Firm Entry and Exit and Aggregate Growth

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- Is productivity growth due to
  - Continuing firms?
  - Entry and exit of firms?

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  - Net entry accounts for 25 percent of U.S. manufacturing productivity growth

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  - Continuing firms?
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- Foster, Haltiwanger, and Krizan (FHK) (2001)
  - Net entry accounts for 25 percent of U.S. manufacturing productivity growth
- Brandt, Van Biesebroeck, and Zhang (2012)
  - Net entry accounts for 72 percent of Chinese manufacturing productivity growth
- We use data from other countries and develop a simple model to analyze these relationships

Firm entry and aggregate growth: empirics

- How does firm entry and exit contribute to aggregate productivity growth?
  - During periods of rapid GDP growth
  - During periods of slow GDP growth

Firm entry and aggregate growth: empirics

- How does firm entry and exit contribute to aggregate productivity growth?
  - During periods of rapid GDP growth
  - During periods of slow GDP growth
- Apply FHK decomposition to manufacturing plant-level data from Chile and Korea
- Review literature that uses identical decomposition
- Net entry is more important for productivity growth in periods of rapid GDP growth
  - Average contribution, rapid growth: 47 percent
  - Average contribution, slow growth: 22 percent

Firm entry and aggregate growth: model

- Construct a simple model of firm entry and exit, based on Hopenhayn (1992)
  - Analytic expressions of FHK decompositions

Firm entry and aggregate growth: model

- Construct a simple model of firm entry and exit, based on Hopenhayn (1992)
  - Analytic expressions of FHK decompositions
- Introduce reforms to
  - Entry costs
  - Barriers to technology adoption
- Rapid growth with high contribution of entry and exit
  - Driven by changes in relative productivities of entrants and exiters, as in data

Data

Plan

- Decompose aggregate productivity growth
  - Terms related to entry and exit of firms
  - Terms related to growth in continuing firms
  - Follow Foster, Haltiwanger, and Krizan (2001)

Plan

- Decompose aggregate productivity growth
  - Terms related to entry and exit of firms
  - Terms related to growth in continuing firms
  - Follow Foster, Haltiwanger, and Krizan (2001)
- Use manufacturing plant data from Chile and Korea
  - Periods of rapid GDP growth vs. slow GDP growth
  - Look within the same country over time
  - Avoids cross-country differences
  - Uses consistent datasets
- Review comparable studies in the literature

Defining industry productivity

- Productivity of industry i:

$$\log Z_{it} = \sum_{e \in E_{it}} s_{et} \log z_{et}$$

- s_{et}: gross output share of plant e in time t in industry i
- z_{et}: TFP of plant e in time t in industry i

- Change in productivity (window defined by $t-1$, t):

$$\Delta \log Z_{it} = \log Z_{it} - \log Z_{i,t-1}$$

Estimating plant productivity

- Plant e in industry i production function

$$\log y_{eit} = \log z_{eit} + \beta_k^i \log k_{eit} + \beta_\ell^i \log \ell_{eit} + \beta_m^i \log m_{eit}$$

- Following Foster et al. (2001)
  - β_j^i: average cost shares of input j in industry i

- Robust to alternative methods to estimate z,
  such as Woolridge-Levinsohn-Petrin

Productivity decomposition of industry growth

$$\Delta \log Z_{it} = \Delta \log Z_{it}^{NE} + \Delta \log Z_{it}^{C}$$

- $\Delta \log Z_{it}^{NE}$: change due to entering/exiting plants
- $\Delta \log Z_{it}^{C}$: change due to continuing plants

Net entry

$$
\begin{aligned}
\Delta \log Z_{it}^{NE} &= \underbrace{\sum_{e \in N_{it}} s_{et} \left(\log z_{et} - \log Z_{i,t-1}\right)}_{\text{entering plants}} \\
&\quad \underbrace{- \sum_{e \in X_{it}} s_{e,t-1} \left(\log z_{e,t-1} - \log Z_{i,t-1}\right)}_{\text{exiting plants}}
\end{aligned}
$$

N_{it} and X_{it} are sets of entering and exiting plants

- "entering plants" is positive if entrants have high productivity (compared to initial aggregate productivity)
- "exiting plants" is negative if exiting plants are unproductive

Continuing plants

$$\Delta \log Z_{it}^{C} = \underbrace{\sum_{e \in C_{it}} s_{e,t-1} \Delta \log z_{et}}_{\text{within plant}} + \underbrace{\sum_{e \in C_{it}} \left(\log z_{et} - \log Z_{i,t-1}\right) \Delta s_{et}}_{\text{reallocation}}$$

C_{it} is the set of continuing plants

- "within plant" is average within-plant productivity growth
- "reallocation" is positive if relatively productive plants expand market share

Productivity growth and aggregation

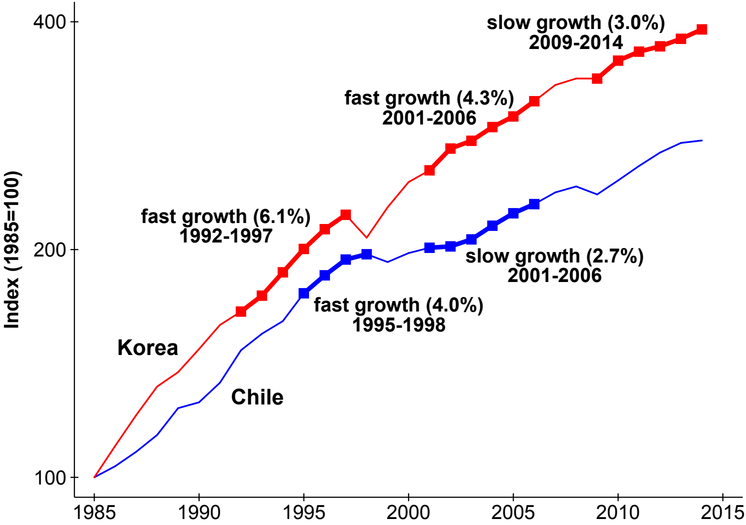
- At the industry-level we determine
  1. Productivity change
  2. Productivity change from entry/exit
  3. Productivity change from continuing plants

- To aggregate, weight each of these three components by gross output of industry (using average of beginning and end of window)
- Results robust to alternative weights

Decomposing productivity growth: Chile and Korea

- How does the net entry term change in Chile and Korea?
- Look within the same country at different windows
  - Avoids cross-country differences
  - Uses consistent datasets

Real GDP per working-age person



Plant-level manufacturing data

- Chile
  - Encuesta Nacional Industrial Anual
  - Collected by the Chilean national statistical agency
  - Covers all plants with more than 10 employees
  - 127 industries and 5,500 plants (2005)
  - Panel: 1995–2006

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  - Panel: 1995–2006
- Korea
  - Survey of Mining and Manufacturing
  - Collected by the Korean national statistical agency
  - Covers all plants with more than 10 employees
  - 180 industries and 68,640 plants (2014)
  - Three panels: 1992–1997, 2001–2006, and 2009–2014

Net entry contribution higher in rapid growth

Country	Period	GDP WAP growth, annual (percent)	Aggregate manufacturing productivity growth, annual (percent)	Contribrution of net entry (percent)
Chile	1995–1998	4.0	3.3	50.4*
Chile	2001–2006	2.7	1.9	22.8
Korea	1992–1997	6.1	3.6	48.0
Korea	2001–2006	4.3	3.3	37.3
Korea	2009–2014	3.0	1.5	25.1

*: 5-year equivalent

- Results robust to using other productivity decompositions and alternative weights ▸ details

Net entry, further decomposed

- Entering term can be decomposed into
  - Market share of entrants (t)
  - Average entrant productivity (t) relative to aggregate productivity ($t-1$)
- Exiting term can be decomposed into
  - Market share of exiters ($t-1$)
  - Average exiter productivity ($t-1$) relative to aggregate productivity ($t-1$)

FHK entering, decomposed multiplicatively

- Rapid growth features more-productive entrants

Country	Period	FHK entering (percent)	Relative productivity of entrants (percent)	Market share of entrants
Chile	1995–1998	6.6*	28.1*	0.24*
Chile	2001–2006	2.5	6.8	0.36
Korea	1992–1997	5.6	15.0	0.38
Korea	2001–2006	2.0	7.3	0.27
Korea	2009–2014	–0.6	–2.4	0.27

*: 5-year equivalent

FHK exiting, decomposed multiplicatively

- Rapid growth features less-productive exiting plants

Country	Period	FHK exiting (percent)	Relative productivity of exiters (percent)	Market share of exiters
Chile	1995–1998	–1.1*	–5.7*	0.20*
Chile	2001–2006	0.2	0.9	0.23
Korea	1992–1997	–3.7	–10.5	0.35
Korea	2001–2006	–4.6	–18.9	0.24
Korea	2009–2014	–2.6	–10.5	0.24

*: 5-year equivalent

Other empirical studies

- Existing studies with identical methodology
  - Slow growth: Japan, Portugal, U.K., U.S.
  - Rapid growth: Chile, China, Korea

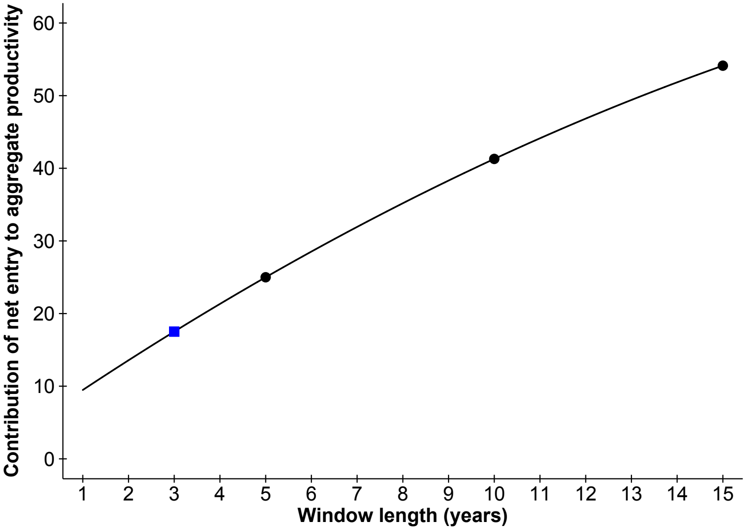
Other empirical studies

- Existing studies with identical methodology
  - Slow growth: Japan, Portugal, U.K., U.S.
  - Rapid growth: Chile, China, Korea
- Problem: Studies use different length time windows
  - Makes comparisons difficult
- Solution: Use calibrated model to make adjustments details

Use model to make window adjustments

- Solve the baseline equilibrium for the U.S.
- Decompose model output using 5, 10, 15 year windows
- Fit a quadratic to contribution of net entry to productivity growth for the 3 windows

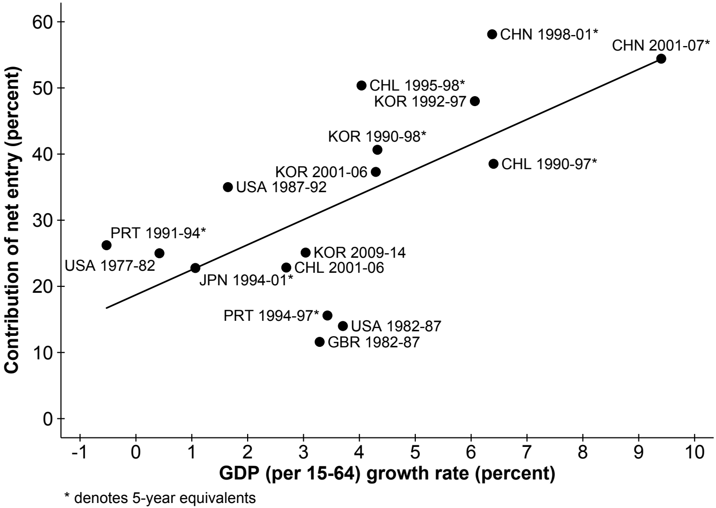
Net entry under various windows in the model



Use model to make window adjustments

- Portugal: 3-year window, 19 percent net entry contribution
- In the calibrated model
  - 5-year window generates 25 percent contribution
  - 3-year window generates 18 percent contribution
- Adjust proportionally
- Adjustment: $19 \times 25/18 = 26$ (5-year window equivalent)

Net entry more important during fast growth



Average contribution: 47 percent (fast) and 22 percent (slow)

Model

Model

- We develop a simple model in which
  - Potential entrants draw from frontier efficiency distribution, which improves by growth factor g_e
  - Efficiency of continuing firms grows
  - Entry and exit of firms
- Tractable balanced growth path
  - BGP growth factor g_e
  - BGP level determined by barriers to entry, technology adoption
- Use model to investigate the relation between productivity growth and net entry

Household problem

- Representative household solves

$$\max_{C_t, B_{t+1}} \sum_{t=0}^{\infty} \beta^t \log C_t$$

subject to

$$P_t C_t + q_{t+1} B_{t+1} = w_t + D_t + B_t$$
$$C_t \geq 0, \;\; \text{No Ponzi condition}, \;\; B_0 \text{ given}$$

D_t: aggregate dividends

- Normalize $P_t = 1, \;\; \forall t$

Firm dynamics

- Based on Hopenhayn (1992)
- Continuum of perfectly competitive firms
  - A firm in the model is a plant in the data
- Heterogenous in efficiency x
  - Productivity depends on efficiency
  - Measure productivity as in data
- Pay κ to draw initial efficiency, f to operate
- Exogenous exit probability δ and endogenous exit

Fixed costs paid by firms

- Potential entrants pay $\kappa_t = \kappa g_e^t$ to draw efficiency x

$$\kappa = \kappa^T(1+\tau)$$

- Paid in consumption/investment good
- g_e: growth factor
- κ^T: the technological cost, common across countries
- $\tau \geq 0$: policy induced barriers to entry

Fixed costs paid by firms

- Potential entrants pay $\kappa_t = \kappa g_e^t$ to draw efficiency x

$$\kappa = \kappa^T (1 + \tau)$$

- Paid in consumption/investment good
- g_e: growth factor
- κ^T: the technological cost, common across countries
- $\tau \geq 0$: policy induced barriers to entry
- Firms pay fixed cost of operating, $f_t = f g_e^t$, or exit
- Fixed costs are treated as investment

Firms face two decisions

1. Entry/exit decision
2. Conditional on operating: maximize profits

Firm's static problem

- Conditional on operating, firm with efficiency x solves

$$d_t(x) = \max_{\ell_t(x)} x\ell_t(x)^\alpha - w_t\ell_t(x) - f_t$$

- Solution is

$$\ell_t(x) = \left(\frac{w_t}{\alpha x}\right)^{\frac{1}{\alpha-1}}$$

- More efficient firms are larger

Firm's dynamic problem

- Firms with efficiency x choose to exit or continue to solve

$$V_t(x) = \max \{d_t(x) + q_{t+1}(1-\delta)V_{t+1}(g_{c,t+1}x), 0\}$$

- Efficiency grows by $g_{c,t+1}$

Operating firm efficiency growth

- Efficiency of existing firms grow by

$$g_{ct} = \bar{g} g_t^{\varepsilon}$$

- $\bar{g}$ is constant
- g_t is average efficiency growth
- ε measures the degree of spillovers

Operating firm efficiency growth

- Efficiency of existing firms grow by

$$g_{ct} = \bar{g} g_t^{\varepsilon}$$

- $\bar{g}$ is constant
- g_t is average efficiency growth
- ε measures the degree of spillovers
- Quantitatively, but not qualitatively important
  - Further discussion in calibration

New entrant's problem

- Potential entrants draw efficiency from

$$F_t(x) = 1 - \left(\frac{\varphi x}{g_e^t}\right)^{-\gamma}, \, x \geq \frac{g_e^t}{\varphi}$$

- Mean grows by growth factor g_e
- Barrier to technology adoption, φ (Parente-Prescott 1994)

New entrant's problem

- Potential entrants draw efficiency from

$$F_t(x) = 1 - \left(\frac{\varphi x}{g_e^t}\right)^{-\gamma}, \, x \geq \frac{g_e^t}{\varphi}$$

- Mean grows by growth factor g_e
- Barrier to technology adoption, φ (Parente-Prescott 1994)
- Mass of potential entrants, μ_t, from free entry condition:

$$E_x \left[V_t(x) \right] = \kappa_t$$

- Firm enters if and only if $x \geq \hat{x}_t$ (succesful entrants)

Measure of firms

- Measure of firms of age j in operation

$$\eta_{jt} = \mu_{t-j+1}(1-\delta)^{j-1}\left[1 - F_{t-j+1}\left(\frac{\hat{x}_{jt}}{\tilde{g}_{jt}}\right)\right]$$

- Convert age-j efficiency to initial efficiency

$$\tilde{g}_{jt} = \prod_{s=1}^{j-1} g_{c,t-s+1}$$

- Total measure of operating firms

$$\eta_t = \sum_{i=1}^{\infty} \eta_{it}$$

Equilibrium definition

Given initial conditions, an equilibrium is

- Household consumption and bond plans
- Allocations and entry/exit thresholds for firms
- Measure of potential entrants for firms
- Prices and aggregate dividends

Equilibrium definition

such that

- Household maximizes lifetime utility
- Firms maximize discounted dividends
- Costly entry condition binds
- Goods, labor, and bond markets clear
- Dividends satisfy

$$D_t = \sum_{j=1}^{\infty} \left[\mu_{t-j+1} (1-\delta)^{j-1} \int_{\hat{x}_{jt}}^{\infty} d_t(x) dF_{t-j+1}\left(\frac{\hat{x}_t}{\tilde{g}_{jt}}\right) \right] - \mu_t \kappa_t$$

Existence of balanced growth path

Equilibrium converges to a balanced growth path in which

1. Entry and exit thresholds grow by g_e
2. Real consumption, output, wages, and dividends grow by g_e
3. Masses of potential entrants and operating firms are constant

Characterizing BGP: growth

$$
\begin{aligned}
\hat{x}_t &= \frac{g_e^t}{\varphi}\left(\frac{\omega\mu}{\eta}\right)^{\frac{1}{\gamma}} \\
w_t &= \alpha\left(\frac{1-\alpha}{\psi}\eta\right)^{1-\alpha}\hat{x}_t, \quad Y_t = \left(\frac{1-\alpha}{\psi}\eta\right)^{1-\alpha}\hat{x}_t \\
\mu &= \frac{\xi}{\gamma\lambda\kappa\omega}, \quad \eta = \frac{\psi}{\lambda f} \\
\lambda &= \varphi^{\frac{1}{\alpha}}\kappa^{\frac{1}{\gamma\alpha}} f^{\frac{\gamma(1-\alpha)-1}{\gamma\alpha}}\nu
\end{aligned}
$$

- Economy grows by g_e
- ξ, ω, ν, ψ are constants
- $\lambda\kappa$ measures fixed cost, relative to output per capita

fixed costs as labor

Comparative statics: entry costs

$$
\begin{aligned}
\mu &= \frac{\xi}{\gamma\lambda\kappa\omega}, \quad \eta = \frac{\psi}{\lambda f} \\
\hat{x}_t &= \frac{g_e^t}{\varphi}\left(\frac{\omega}{\eta}\mu\right)^{\frac{1}{\gamma}} \\
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\lambda &= \varphi^{\frac{1}{\alpha}}\kappa^{\frac{1}{\gamma\alpha}} f^{\frac{\gamma(1-\alpha)-1}{\gamma\alpha}}\nu
\end{aligned}
$$

- As κ decreases
  - More potential entrants pay to draw efficiency ($\mu \uparrow$)
  - More-efficient firms enter ($\hat{x}_t \uparrow$)
  - Indirect effect: fixed costs relatively cheaper ($\lambda \downarrow$)
  - Overall: wages and output increase

Comparative statics: barriers to adoption

$$\begin{aligned}
\mu &= \frac{\xi}{\gamma\lambda\kappa\omega}, \quad \eta = \frac{\psi}{\lambda f} \\
\hat{x}_t &= \frac{g_e^t}{\varphi}\left(\frac{\omega}{\eta}\mu\right)^{\frac{1}{\gamma}} \\
w_t &= \alpha\left(\frac{1-\alpha}{\psi}\eta\right)^{1-\alpha}\hat{x}_t, \quad Y_t = \left(\frac{1-\alpha}{\psi}\eta\right)^{1-\alpha}\hat{x}_t \\
\lambda &= \varphi^{\frac{1}{\alpha}}\kappa^{\frac{1}{\gamma\alpha}} f^{\frac{\gamma(1-\alpha)-1}{\gamma\alpha}}\nu
\end{aligned}$$

- As φ decreases
  - Potential entrants draw higher efficiency ($\hat{x}_t \uparrow$)
  - Indirect effect: fixed costs relatively cheaper ($\lambda \downarrow$)
  - Overall: wages and output increase

Comparative statics: continuation costs

$$
\begin{aligned}
\mu &= \frac{\xi}{\gamma\lambda\kappa\omega}, \quad \eta = \frac{\psi}{\lambda f} \\
\hat{x}_t &= \frac{g_e^t}{\varphi}\left(\frac{\omega}{\eta}\mu\right)^{\frac{1}{\gamma}} \\
w_t &= \alpha\left(\frac{1-\alpha}{\psi}\eta\right)^{1-\alpha}\hat{x}_t, \quad Y_t = \left(\frac{1-\alpha}{\psi}\eta\right)^{1-\alpha}\hat{x}_t \\
\lambda &= \varphi^{\frac{1}{\alpha}}\kappa^{\frac{1}{\gamma\alpha}} f^{\frac{\gamma(1-\alpha)-1}{\gamma\alpha}}\nu
\end{aligned}
$$

- As f decreases
  - More firms operate ($\eta \uparrow$)
  - Less-efficient firms produce ($\hat{x}_t \downarrow$)
  - Indirect effects: fixed costs relatively cheaper ($\lambda \downarrow$)
  - Overall: wages and output increase

Measuring productivity

- Need model measurement consistent with data measurement
- Productivity z of firm with efficiency x

$$\log(z_t(x)) = \log(P_t y_t(x)) - \alpha_{\ell t} \log(\ell_t(x)) - \alpha_{kt} \log(k_t)$$

  where $\alpha_{\ell t}$ and α_{kt} denote labor and capital shares
- Firm capital: $k_t = \kappa_t + f_t$ details

Measuring productivity

- Need model measurement consistent with data measurement
- Productivity z of firm with efficiency x

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  where $\alpha_{\ell t}$ and α_{kt} denote labor and capital shares
- Firm capital: $k_t = \kappa_t + f_t$ details
- Total factor productivity (our measure):

$$\log(z_t(x)) = \log(x) - \alpha_{kt}\log(\kappa_t + f_t)$$

- Labor productivity (alternative measure): $\dfrac{P_t y_t(x)}{\ell_t(x)} = \dfrac{w_t}{\alpha}$

FHK contribution of entry and exit

- In the balanced growth path, FHK contribution of
  - entry: $1-(1-\delta)\left(\frac{g_c}{g_e}\right)^{\gamma}$
  - exit: $(1-\delta)\left(\frac{g_c}{g_e}\right)^{\gamma-\frac{1}{1-\alpha}}\frac{\log(g_e)-\log(g_c)}{(1-\alpha_k)\log(g_e)}$
- When $g_c = g_e$
  - only exogenous exit
  - FHK contribution of entry and exit: δ
- FHK contribution of entry and exit decreasing in g_c conditions
- Distortions affect levels, but not FHK contributions

quantitative exercise

Removing distortions

1. Calibrate model to U.S. (high BGP)
   - No policy distortions
2. Model three distorted economies on lower BGP
   - Income level is 15 percent lower than U.S.
   - $\kappa_D = 1.94 \times \kappa_{us}$
   - $\varphi_D = 1.12 \times \varphi_{us}$
   - $f = 1.93 \times f_{us}$
3. Remove distortions
   - Solve for transition to higher balanced growth path
   - Analyze changes to productivity and contribution of net entry

Calibration

Calibrate model to match

- Size distribution of plants
- Effect of continuing plants on aggregate productivity growth
- Employment share of exiting plants

Calibrated parameters

- Model period is 5 years
- Calibrate to United States

Parameter	Value	Target
Operating cost f^T	0.46×5	Average U.S. establishment size: 14.0
Entry cost κ^T	0.38	Entry cost / continuation cost*: 0.82
Pareto parameter γ	6.10	S.D. of U.S. Establishment size: 89.0
Growth factor g_e	$(1.02)^5$	BGP growth rate of U.S.: 2 percent
Returns to scale α	0.67	BGP labor share of U.S.: 0.67 ▸ 0.85
Death rate δ	$1-(0.96)^5$	Employment share of U.S. exiting plants: 19.3%
Discount factor β	$(0.98)^5$	Real interest rate‡: 4 percent
Firm growth $\bar{g}$	$(1.006)^5$	Effect of entry and exit on U.S. manufacturing productivity growth†: 25%

*Barseghyan and DiCecio (2011); †Foster et al. (2001); ‡McGrattan and Prescott (2005)

Technological spillovers

- Take logs of equation that characterizes spillovers

$$\log g_{ct} = \log \bar{g} + \varepsilon \log g_t$$

- We estimate this equation as follows

$$\log g_{ct,i} = \beta_0 + \varepsilon \log g_{it} + \upsilon_{it}$$

  - $g_{ct,i}$ is weighted productivity growth of continuing plants in i
  - g_{it} is weighted productivity growth of entire industry i
- Estimate using Chile and Korea data (would like U.S. data)
- Average estimate: $\varepsilon = 0.64$ sensitivity

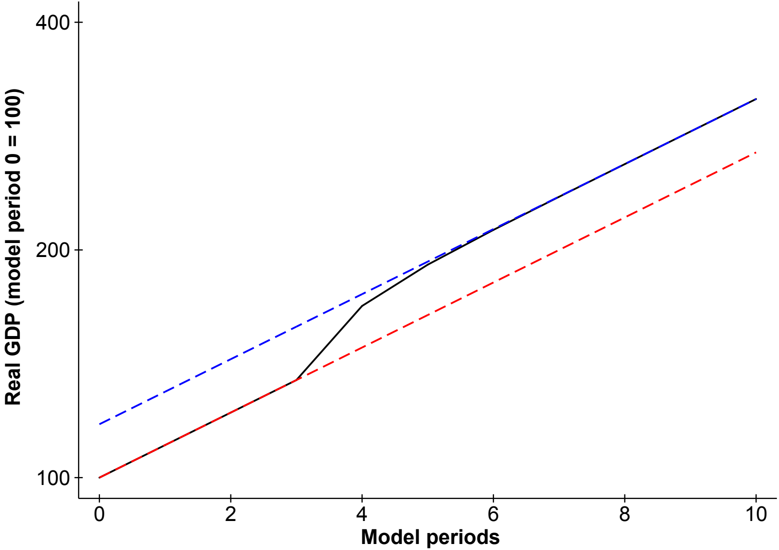
Major reforms in Korea

- 1990–95 (affecting 1992–97 window)
  - Relax FDI restrictions (1991,1992,1995) $\rightarrow$ tech adoption
  - Pro-competition reforms (1990,1993,1994) $\rightarrow$ entry
  - Financial reforms (1993,1994) $\rightarrow$ entry & tech adoption
- 1998–2004 (affecting 2002–07 window)
  - Abolish FDI restrictions (1998) $\rightarrow$ tech adoption
  - Pro-competition reforms (1999,2004) $\rightarrow$ entry
  - Financial reforms (1998,2004) $\rightarrow$ entry & tech adoption
  - Reforms to labor and corporate governance (1998–2001)
- Pace of reforms that affect productivity has slowed since 2004

Major reforms in Chile

- Reforms in the 1970s and early 1980s $\rightarrow$ successful performance of the late 1980s and 1990s (Bergoeing et al. 2002)
- 1993–97 (affecting 1995–98 window)
  - Relax FDI restrictions (1993) $\rightarrow$ tech adoption
  - Financial reforms (1993,1997) $\rightarrow$ entry & tech adoption
  - Privatization/deregulation of services (1993,1997)
- Pace of reforms that affect productivity has slowed since 1998

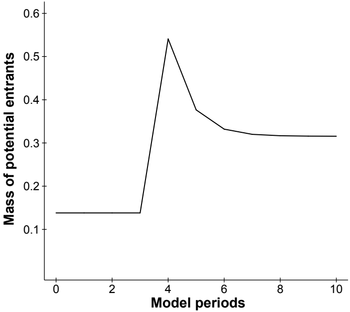
Output per worker



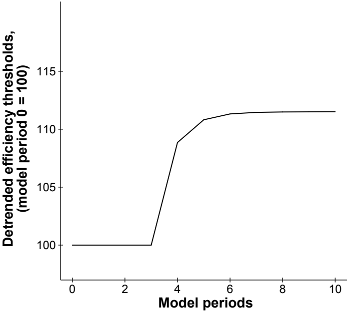
Entry cost reform: more potential entrants

- More potential entrants
  - Increases the efficiency threshold needed for successful entry
  - Increases the mass of failed entrants

Mass of potential entrants

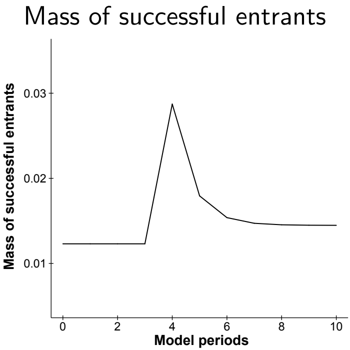


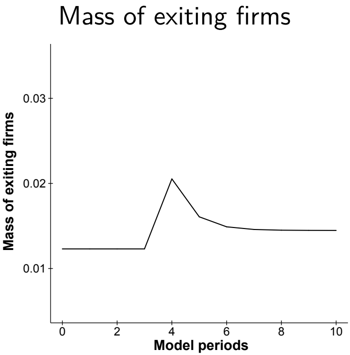
Detrended efficiency thresholds



Entry cost reform: more entry and exit

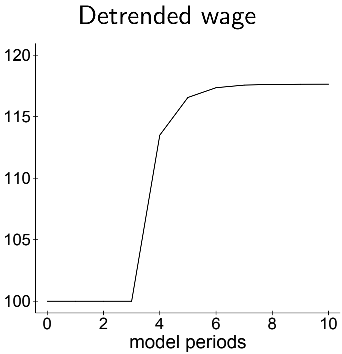
- Efficient firms enter, inefficient firms exit

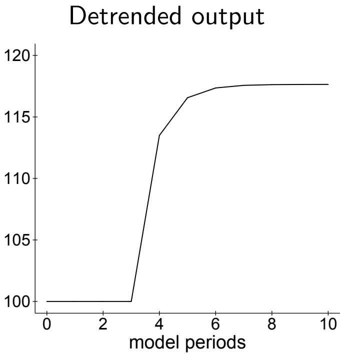




Entry cost reform: wages and output

- More efficient firms increase wages and output





Productivity growth decompositions

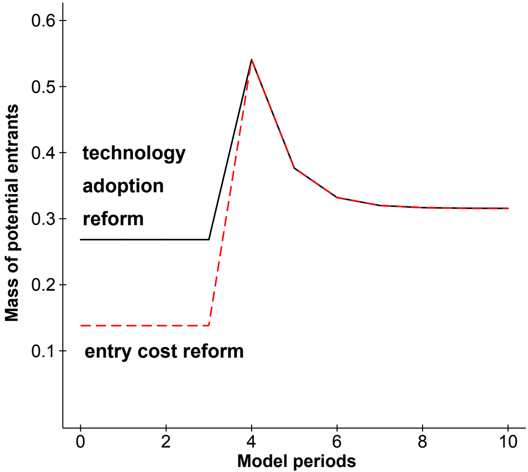
Model periods (5 years)	Entry cost	Real GDP growth (percent) (annual)	Aggregate productivity growth (percent, annual)	Contribution of net entry to aggregate productivity growth (percent)
0–3	0.74	2.0	1.3	25.0
4 (reform)	0.38	4.6	2.9	59.6
5	0.38	2.5	1.5	36.5
6	0.38	2.1	1.3	28.1
7+	0.38	2.0	1.3	25.0

▸ labor as amalgam

▸ fixed costs denominated in labor

Remove barriers to technology adoption

- Smaller increase in mass of potential entrants
- Other figures and tables are identical



Net entry and productivity in model and data

- Model generates quantitatively reasonable numbers

	Real GDP/WAP growth rate (percent, annual)	Contribution of net entry to productivity growth (percent)
Data fast growth	5.8	47
Model reform (κ)	4.6	60
Model reform (φ)	4.6	60
Data slow growth	2.1	22
Model BGP	2.0	25

- Alternative decompositions ▸ details

FHK entering, decomposed multiplicatively

- Reforms increase relative productivity of entrants, as in data

	Model reform	Model BGP	Data rapid*	Data slow*
FHK entering (percent)	5.9	1.3	4.7	1.0
relative productivity (percent)	14.1	6.4	16.8	2.2
entrant market share	0.42	0.20	0.30	0.32

*: averages for Chile and Korea details

FHK exiting, decomposed multiplicatively

- Reforms decrease relative productivity of exiters, as in data

	Model reform	Model BGP	Data rapid*	Data slow*
FHK exiting (percent)	–2.5	–0.3	–3.1	–1.2
relative productivity (percent)	–9.5	–1.6	–11.7	–4.8
exiting plant market share	0.27	0.19	0.26	0.24

*: averages for Chile and Korea details

Not all reforms lead to productivity growth

- Lower continuation costs $\Rightarrow$ less productive firms operate
- Lowers aggregate productivity (more capital)
- Higher consumption and output

Model periods (5 years)	Annual cont. cost	Real GDP growth (percent) (annual)	Aggregate productivity growth (percent, annual)	Contribution of net entry to aggregate productivity growth (percent)
0–3	0.90	2.0	1.3	25.0
4	0.46	4.1	–1.1	88.8
5	0.46	2.8	1.1	36.9
6	0.46	2.2	1.2	28.5
7+	0.46	2.0	1.3	25.1

Reform and growth

- Reforms that increase aggregate productivity feature
  - Entry of more productive plants
  - Exit of less productive plants
  - Increase the contribution of net entry
- Future work
  - Productivity decompositions of the whole economy
  - Open economy extensions
  - Mapping potential, successful, and failed entrants to the data

Thank you

Appendix

Defining industry productivity ▸ back

- Productivity of industry i:

$$\log Z_{it} = \sum_{e \in E_{it}} s_{et} \log z_{et}$$

- s_{et}: gross output share of plant e in time t in industry i
- z_{et}: TFP of plant e in time t in industry i

- Change in productivity (window defined by $t-1$, t):

$$\Delta \log Z_{it} = \log Z_{it} - \log Z_{i,t-1}$$

Estimating plant productivity back

- Plant e in industry i production function

$$\log y_{eit} = \log z_{eit} + \beta^i_k \log k_{eit} + \beta^i_\ell \log \ell_{eit} + \beta^i_m \log m_{eit}$$

- Following Foster et al. (2001)
  - β^i_j: average cost shares of input j in industry i
- Robust to alternative methods to estimate z, such as Woolridge-Levinsohn-Petrin

Productivity decomposition of industry growth ▸ back

$$\Delta \log Z_{it} = \Delta \log Z_{it}^{NE} + \Delta \log Z_{it}^{C}$$

- $\Delta \log Z_{it}^{NE}$: change due to entering/exiting plants
- $\Delta \log Z_{it}^{C}$: change due to continuing plants

Net entry ▸ back

$$\Delta \log Z_{it}^{NE} = \underbrace{\sum_{e \in N_{it}} s_{et} \left(\log z_{et} - \log Z_{i,t-1} \right)}_{\text{entering plants}}$$
$$- \underbrace{\sum_{e \in X_{it}} s_{e,t-1} \left(\log z_{e,t-1} - \log Z_{i,t-1} \right)}_{\text{exiting plants}}$$

N_{it} and X_{it} are sets of entering and exiting plants

- "entering plants" is positive if entrants have high productivity (compared to initial aggregate productivity)
- "exiting plants" is negative if exiting plants are unproductive

Continuing plants ▸ back

$$\Delta \log Z_{it}^{C} = \underbrace{\sum_{e \in C_{it}} s_{e,t-1} \Delta \log z_{et}}_{\text{within plant}} + \underbrace{\sum_{e \in C_{it}} \left(\log z_{et} - \log Z_{i,t-1}\right) \Delta s_{et}}_{\text{reallocation}}$$

C_{it} is the set of continuing plants

- "within plant" is average within-plant productivity growth
- "reallocation" is positive if relatively productive plants expand market share

Productivity growth and aggregation ▸ back

- At the industry-level we determine
  1. Productivity change
  2. Productivity change from entry/exit
  3. Productivity change from continuing plants

- To aggregate, weight each of these three components by gross output of industry (using average of beginning and end of window)

Other decompositions ▸ back

- Net entry more important during periods of rapid growth

Country	Period	FHK	GR	MP
Chile	1995-1998	50.4*	23.5*	22.4*
Chile	2001-2006	22.8	10.8	-50.9
Korea	1992-1997	48.0	43.1	3.9
Korea	2001-2006	37.3	31.5	-2.7
Korea	2009-2014	25.1	25.6	-16.5

*: 5-year equivalent

Constant weights ▸ back

- Use average weights across all windows
- Net entry more important during periods of rapid growth

Country	Period	GDP WAP growth, annual (percent)	Aggregate manufacturing productivity growth, annual (percent)	Contribution of net entry (percent)
Chile	1995–1998	4.0	6.0	87.4*
Chile	2001–2006	2.7	1.5	33.4
Korea	1992–1997	6.1	5.1	47.2
Korea	2001–2006	4.3	4.0	36.8
Korea	2009–2014	3.0	1.2	17.4

*: 5-year equivalent

Alternative weights ‣ back

- Use industry value added as weights
- Net entry more important during periods of rapid growth

Country	Period	GDP WAP growth, annual (percent)	Aggregate manufacturing productivity growth, annual (percent)	Contribution of net entry (percent)
Chile	1995–1998	4.0	4.2	59.1*
Chile	2001–2006	2.7	1.7	−9.4
Korea	1992–1997	6.1	3.9	45.9
Korea	2001–2006	4.3	4.0	35.8
Korea	2009–2014	3.0	1.9	20.7

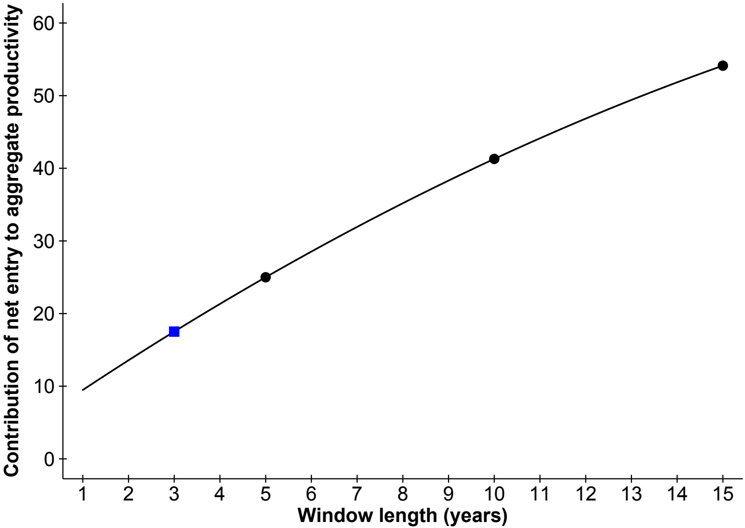
*: 5-year equivalent

Use model to make window adjustments back

- Solve the baseline equilibrium for the U.S.
- Decompose model output using 5, 10, 15 year windows
- Fit a quadratic to contribution of net entry to productivity growth for the 3 windows

Net entry under various windows in the model

back



Use model to make window adjustments ▸ back

- Portugal: 3-year window, 19 percent net entry contribution
- In the calibrated model
  - 5 year window generates 25 percent contribution
  - 3 year window generates 18 percent contribution
- Adjust proportionally
- Adjustment: $19 \times 25/18 = 26$ (5-year window equivalent)

Net entry more important during fast growth

Country	Period	GDP15–64 growth	Effect of NE	5 year equivalent
Japan	1994–2001	1.1	29	23
Portugal	1991–1994	–0.5	19	26
Portugal	1994–1997	3.4	11	16
UK	1982–1987	3.3	12	12
US	1977–1982	0.4	25	25
US	1982–1987	3.7	14	14
US	1987–1992	1.6	35	35
Chile	2001–2006	2.7	23	23
Korea	2009–2014	3.0	25	25
Average		**2.1**		**22**
China	1998–2001	6.4	41	58
China	2001–2007	9.4	62	54
Chile	1990–1997	6.4	49	39
Korea	1990–1998	4.3	57	41
Chile	1995–1998	4.0	36	50
Korea	1992–1997	6.1	48	48
Korea	2001–2006	4.3	37	37
Average		**5.8**		**47**

Sources: U.S.: Foster et al. (2002); U.K.: Disney et al. (2005); Portugal: Carreira and Teixeira (2008); China: Brandt et al. (2012); Chile (1990–97): Bergoeing and Repetto (2006); Korea (1990–98) Ahn et al. (2005)

Measuring capital ▸ back

- Fixed costs (κ_t, f_t) are investments
- How are they accounted for
  - In the firm's accounts?
  - In the national accounts?

Measuring capital back

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- How are they accounted for
  - In the firm's accounts?
  - In the national accounts?
- Aggregate investment $= \mu_t \kappa_t + \eta_t f_t$
- Depreciation is the sum of
  - Capital of firms that die or exit
  - κ_t of potential entrants that do not enter
  - f_t minus costs of upgrading capital for continuing firms

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  - Capital of firms that die or exit
  - κ_t of potential entrants that do not enter
  - f_t minus costs of upgrading capital for continuing firms
- Aggregate capital stock $= \eta_t(\kappa_t + f_t) + (\mu_t - \eta_{1t})\kappa_t$
- Depreciation rate constant on BGP, not in transition

Measuring productivity ▸ back

- Need model measurement consistent with data measurement
- Productivity z of firm with efficiency x

$$\log(z_t(x)) = \log(y_t(x)) - \alpha \log(\ell_t(x)) - \alpha_{kt} \log(k_t)$$

- Firm capital: $k_t = \kappa_t + f_t$
- Capital share is given by

$$\alpha_{kt} = \frac{R_t K_t}{Y_t}$$

where $R_t = \dfrac{1}{q_t} - 1 + \delta_{kt}$

The Importance of entry and exit ▸ back

Country	Period	Aggregate productivity growth (percent)	FHK entering (percent)	FHK exiting (percent)
Chile	1995-1998	17.6*	6.6*	-1.1*
Chile	2001-2006	9.8	2.5	0.2
Korea	1992-1997	19.5	5.6	-3.7
Korea	2001-2006	17.7	2.0	-4.6
Korea	2009-2014	7.7	-0.6	-2.6

*: 5-year equivalent

- Korea 1992–1997: $(5.6+3.7)/19.5\times 100 = 48.0$

FHK entering, decomposed multiplicatively ▸ back

Country	Period	FHK entering (percent)	Relative productivity of entrants (percent)	Market share of entrants
Chile	1995-1998	6.6*	28.1*	0.24*
Chile	2001-2006	2.5	6.8	0.36
Korea	1992-1997	5.6	15.0	0.38
Korea	2001-2006	2.0	7.3	0.27
Korea	2009-2014	-0.6	-2.4	0.27

*: 5-year equivalent

- Rapid growth features more productive entrants

FHK exiting, decomposed multiplicatively ▸ back

Country	Period	FHK exiting (percent)	Relative productivity of exiters (percent)	Market share of exiters
Chile	1995-1998	-1.1*	-5.7*	0.20*
Chile	2001-2006	0.2	0.9	0.23
Korea	1992-1997	-3.7	-10.5	0.35
Korea	2001-2006	-4.6	-18.9	0.24
Korea	2009-2014	-2.6	-10.5	0.24

*: 5-year equivalent

- Rapid growth features more unproductive exiting plants

Model with fixed costs as labor ‣ back

- Potential entrants pay $\kappa_t = w_t \kappa$ to draw efficiency x
- Firms pay fixed cost of operating, $f_t = w_t f$, or exit
- Labor market:

$$1 = \sum_{j=1}^{\infty} \left[\mu_{t-j+1} (1-\delta)^{j-1} \int_{\hat{x}_{jt}}^{\infty} \left[\ell_t(x) + f \right] dF_{t-j+1} \left(\frac{x}{\tilde{g}_{jt}} \right) \right] + \mu_t \kappa$$

- Goods market:

$$C_t = \sum_{j=1}^{\infty} \left[\mu_{t-j+1} (1-\delta)^{j-1} \int_{\hat{x}_{jt}}^{\infty} x \ell_t(x)^{\alpha} dF_{t-j+1} \left(\frac{x}{\tilde{g}_{jt}} \right) \right]$$

- Rental rate of capital: $R_t = \frac{1}{q_t} - (1 - \delta_{kt}) \frac{w_{t+1}}{w_t}$
- Measured productivity: $\log(z(x)) = \log(x) - \alpha_k \log(\kappa + f)$

Characterizing BGP with fixed costs as labor ▸ back

$$
\begin{aligned}
\hat{x}_t &= \frac{g_e^t}{\varphi}\left(\frac{\omega\mu}{\eta}\right)^{\frac{1}{\gamma}} \\
w_t &= \alpha\left(\frac{1-\alpha}{\alpha f}\right)^{1-\alpha}\hat{x}_t \\
Y_t &= \psi\alpha\left(\frac{1-\alpha}{\alpha f}\right)^{1-\alpha}\hat{x}_t \\
\mu &= \frac{\xi}{\gamma\kappa\omega}\psi \\
\eta &= \frac{\gamma(1-\alpha)-1}{\gamma f}\psi \\
\psi &= \frac{\gamma\omega}{(\gamma-1)\omega+\xi}
\end{aligned}
$$

Major reforms in China ▸ back

- 1996-2005 (affecting 1985-2007 window)
  - relax FDI restrictions (1998,2000-01) $\rightarrow$ tech adoption
  - lower trade barriers (1996-97,2001-02) $\rightarrow$ tech adoption
  - deregulation/privatization (2001-02) $\rightarrow$ entry
  - financial reforms (2000) $\rightarrow$ entry & tech adoption
  - bankruptcy reforms (1999)

Net entry contributions decreasing in g_c back

- FHK contribution of entry in the BGP is unconditionally decreasing in g_c
- FHK contribution of exit in the BGP is decreasing in g_c if

$$\log\left(\frac{g_e}{g_c}\right) g_e < \frac{1-\alpha}{\gamma(1-\alpha)-1}$$

Calibrated with labor as amalgam ‣ back

- Model period is 5 years
- Data from United States

Parameter	Value	Target
Operating cost f^T	0.25×5	average establishment size: 14.0
Entry cost κ^T	0.20	entry cost / fixed cost*: 0.82
Pareto parameter γ	13.42	establishment size s.d.: 89.0
Firm growth $\bar{g}$	1.006^5	incumbent effect on growth†: 75%
Death rate δ	$1 - 0.96^5$	employment share (exiters): 19.3%
Growth factor g_e	1.02^5	long-run growth: 2 percent
Discount factor β	0.98^5	real interest rate‡: 4 percent
Returns to scale α	0.85	Atkeson and Kehoe (2005)

*Barseghyan and DiCecio (2011); †Foster et al. (2001); ‡McGrattan and Prescott (2005)

Decomposition with labor as amalgam

back

Model periods (5 years)	Entry cost	Annual output growth (percent)	Productivity growth (percent)	Contribution of net entry (percent)
0-3	1.80	2.0	1.7	25.0
4 (reform)	0.20	5.0	4.8	74.0
5	0.20	2.3	1.6	33.5
6	0.20	2.1	1.7	26.6
7+	0.20	2.0	1.7	25.0

Sensitivity ▸ back

Table: Contribution of net entry (percent)

	BGP	reform
$\varepsilon = 0.38$	25.0	73.9
$\varepsilon = 0.83$	25.0	46.9
baseline	25.0	59.6

Calibration with fixed costs as labor ▸ back

- Model period is 5 years
- Data from United States

Parameter	Value	Target
Operating cost f^T	0.69×5	average establishment size: 14.0
Entry cost κ^T	0.57	entry cost / fixed cost*: 0.82
Pareto parameter γ	6.10	establishment size s.d.: 89.0
Firm growth $\bar{g}$	1.006^5	incumbent effect on growth†: 75%
Death rate δ	$1 - 0.96^5$	variable labor share (exiters): 19.3%
Growth factor g_e	1.02^5	long-run growth: 2 percent
Discount factor β	0.98^5	real interest rate‡: 4 percent
Returns to scale α	0.67	BGP labor share: 0.67

*Barseghyan and DiCecio (2011); †Foster et al. (2001); ‡McGrattan and Prescott (2005)

Decomposition with fixed costs as labor ▸ back

Model periods (5 years)	Entry cost	Annual output growth (percent)	Productivity growth (percent)	Contribution of net entry (percent)
0-3	1.53	2.0	1.3	25.0
4 (reform)	0.57	4.7	4.3	56.5
5	0.57	2.4	1.3	34.0
6	0.57	2.2	1.3	28.0
7+	0.57	2.0	1.3	24.9

Alternative decompositions, model and data back

- Contributions of entry and exit are higher in rapid growth, as in data

	Model reform	Model BGP	Data rapid*	Data slow*
FHK (percent)	59.6	25.0	45.2	24.0
GR (percent)	42.8	15.3	32.7	18.2
MP (percent)	24.4	5.9	7.9	−33.7

*: averages for Chile and Korea

Plant size distribution in Korea

- Average: 15.7
- Standard Deviation: 136.2
- Skewness: 99.9
- Kurtosis: 13370.1