# Firm Entry and Exit and Growth

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  - net entry accounts for 72% of Chinese productivity growth
- These studies are widely cited to justify assumptions that net entry (creative destruction) is unimportant/important.

# 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
- Plant-level data from Chile and Korea
- Review literature that uses identical decomposition
- Net entry is more important in periods of rapid growth
  - Average contribution, rapid growth: 54 percent
  - Average contribution, slow growth: 26 percent

# Firm entry and aggregate growth: model

- Construct a model of firm entry and exit
  - Calibrate to the United States

# Firm entry and aggregate growth: model

- Construct a model of firm entry and exit
  - Calibrate to the United States
- Use the calibrated model for policy analysis
  - Reduce entry barriers
  - Reduce barriers to technology adoption
- Quantitatively accounts for Chile and Korea data
- Entry and exit are crucial to understanding reform

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)
- Use manufacturing plant data from Chile and Korea
  - Periods of rapid growth
  - Periods of slow growth
- 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)
  - $\beta_j^i$: average cost shares of input $j$ in industry $i$
- Consider alternative methods to estimate $z$
  - Woolridge-Levinsohn-Petrin methods (Chile)
  - Generate similar productivity decompositions

# 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

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

$N_{it}$ 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 have low productivity

# Continuing plants

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

$C_{it}$ is the set of continuing plants

- "within plant" is average within-plant productivity growth
- "between plant" is positive if relatively productive plants expand market share
- "covariance" is positive if plants that expand also increase their productivity

# Productivity growth and aggregation

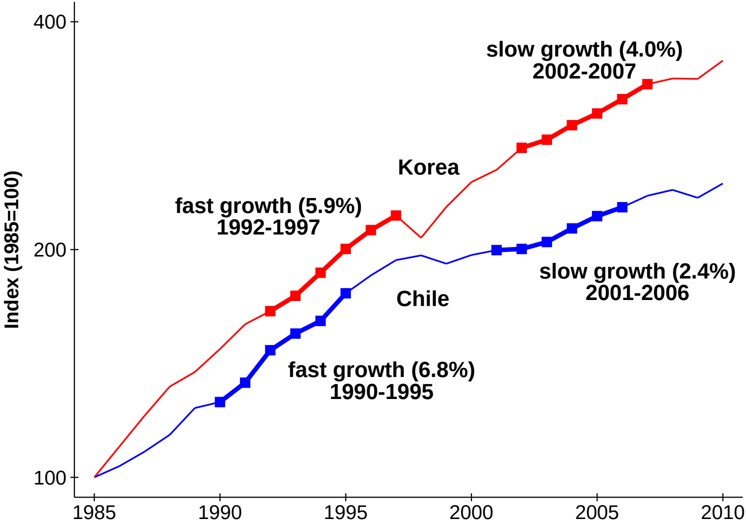
- At the industry-level we determine
  1. Productivity change
  2. Productivity change from entry/exit
  3. Productivity change from continuing plants

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

# Decomposing productivity growth: Chile and Korea

- How does the net entry term change in Chile and Korea?
- Look within the same country at two 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)
  - Two panels: 1986-1996 and 1995-2006
- Korea
  - Survey of Mining and Manufacturing
  - Collected by the Korean national statistical agency
  - Covers all plants with more than 10 employees
  - 104 industries and 8,300 plants
  - Panel: 1992, 1997, 2002, and 2007

# The relative importance of net entry

| Country | Period | GDP WAP growth (percent) | Window | Effect of net entry (percent) |
|---|---|---|---|---|
| Chile | 1990-1995 | 6.8 | 5 years | 85 |
| Chile | 2001-2006 | 2.4 | 5 years | 35 |
| Korea | 1992-1997 | 5.9 | 5 years | 44 |
| Korea | 2002-2007 | 4.0 | 5 years | 39 |

# Other empirical studies

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

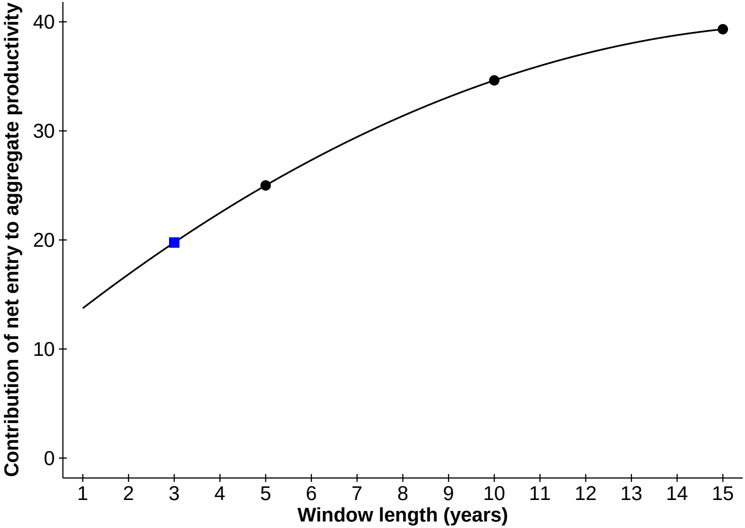
# Other empirical studies

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

# 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, 15 percent net entry contribution
- In the calibrated model
  - 5 year window generates 25 percent contribution
  - 3 year window generates 20 percent contribution
- Adjust proportionally
- Adjustment: $15 \times 25/20 = 19$ (5-year window equivalent)

# Contribution of net entry

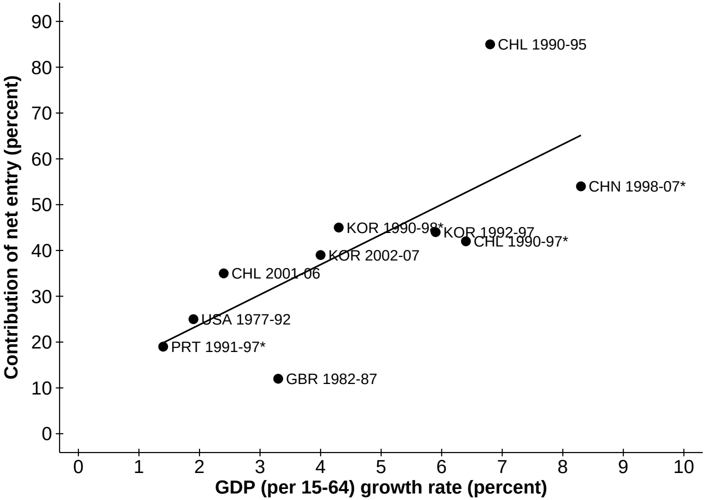
## Net entry more important during periods of fast growth

| Country | Period | GDP growth 15–64 | Window | Effect of net entry | 5 year equiv. |
|---|---|---|---|---|---|
| US | 1977–1992 | 1.9 | 5 years* | 25 | 25 |
| UK | 1982–1987 | 3.3 | 5 years | 12 | 12 |
| Portugal | 1991–1997 | 1.4 | 3 years* | 15 | 19 |
| Chile | 2001–2006 | 2.4 | 5 years | 35 | 35 |
| Korea | 2002–2007 | 4.0 | 5 years | 39 | 39 |
| **Average** | | **2.6** | | | **26** |
| China | 1998–2007 | 8.3 | 9 years | 72 | 54 |
| Chile | 1990–1997 | 6.4 | 7 years | 49 | 42 |
| Korea | 1990–1998 | 4.3 | 8 years | 57 | 45 |
| Chile | 1990–1995 | 6.8 | 5 years | 85 | 85 |
| Korea | 1992–1997 | 5.9 | 5 years | 44 | 44 |
| **Average** | | **6.3** | | | **54** |

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)

*Average over multiple windows

# Net entry important for fast-growth economies




*adjusted to 5 year windows using elasticities generated by model

model

# Model

- We develop a model in which
  - Potential entrants draw from frontier efficiency distribution, which improves by growth factor $g_e$
  - Efficiency of continuing firms grows, by $g_c < g_e$
  - Endogenous entry/exit of firms
- Easy to characterize balanced growth path

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  - Efficiency of continuing firms grows, by $g_c < g_e$
  - Endogenous entry/exit of firms
- Easy to characterize balanced growth path
- Implications:
  - BGP growth factor $g_e$
  - Level is determined by barriers to entry, technology adoption
- Purpose of model: Investigate policy reforms

# 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
- Pay $\kappa$ to draw initial efficiency, $f$ to operate
- Exogenous exit probability $\delta$ and endogenous exit

# Fixed costs paid by firms

- Potential entrants pay $\kappa_t = \kappa Y_t$ to draw efficiency $x$

$$\kappa = \kappa^T + \kappa^P$$

- Paid in consumption/investment good
- $\kappa^T$ is the technological cost, common across countries
- $\kappa^P$ is the policy induced cost

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- Firms pay fixed cost of operating, $f_t = fY_t$, or exit

- $\kappa_t + f_t$ is the capital of a firm in $t$

# 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

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

- 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

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

- Efficiency grows at $g_c$

# 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
- $\varepsilon$ measures the degree of spillovers

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

- $\bar{g}$ is constant
- $g_t$ is average efficiency growth
- $\varepsilon$ 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, $\varphi$ (Parente-Prescott 1994)

- Mass of potential entrants, $\mu_t$, from costly entry condition:

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

- Firm enters if and only if $x \geq \hat{x}_t$

# Measure of firms

- Measure of firms of age $j$ in operation

$$\eta_{jt} = \mu_{t-j+1}(1-\delta)^{j-1}\left[1 - F_{t-j+1}\left(\frac{\hat{x}_t}{\prod_{s=1}^{j-1} g_{c,t-s+1}}\right)\right]$$

- Convert age-$j$ efficiency to initial efficiency

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

- 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

$$D_t = \Pi_t - \mu_t \kappa_t$$

# Existence of balanced growth path

Economy 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

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

Economy grows by $g_e$

# Characterizing BGP: levels

$$\mu = \frac{\xi}{\gamma\kappa\omega}$$

$$\hat{x}_t = \frac{g_e^t}{\varphi}\left(\frac{\omega}{\eta}\mu\right)^{\frac{1}{\gamma}}$$

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

$$Y_t = \left(\frac{1-\alpha}{f}\right)^{1-\alpha}\hat{x}_t$$

$$\eta = \frac{\gamma(1-\alpha)-1}{\gamma f}$$

- As $\kappa$ decreases
  - More potential entrants pay to draw efficiency
  - More-efficient firms enter and aggregate income increases

quantitative exercise

# Entry cost reform

1. Calibrate model to U.S. (high BGP)
   - No policy distortions in entry costs
   - $\kappa_{us} = \kappa^T$
2. Model a distorted country on a lower balanced growth path
   - Income level is 15 percent lower than U.S.
   - $\kappa_D = \kappa^T + \kappa^P$
   - $\kappa_D = 5 \times \kappa_{us}$
3. Reform entry costs in distorted country to U.S. level
   - Solve for transition to higher balanced growth path

# Measuring capital

- Fixed costs ($\kappa, f$) are investments (new approach)
- How are they accounted for
  - In the firm's accounts?
  - In the national accounts?

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- Aggregate investment $= \mu_t \kappa_t + \eta_t f_t$
- Depreciation is the sum of
  - Capital of firms that die or exit
  - $\kappa_t$ of potential entrants that do not enter
  - $f_t$ minus costs of upgrading capital for continuing firms

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  - $f_t$ minus costs of upgrading capital for continuing firms
- Aggregate capital stock $= \eta_t(\kappa_t + f_t)$
- Depreciation rate constant on BGP, not in transition

# Measuring capital

- Alternatives we are considering
- In the model
  - $\kappa_t, f_t$ scale with $g_e^t$ rather than $Y_t$
  - Policy distortions are ad valorem, $\kappa^T + \kappa^P = \tau\kappa^T$
- In the accounting
  - Some parts of $\kappa$ and $f$ are intermediate inputs
  - Expensed, rather than counted as investment

# Measuring productivity

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

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

- Capital share is given by

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

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

# Calibration

Calibrate model to match size distribution of plants as well as effect of net entry on aggregate productivity growth.

# Calibrated parameters

- Model period is 5 years
- Data from United States

| Parameter | Value | Target |
|---|---|---|
| Operating cost $f$ | $0.32 \times 5$ | average establishment size $= 16.0$ |
| Entry cost $\kappa$ | 0.26 | entry cost / fixed cost$^* = 0.82$ |
| Pareto parameter $\gamma$ | 10.08 | establishment size s.d. $= 91.2$ |
| Firm growth $\bar{g}^{1/(1-\varepsilon)}$ | $(1.017)^5$ | effect of net entry on growth$^\dagger = 25\%$ |
| Death rate $\delta$ | $1-(0.97)^5$ | exiting plant employment share$^\ddagger$ =17.7% |
| Entrant productivity $g_e$ | $(1.02)^5$ | BGP growth factor $= 1.02$ |
| Discount factor $\beta$ | $(0.98)^5$ | 4 percent real interest rate |
| Returns to scale $\alpha$ | 0.8 | Atkeson and Kehoe (2005) |

$^*$Survey in Barseghyan and DiCecio (2011); $^\dagger$Foster et al. (2001); $^\ddagger$Dunne et al. (1989)

# 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: $\varepsilon = 0.52$

# Solving for transition path

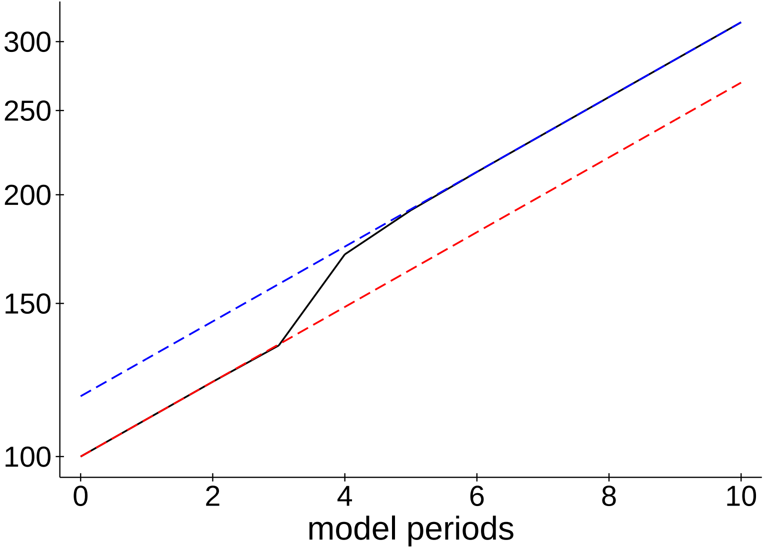
- Unanticipated reform at $t = t_0$: $\kappa_D = \kappa_{us}$
- System of $2T$ equations and $2T$ unknowns for large $T$
  - Labor market clearing

$$\hat{x}_t^{\gamma} = \frac{g_e^{\gamma t}}{\eta} \sum_{i=1}^{N} \varphi_{t-i+1}^{-\gamma} \mu_{t-i+1} (1-\delta)^{i-1} g_e^{\gamma(1-i)} \prod_{s=1}^{i-1} g_{c,t-s+1}^{\gamma}$$

  - Costly entry condition

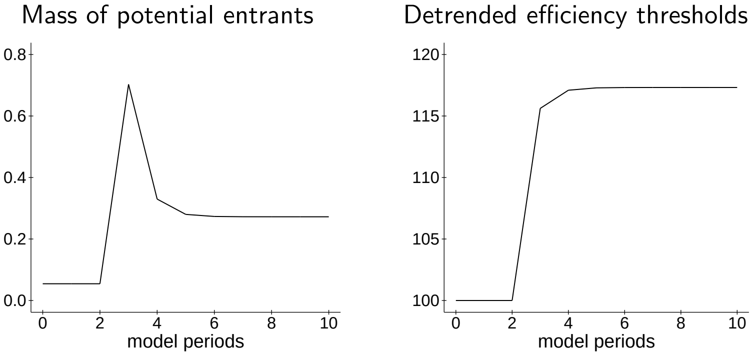
$$\kappa_t = \frac{g_e^{\gamma t}}{\gamma \eta} \varphi_t^{-\gamma} \sum_{i=1}^{N} (1-\delta)^{i-1} \left( \prod_{s=1}^{i-1} q_{t+s} g_{c,t+s}^{\gamma} \right) \frac{w_{t+i-1}}{\alpha} \hat{x}_{t+i-1}^{-\gamma}$$

# Output per worker



# Transition: more potential entrants

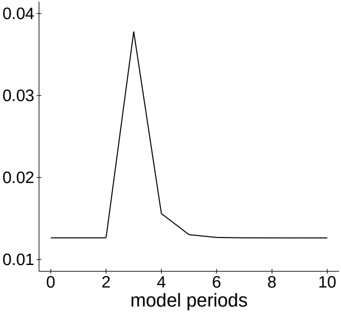
- More potential entrants increases efficiency thresholds



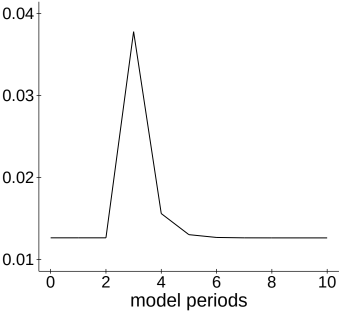
# Transition: more entry and exit

- Efficient firms enter, inefficient firms exit
- Total mass of firms is constant

Mass of entering firms

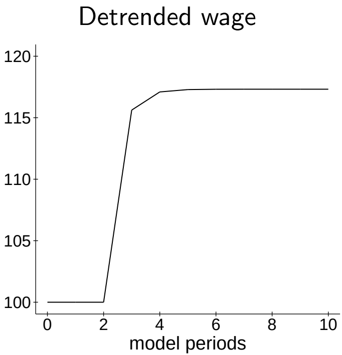


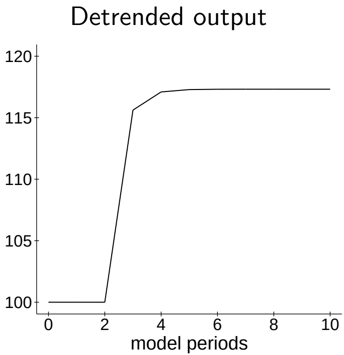

Mass of exiting firms



# Transition: wages and output

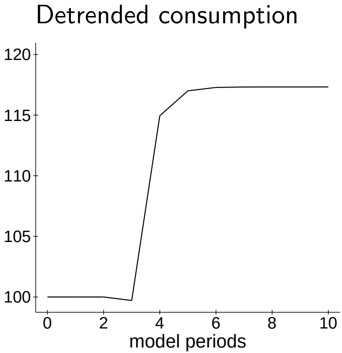
- Higher wages increase efficiency thresholds
- More efficient firms increase output

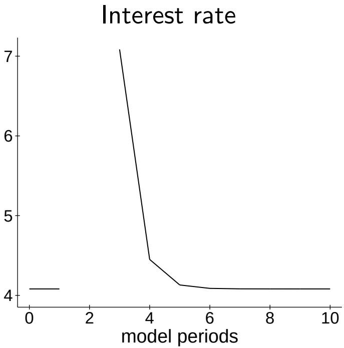


# Transition: consumption and interest rates

- More attractive investment opportunities



# Productivity growth decompositions

| Model periods (5 years) | Entry Cost | Output growth (%, annualized) | Contribution of net entry (%) |
|---|---|---|---|
| 0-2 | 1.32 | 2.0 | 25.0 |
| 3 (reform) | 0.26 | 5.0 | 78.3 |
| 4 | 0.26 | 2.3 | 33.5 |
| 5 | 0.26 | 2.0 | 26.3 |
| 6+ | 0.26 | 2.0 | 25.0 |

# Net entry and productivity in model and data

- Model generates quantitatively reasonable numbers

| | Model reform | Data rapid | Model BGP | Data slow |
|---|---|---|---|---|
| GDP/WAP growth (%) | 5.0 | 6.3 | 2.0 | 2.6 |
| Contribution of net entry (%) | 78.3 | 54.0 | 25.0 | 26.0 |

- Calibration and experiment need further work

# Reforming barriers to technology adoption

- A reform that does not involve entry costs
- Potential entrants draw efficiency from

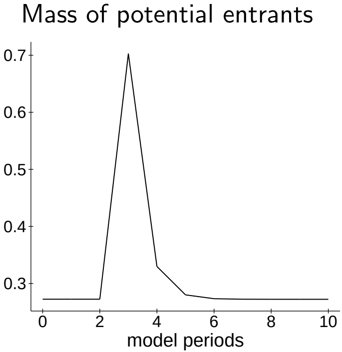
$$F_t(x) = 1 - \left(\frac{\varphi x}{g_e^t}\right)^{-\gamma}, \; x \geq \frac{g_e^t}{\varphi}$$

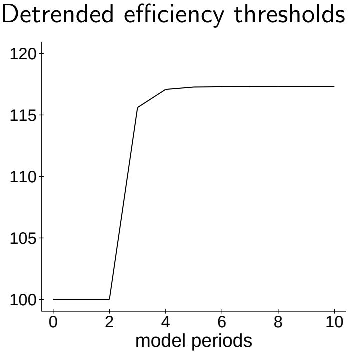
  $\varphi \geq 1$: policy-induced barriers to technology adoption

- Set $\varphi$ so that distorted BGP is 15 percent lower than U.S.
- Reform $\varphi$ to generate a transition to higher BGP

# Transition: more potential entrants

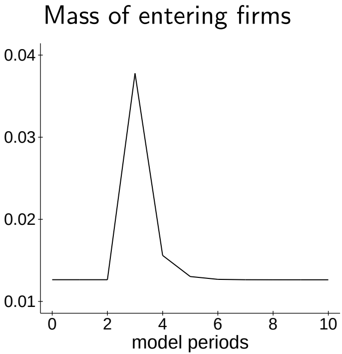
- More potential entrants only in the transition
- Efficiency thresholds increase

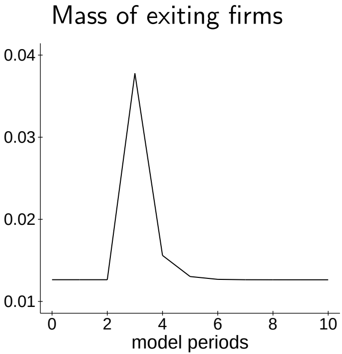


# Transition: more entry and exit

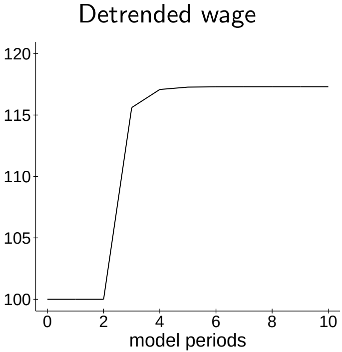
- Efficient firms enter, inefficient firms exit
- Total mass of firms is constant

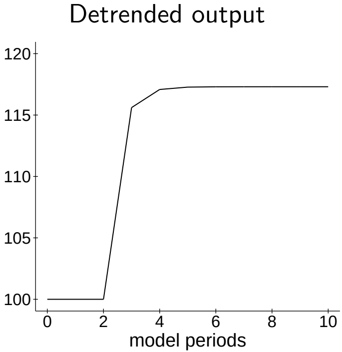


# Transition: wages and output

- Higher wages increase efficiency thresholds
- More efficient firms increase output

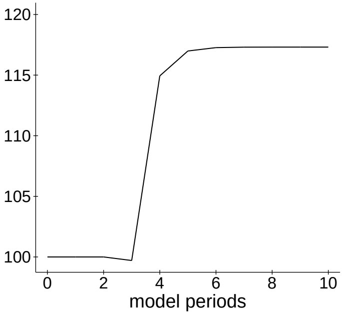


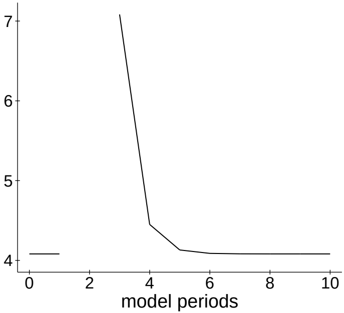
# Transition: consumption and interest rates

- More attractive investment opportunities

Detrended consumption




Interest rate



# Productivity growth decompositions

| Model periods (5 years) | Barrier to tech. adoption | Productivity growth (%, annualized) | Contribution of net entry (%) |
|---|---|---|---|
| 0-2 | 1.17 | 2.0 | 25.0 |
| 3 (reform) | 1.00 | 5.0 | 78.2 |
| 4 | 1.00 | 2.3 | 33.5 |
| 5 | 1.00 | 2.0 | 26.2 |
| 6+ | 1.00 | 2.0 | 25.0 |

- Almost identical to reform in entry cost

# Reform and growth

- Reforms that increase aggregate productivity
  - Increase entry and exit in the transition
  - Increase the contribution of net entry
- Need models of entry and exit to understand productivity