growth followed by stabilization
Introduction

TFP largely accounts for cross-country GDP per capita differences.
Introduction

TFP largely accounts for cross-country GDP per capita differences. (e.g. Caselli, 2005: capital + human capital explains <50% cross country income per capita)

Part of these TFP differences have been attributed to:

• Larger dispersion of marginal product of capital and labor across firms in developing economies, misallocation.
  ▶ Evidence found in many countries: Hsieh & Klenow (2009), Busso, Madrigal & Pages (2012).
  ▶ For example: reducing dispersion across manufacturing plants in Mexico to level of US implies a TFP gain of approx. 50%.

• Lower growth of productivity at the firm level (Hsieh & Klenow, 2014).

What models (and frictions) can explain these observations?
Introduction

TFP largely accounts for cross-country GDP per capita differences. (e.g. Caselli, 2005: capital + human capital explains <50% cross country income per capita)

Part of these TFP differences have been attributed to:

- Larger dispersion of marginal product of capital and labor across firms in developing economies, *misallocation*.

Evidence found in many countries: Hsieh & Klenow (2009), Busso, Madrigal & Pages (2012).

For example: reducing dispersion across manufacturing plants in Mexico to level of US implies a TFP gain of approx. 50%.

- Lower growth of productivity at the firm level (Hsieh & Klenow, 2014).

What models (and frictions) can explain these observations?
TFP largely accounts for cross-country GDP per capita differences. (e.g. Caselli, 2005: capital + human capital explains <50% cross country income per capita)

Part of these TFP differences have been attributed to:
  
  ● Larger dispersion of marginal product of capital and labor across firms in developing economies, *misallocation*.
    
    ▶ Evidence found in many countries: Hsieh & Klenow (2009), Busso, Madrigal & Pages (2012).
    
    ▶ For example: reducing dispersion across manufacturing plants in Mexico to level of US implies a TFP gain of approx. 50%.
Introduction

TFP largely accounts for cross-country GDP per capita differences. (e.g. Caselli, 2005: capital + human capital explains <50% cross country income per capita)

Part of these TFP differences have been attributed to:

- Larger dispersion of marginal product of capital and labor across firms in developing economies, *misallocation.*
  - Evidence found in many countries: Hsieh & Klenow (2009), Busso, Madrigal & Pages (2012).
  - For example: reducing dispersion across manufacturing plants in Mexico to level of US implies a TFP gain of approx. 50%.

- Lower growth of productivity at the firm level (Hsieh & Klenow, 2014).
Introduction

TFP largely accounts for cross-country GDP per capita differences. (e.g. Caselli, 2005: capital + human capital explains <50% cross country income per capita)

Part of these TFP differences have been attributed to:

• Larger dispersion of marginal product of capital and labor across firms in developing economies, *misallocation*.
  ▶ Evidence found in many countries: Hsieh & Klenow (2009), Busso, Madrigal & Pages (2012).
  ▶ For example: reducing dispersion across manufacturing plants in Mexico to level of US implies a TFP gain of approx. 50%.

• Lower growth of productivity at the firm level (Hsieh & Klenow, 2014).

What models (and frictions) can explain these observations?
What frictions can generate misallocation?

- Financial constraints: firms without sufficient collateral are not able to produce with optimal level of capital, then mg. product of capital is not equalized across firms.
What frictions can generate misallocation?

- Financial constraints: firms without sufficient collateral are not able to produce with optimal level of capital, then mg. product of capital is not equalized across firms.
- However: models of financial constraints and firm dynamics generate modest TFP losses through misallocation relative to data (4-5% in Midrigan & Xu, 2013).
Introduction

Additional channel through which financial constraints affect TFP:

- Financial constraints affect incentives to invest in **knowledge/intangible capital**: if entrepreneur is not able to produce at optimal scale (e.g. optimal level of physical capital) will reduce investments in productivity,
Introduction

Additional channel through which financial constraints affect TFP:

- Financial constraints affect incentives to invest in **knowledge/intangible capital**: if entrepreneur is not able to produce at optimal scale (e.g. optimal level of physical capital) will reduce investments in productivity,

- then financial constraints reduce the growth of productivity at the firm level, reducing aggregate TFP.
Introduction

To analyze this mechanism we can extend previous models w/endogenous firm productivity accumulation:

- firms make investments to improve productivity every period (Pakes & McGuire, 1994; Klette & Kortum, 2004), firm productivity evolves stochastically,
To analyze this mechanism we can extend previous models with endogenous firm productivity accumulation:

- firms make investments to improve productivity every period (Pakes & McGuire, 1994; Klette & Kortum, 2004), firm productivity evolves stochastically,
- the model can tell us how much of the differences in the productivity growth of firms and aggregate TFP across countries is accounted for by financial constraints.
Productivity Growth of Firms over their Life Cycle

USA

MEXICO

productivity (TFPQ in log base 2)

age of firm
Distribution of Employment by Size of Firm

USA

MEXICO
In the model the following mechanisms come into play:

- financial constraints lower the incentives of entrepreneurs to invest in productivity (entrepreneur will not be able to produce at optimal level and reap benefits of higher productivity),
- lower wages lead to lower ability individuals entering the economy (a standard result since Lucas, 1978).
Quantitative Model: Outline

Main elements of the model:
- occupational choice: entrepreneur or worker,
- financial constraints,
- investment in knowledge capital (stochastic),
- small open economy,
- (extended model with productivity shocks, informal sector in paper).

Entrepreneur w/ability $\varphi$ (fixed) has access to the technology:

$$q = (\varphi n)^{1-\nu} f(k, l)^\nu$$

where:

- $q$ is production of final good,
- $f(k, l) = k^\alpha l^{1-\alpha}$, $\nu \in (0, 1)$ decreasing returns-to-scale,
- $\varphi$ is permanent ability of the entrepreneur, distribution $h(\varphi)$,
- knowledge capital $n$, accumulated through investment in innovation good $x$. 

Innovation Technology

- Every period knowledge capital $n$ can **increase**:

$$P(n' = n(1 + \Delta) \mid n, x) = (1 - \gamma) \frac{(1 - \lambda) a(x/n)}{1 + a(x/n)} + \gamma$$
Innovation Technology

- Every period knowledge capital \( n \) can **increase**:

\[
P(n' = n(1 + \Delta) \mid n, x) = (1 - \gamma) \frac{(1 - \lambda) a(x/n)}{1 + a(x/n)} + \gamma
\]

- Probability of a **decrease** (*bad shock*) in knowledge capital:

\[
P(n' = n/(1 + \Delta) \mid n, x) = \frac{(1 - \gamma) \lambda}{1 + a(x/n)}
\]

- With remaining probability, remains **unchanged**.
Workers

\[ s = \{ \varphi, n_w, b \}, \] problem of worker is a savings \( b' \geq 0 \) decision:

\[
v_w(s) = \max_{\{b' \geq 0\}} \left[ u(c) + \beta (1 - \mu) \sum_{\{z'\}} Q(z') v(s') \right]
\]

s.t. \( c + b' = w + (1 + r) b \)
Workers

\[ s = \{ \varphi, n_w, b \}, \text{ problem of worker is a savings } b' \geq 0 \text{ decision:} \]

\[
v_w(s) = \max_{\{b' \geq 0\}} u(c) + \beta (1 - \mu) \sum_{\{z'\}} Q(z') v(s')
\]

\[ s.t. \quad c + b' = w + (1 + r) b \]

and occupation decision with random opportunity \( z \in \{0, 1\} \):

\[
v(s) = \max\{v_e(z \varphi, n_w, b), v_w(s)\}
\]

initial level of knowledge capital available to the worker is \( n_w \).
s = \{\varphi, n, b\}, entrepreneurs choose b' \geq 0 and x \geq 0 to max:

\[ v_e(s) = u(c) + \beta (1 - \mu) \sum_{\{n'\}} P(n' | n, x) \max\{v_w(s'), v_e(s')\} \]

subject to budget constraint:

\[ c + b' = \pi(s) - x + (1 + r) b \]
Entrepreneurs

\[ s = \{ \varphi, n, b \} , \text{ entrepreneurs choose } b' \geq 0 \text{ and } x \geq 0 \text{ to max:} \]

\[ v_e(s) = u(c) + \beta (1 - \mu) \sum_{n'} P(n' \mid n, x) \max\{ v_w(s'), v_e(s') \} \]

subject to budget constraint:

\[ c + b' = \pi(s) - x + (1 + r) b \]

profits are \( \pi(s) = q - (\delta + r) k - wI \) subject to constraint (next slide): \( k \leq \overline{k}(s) \).
Financial Enforcement Constraint

In the case of no-default the entrepreneur receives $\text{ND}$:

$$\max_{\{I\}} q - w I - (r + \delta) k - x + (1 + r) b$$

while in the case of default the entrepreneur would receive $\text{D}$:

$$\max_{\{I\}} (1 - \psi) (q - w I + (1 - \delta) k) - x$$

A capital level is **enforceable** if it satisfies $\text{ND} \geq \text{D}$, implying a bound $\bar{k}(s)$ on capital rental (a reduced form of capturing differences in property rights/creditor protection).
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta (1 - \mu)$</td>
<td>0.92</td>
<td>effective discount factor</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>1.50</td>
<td>risk aversion</td>
</tr>
<tr>
<td>$r$</td>
<td>0.04</td>
<td>interest rate (small open economy)</td>
</tr>
<tr>
<td>$\nu$</td>
<td>0.85</td>
<td>span-of-control</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>1/3</td>
<td>income share of capital</td>
</tr>
<tr>
<td>$\delta$</td>
<td>0.08</td>
<td>capital depreciation rate</td>
</tr>
<tr>
<td>$a$</td>
<td>3.00</td>
<td>innovation technology</td>
</tr>
<tr>
<td>$\lambda$</td>
<td>0.70</td>
<td>innovation technology</td>
</tr>
</tbody>
</table>
### Calibrated Parameters - US Moments.

<table>
<thead>
<tr>
<th>parameter</th>
<th>symbol</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>exogenous exit rate</td>
<td>$\mu$</td>
<td>0.05</td>
</tr>
<tr>
<td>firm entry probability</td>
<td>$\theta$</td>
<td>0.04</td>
</tr>
<tr>
<td>Pareto dist.</td>
<td>$\theta$</td>
<td>4.34</td>
</tr>
<tr>
<td>innovation technology</td>
<td>$\gamma$</td>
<td>0.24</td>
</tr>
<tr>
<td>initial knowledge capital</td>
<td>$n_w/n$</td>
<td>1.91</td>
</tr>
<tr>
<td>size innovation steps</td>
<td>$\Delta$</td>
<td>0.38</td>
</tr>
</tbody>
</table>

### Target Statistics

<table>
<thead>
<tr>
<th>statistic</th>
<th>data</th>
<th>model</th>
</tr>
</thead>
<tbody>
<tr>
<td>death rate large firms</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>total firm entry/exit rate</td>
<td>0.10</td>
<td>0.11</td>
</tr>
<tr>
<td>std. deviation growth rates</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>relative size firms [20-25]/[1-5] years</td>
<td>2.48</td>
<td>2.46</td>
</tr>
<tr>
<td>employment at firms w/50+ workers</td>
<td>0.69</td>
<td>0.60</td>
</tr>
<tr>
<td>knowledge capital investment/total output</td>
<td>4.40</td>
<td>3.83</td>
</tr>
</tbody>
</table>
Quantitative Exercise

We lower $\psi$ to target the ratio of private credit/output in an emerging economy of 20%.
### Main Results

<table>
<thead>
<tr>
<th>statistics</th>
<th>US</th>
<th>EE</th>
</tr>
</thead>
<tbody>
<tr>
<td>weighted firm productivity</td>
<td>1.00</td>
<td>0.80</td>
</tr>
<tr>
<td>TFP</td>
<td>1.00</td>
<td>0.92</td>
</tr>
<tr>
<td>aggregate output</td>
<td>1.00</td>
<td>0.66</td>
</tr>
<tr>
<td>firm productivity [20-25]/[1-5] years</td>
<td>2.61</td>
<td>1.26</td>
</tr>
</tbody>
</table>
Final Comments

- We have explored a new channel through which financial constraints have an impact on aggregate TFP: they distort the incentives to invest in productivity at the firm level.

- Extended model with informal sector (low productivity and low growth firms w/no access to credit) and forthcoming: quantitative relevance of size dependent distortions vs. financial constraints.

- Buera, Kaboski and Shin (2015): more research is needed in endogenous entrepreneurial productivity!