Corporate Profits Tax and Innovative Investments

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Introduction

- Impact of changes in corporate profits taxes on dynamics of aggregate output?
- How much do changes in firms' incentives to invest in innovation matter?

- Barro-Furman (2018), CBO, Penn-Wharton Budget Model
  - R&D capital accumulation, parallel to physical capital
- Atkeson-Burstein (2018) model of firm dynamics and innovation:
- Expensing for tax purposes of investment in entry vs. innovation by incumbents, business stealing, markups, gap btw private & social returns due to spillovers
- Extend results on aggregate implications of policy-induced changes in innovation

AB Model

- Pros:
  - Nest range of models that allow for innovation by incumbents and entrants
    - Jones (2002)
    - NS: Grossman Helpman (1991), Aghion Howitt (1992), Klette Kortum (2004), Acemoglu and Cao (2015)
    - EV: Romer (1990), Luttmer (2007, 11), Atkeson and Burstein (2010)
  - Tractable aggregate transition dynamics and welfare
  - Clear guide for measurement, building on Ackigit and Kerr (2016), Garcia, Hsieh, and Klenow (2016)
- Cons:
  - Does not nest models that need state variable for firm types
    - Lentz and Mortensen (2008), Luttmer (2011), Acemoglu, Ackigit, Bloom, and Kerr (2013) and Peters (2016)

Impact of a permanent $\downarrow$ in corporate profits tax

Log change	**Output 10 years**	**Output Long run**	**Welfare**
Exogenous productivity	0.02	0.03	0.004
Endogenous innovation	$[0.002, 0.05]$	$[-3.26, 3.28]$	$[-0.11, 0.22]$

- Ten-year horizon: consideration of impact of corporate profits taxes on firms' incentives to innovate does not results in large absolute differences (relative to e.g. business cycle variation)
- Long-run: potentially large impact (positive or negative) depending on
  - intertemporal knowledge spillovers
  - is there too much or too little entry in the initial equilibrium?

Talk Outline

- Simple model
  - only entrants invest
  - two sufficient statistics for long-run, transition dynamics
  - simple bound on impact elasticity
- Add investment by incumbent firms
  - reallocation of innovation between entrants and incumbents
- Calibration and policy experiment
- Results

Model outline

- Two final goods
  - output: consumption and physical investment
  - research good: input to innovation
- Output produced from differentiated intermediate goods
  - produced with physical capital and production labor
- Research good produced with research labor
- Entrants invest research good to acquire a differentiated good
  - create new intermediate goods or
  - improve upon existing goods (business stealing)
- Later: add innovation by incumbents

Intermediate Goods and Final Consumption Good

Intermediate Goods

$$y_t(z) = \exp(z) k_t(z)^{\alpha} l_{pt}(z)^{1-\alpha}$$

Measure of products $M_t(z)$, $\quad M_t = \sum_z M_t(z)$

Aggregate Output

$$Y_t = \left[\sum_z y_t(z)^{\frac{\rho-1}{\rho}} M_t(z) \right]^{\frac{\rho}{\rho-1}} = C_t + K_{t+1} - (1 - d_k) K_t$$

Assuming constant markups $\mu > 1$ and common factor prices

$$Y_t = Z_t K_t^{\alpha} L_{pt}^{1-\alpha} \qquad K_t = \sum_z k_t(z) M_t(z) \qquad L_{pt} = \sum_z l_{pt}(z) M_t(z)$$

Aggregate productivity

$$Z_t = \left[\sum_z \exp(z)^{\rho-1} M_t(z) \right]^{1/(\rho-1)}$$

Inputs into Innovative Investment

Research good

$$Y_{rt} = A_{rt} Z_t^{\phi - 1} L_{rt}$$

Research labor $L_{rt} = L_t - L_{pt}$.

Intertemporal knowledge spillovers $\phi \leq 1$

Research TFP $= A_{rt} Z_t^{\phi - 1}$ Jones (2002) and Bloom et. al. (2017)

Exogenous Scientific Progress A_{rt} grows at $\bar{g}_{Ar}$, labor L_t grows at $\bar{g}_L$

$\phi < 1$ ideas get “harder to find"

Balanced growth path — Y_{rt} constant

$$\bar{g}_Z = \frac{\bar{g}_L + \bar{g}_{A_r}}{1 - \phi}$$

Investments and Aggregate Productivity Growth

Innovation technologies imply tractable equilibrium aggregation:

$$\log Z_{t+1} - \log Z_t = G(x_{et})$$

subject to

$$x_{et} = Y_{rt}$$

- Each entrant spends $\frac{1}{M_t}$ units of the research good at $t \implies x_{et} M_t$ new products
- Fraction δ_e stolen, $1 - \delta_e$ new to society
- Externalities in productivity: $\mathbb{E} \exp(z')^{\rho-1} = \eta_e \frac{Z_t^{\rho-1}}{M_t}$

Evolution of aggregate productivity

$$\log Z_{t+1} - \log Z_t = \frac{1}{\rho - 1} \log \left[(1 - \delta_{ct}) + \eta_e x_{et} \right]$$

Product exit $\delta_{ct} = \delta_0 + \delta_e x_{et}$

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Product exit $\delta_{ct} = \delta_0 + \delta_e x_{et}$

Physical capital holding firm and corporate profits tax

Firm chooses investment K_{t+1} to maximize $\sum_{t=0}^{\infty} Q_t D_{kt}$

$$D_{kt} = (1-\tau)R_{kt}K_t - (1-\tau\lambda_k)\left(K_{t+1} - (1-\delta_k)K_t\right)$$

$$\left(\frac{1-\tau}{1-\tau\lambda_k}\right)R_{kt+1} - \delta_k = R_{t+1} \quad \text{where} \quad R_{kt} = \frac{\alpha}{\mu}\frac{Y_t}{K_t}$$

Long run change in user cost of capital

$$\log\frac{\bar{K}_t'}{\bar{Y}_t'} - \log\frac{\bar{K}_t}{\bar{Y}_t} = \log\left(\frac{1-\tau'}{1-\lambda_k'\tau'}\right) - \log\left(\frac{1-\tau}{1-\lambda_k\tau}\right)$$

Intermediate good firms and corporate profits tax

Value of an incumbent firm with productivity z, $V_t(z) = V_t \exp(z)^{\frac{1}{\rho-1}}$

$$V_t = (1-\tau)\frac{\mu-1}{\mu}Y_t + \frac{1}{1+R_t}V_{t+1}(1-\delta_{ct})\frac{Z_t^{\rho-1}}{Z_{t+1}^{\rho-1}}$$

Entry condition:

$$(1-\tau\lambda_e)P_{rt}\frac{1}{M_t} = \frac{1}{1+R_t}V_{t+1}\frac{\eta_e}{M_t}\frac{Z_t^{\rho-1}}{Z_{t+1}^{\rho-1}}$$

Innovation intensity $i_{rt} \equiv \frac{P_{rt}Y_{rt}}{Y_t}$, and labor allocation $L_{rt} = \frac{i_{rt}}{i_{rt}+(1-\alpha)/\mu}$ (w.l.o.g $L_t = 1$)

Long-run change in user cost of intangible capital

$$\log \bar{i}_r' - \log \bar{i}_r = \log\left(\frac{1-\tau'}{1-\lambda_e'\tau'}\right) - \log\left(\frac{1-\tau}{1-\lambda_e\tau}\right)$$

and given $Y_{rt} = A_{rt}Z_t^{\phi-1}L_{rt}$ constant between BGPs:

$$\log \bar{Z}_t' - \log \bar{Z}_t = \frac{1}{1-\phi}\left(\log \bar{L}_r' - \log \bar{L}_r\right)$$

Transition Dynamics

$$\log Z_{t+1} - \log Z_t = G(Y_{rt})$$

Impact Elasticity

$$\log Z_{t+1} - \log Z_t - \bar{g}_Z \approx \Theta \left(\log Y_{rt} - \log \bar{Y}_r\right)$$

$$\Theta \equiv G'(\bar{Y}_r)\bar{Y}_r$$

Combined with research good production function, $Y_{rt} = A_{rt} Z_t^{\phi-1} L_{rt}$:

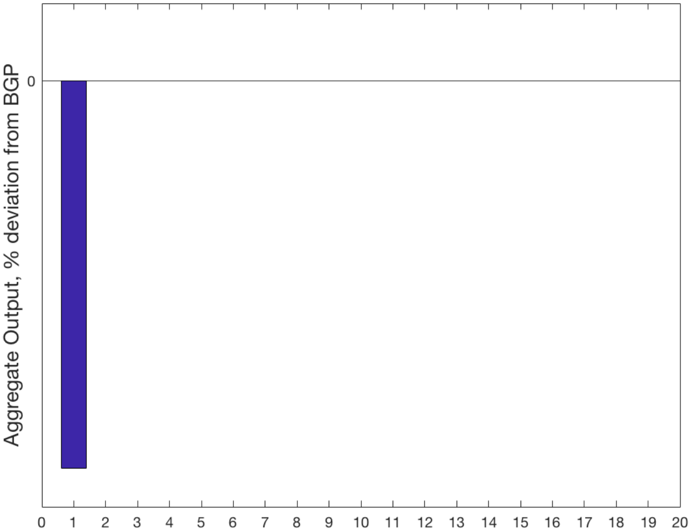
$$\log Z'_{t+1} - \log \bar{Z}_{t+1} = \sum_{k=0}^{t} \Gamma_k \left(\log L_{rt} - \log \bar{L}_r\right)$$

$$\Gamma_0 = \Theta \qquad \Gamma_{k+1} = \left[1 - \Theta(1-\phi)\right] \Gamma_k$$

$$\log Y'_t - \log \bar{Y}_t = \frac{1}{1-\alpha}\left(\log Z'_t - \log \bar{Z}_t\right) + \left(\log L'_{pt} - \log \bar{L}_p\right) - \frac{\alpha}{1-\alpha}\left(\log R'_{kt} - \log \bar{R}_k\right)$$

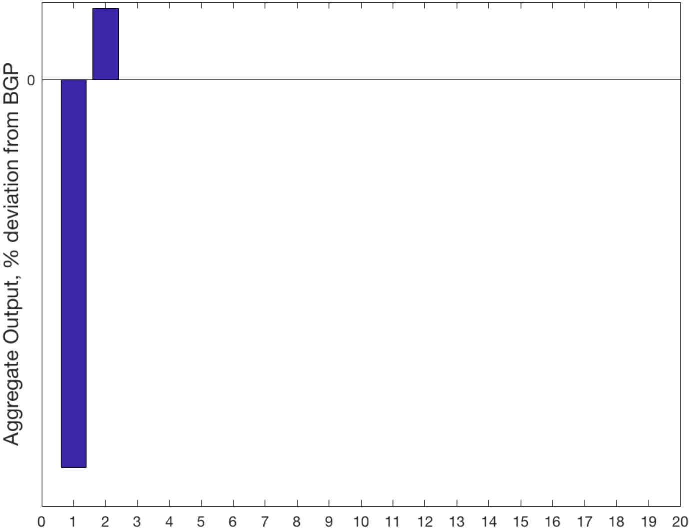
Welfare

One-period reallocation of labor towards research



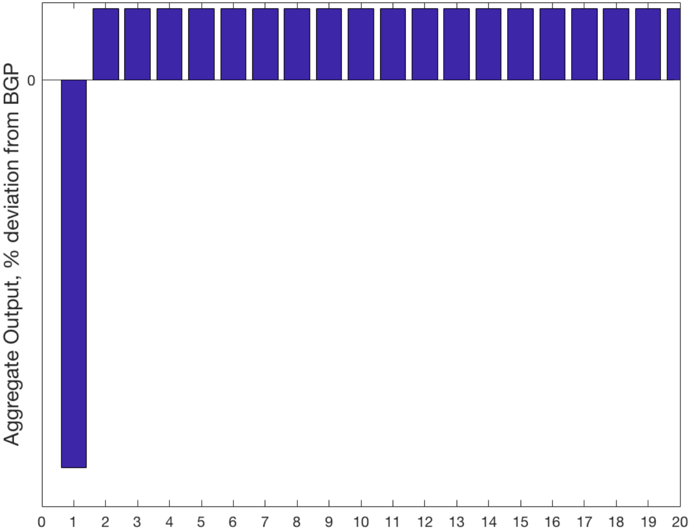
Impact Elasticity

Increase in aggregate productivity above trend



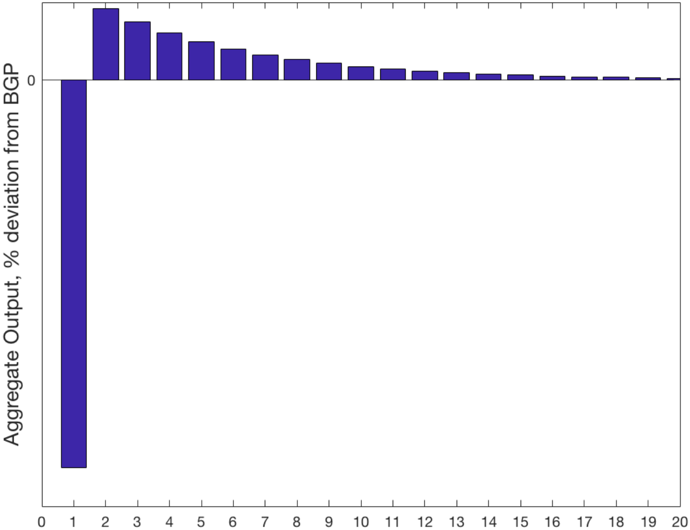
Dynamics: Full Intertemporal Knowledge Spillovers

Permanent increase in aggregate productivity above trend



Limited Intertemporal Knowledge Spillovers

Aggregate productivity reverts back to its initial path



Bounding the Impact Elasticity Θ

$$\Theta = \frac{1}{\rho - 1} \frac{\exp(\bar{g}_Z)^{\rho-1} - \exp(G(0))^{\rho-1}}{\exp(\bar{g}_Z)^{\rho-1}} \leq \bar{g}_z - G(0)$$

$$\text{Impact elasticity} \leq \frac{\bar{g}_Z - G(0)}{\bar{x}_e / \bar{Y}_r} = \frac{\text{contribution of entrants' innovation to growth}}{\text{entrants' share of innovative investment}}$$

Investments by incumbents and productivity growth

Product-level innovation technologies imply tractable equilibrium aggregation:

$$\log Z_{t+1} - \log Z_t = G(x_{ct}, x_{mt}, x_{et})$$

subject to

$$x_{ct} + x_{mt} + x_{et} = Y_{rt}$$

Evolution of aggregate productivity ▸ details

$$Z_{t+1}^{\rho-1} = [(1-\delta_{ct})\,\zeta(x_{ct}) + \eta_m h(x_{mt}) + \eta_e x_{et}]\,\frac{Z_t^{\rho-1}}{M_t} M_t$$

Product exit

$$\delta_{ct} = \delta_0 + \delta_m h(x_{mt}) + \delta_e x_{et}$$

Impact Elasticity

Start from

$$\log Z_{t+1} - \log Z_t = G(x_{ct}, x_{mt}, x_{et}) \quad \text{where} \quad x_{ct} + x_{mt} + x_{et} = Y_{rt}$$

Differentiating

$$\log Z_{t+1} - \log Z_t - \bar{g}_Z \approx \Theta \left(\log Y_{rt} - \log \bar{Y}_r\right)$$

$$\Theta = \frac{dx_c}{dY_r}\Theta_c + \frac{dx_m}{dY_r}\Theta_m + \frac{dx_e}{dY_r}\Theta_e$$

where $\Theta_i = G_i(\bar{x}_c, \bar{x}_m, \bar{x}_e)\bar{Y}_r$ and $\frac{dx_c}{dY_r} + \frac{dx_m}{dY_r} + \frac{dx_e}{dY_r} = 1$

Θ is now policy dependent

Intermediate good firms and corporate profits tax

Value of incumbents:

$$V_t = (1-\tau)\frac{\mu-1}{\mu}Y_t - (1-\tau\lambda_c)\,P_{rt}\,(x_{ct}+x_{mt})$$

$$+\frac{1}{1+R_t}V_{t+1}\left[(1-\delta_{ct})\zeta(x_{ct})+\eta_m h(x_{mt})\right]\frac{Z_t^{\rho-1}}{Z_{t+1}^{\rho-1}}$$

Entry condition:

$$(1-\tau\lambda_e)P_{rt}\frac{1}{M_t} = \frac{1}{1+R_t}V_{t+1}\frac{\eta_e}{M_t}\frac{Z_t^{\rho-1}}{Z_{t+1}^{\rho-1}}$$

Interior equilibrium investment allocation, given Y_{rt}

$$\frac{(1-\tau\lambda_c)}{(1-\tau\lambda_e)}\eta_e = \eta_m h'(x_{mt}) = (1-\delta_{ct})\,\zeta'(x_{ct})$$

$$Y_{rt} = x_{ct}+x_{mt}+x_{et}$$

Equal expensing for incumbents and entrants: $\lambda_e = \lambda_c$

Policy affects Y_{rt} but not mapping between Y_{rt} and $\log(Z_{t+1}) - \log(Z_t)$

Formulas for dynamics in simple model go through

If $\lambda_e = \lambda_c < 1$, $\downarrow \tau$ equivalent to $\uparrow$ uniform subsidy to all innovative investments $\Rightarrow \uparrow i_r$

- No business stealing: $\Theta = \Theta_e = \Theta_c = \Theta_m$
- Business stealing: $\Theta_e < \Theta_c$. $\uparrow x_e$ and $\downarrow x_c$, under regularity condition, $\Theta \leq \Theta_e$

$$\Theta_e \leq \frac{\bar{g}_Z - G(\bar{x}_c, \bar{x}_m, 0)}{\bar{x}_e / \bar{Y}_r} = \frac{\text{contribution of entrants' innovation to growth}}{\text{entrants' share of innovative investment}}$$

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Different expensing for incumbents and entrants

Interior equilibrium investment allocation, given Y_{rt}

$$\frac{(1-\tau\lambda_c)}{(1-\tau\lambda_e)}\eta_e = \eta_m h'(x_{mt}) = (1-\delta_{ct})\,\zeta'(x_{ct})$$

$$Y_{rt} = x_{ct} + x_{mt} + x_{et} \qquad \log Z_{t+1} - \log Z_t = G(x_{ct}, x_{mt}, x_{et})$$

Policies affect mapping btw Y_{rt} and $\log(Z_{t+1}) - \log(Z_t)$, but mapping time-invariant

Transition dynamics around new BGP allocation of investment

$$\log Z'_{t+1} - \log \bar{Z}_{t+1} \approx \sum_{k=0}^{t} \Gamma'_k \left[\log L'_{rt-k} - \log \bar{L}_r - \left(\log \bar{Y}'_r - \log \bar{Y}_r\right)\right]$$

$$\Gamma'_0 = \Theta' \text{ and } \Gamma'_{k+1} = [1-(1-\phi)\Theta']\,\Gamma'_k$$

Long-run efficiency gains from reallocation of investments: $\log \bar{Y}'_r - \log \bar{Y}_r$

If $\lambda_c > \lambda_e$, then it is possible that $\Theta'_e > \Theta'_c$ and $\Theta' > \Theta'_e$, curvatures of h and ζ matter

Measurement

- $\Theta_e \leq (\bar{g}_Z - G(\bar{x}_c, \bar{x}_m, 0))\frac{\bar{Y}_r}{\bar{x}_e}$

  1. Contribution of Entrants to Growth
     - with no business stealing $= \frac{1}{\rho - 1}$ *employment share of entering firms*
     - estimates of $\bar{g}_Z - G(\bar{x}_c, \bar{x}_m, 0)$ from GHK and Akcigit and Kerr (2016)
  2. Share of entrants' innovation expenditure in total innovation expenditure
     - NIPA measures of innovation expenditures of incumbent firms
     - impute investment in entry equal to value of entering firms

- Intertemporal Knowledge Spillovers ϕ
  - $\phi = 0.96$ — $\approx$ endogenous growth
  - $\phi = -1.6$ — Fernald and Jones (2014)

Measurement

- $\Theta_e \leq (\bar{g}_Z - G(\bar{x}_c, \bar{x}_m, 0))\frac{\bar{Y}_r}{\bar{x}_e}$

  1. Contribution of Entrants to Growth
     - $\frac{1}{\rho-1}$ *employment share of entering firms* $= \frac{0.027}{3} = 0.009$
     - AK 2016 $\frac{\bar{g}_Z - G(\bar{x}_c, \bar{x}_m, 0)}{\bar{g}_Z} = 0.257 \implies \bar{g}_Z - G(\bar{x}_c, \bar{x}_m, 0) = 0.0037$
  2. Share of entrants' innovation expenditure in total innovation expenditure
     - incumbent firms invest 6.1% of output in innovation
     - imputed innovative investment of entering firms 3.1% of output

- Intertemporal Knowledge Spillovers ϕ
  - $\phi = 0.96$ — $\approx$ endogenous growth
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Measurement

Implied parameter values

1. Impact elasticity of entrants, Θ_e
   - $\Theta_e = 0.030$ — no business stealing
   - $\Theta_e = 0.011$ — AK 2016
2. Intertemporal Knowledge Spillovers ϕ
   - $\phi = 0.96$ — $\approx$ endogenous growth
   - $\phi = -1.6$ — Fernald and Jones (2014)
3. Ratio of growth rate to interest rate and physical capital share
   - $\tilde{\beta} = 0.986$
   - $\alpha = 0.25$

Policy Experiment

Unanticipated, permanent

Corporate profit taxes $\tau = 0.38$, $\tau' = 0.26$ (BF2018)

- $\lambda_k = 0.87$ ($K/Y = 2.12$), $\lambda_k' = 1$ ($\Delta \log K/Y = 0.08$, BF2018)
- expensing of innovative investments: $\lambda_c = 1$ and $\lambda_e = 0$

Three cases:

1. innovation unchanged
2. only entry responds

$$\log \bar{i}_r' - \log \bar{i}_r = \left[\log\left(1 - \tau'\right) - \log\left(1 - \tau\right)\right] \times \bar{\mathrm{div}}/\bar{\mathrm{prof}},$$

3. entry & incumbents respond

Physical investment / output up by 1.4 percentage points

Innovation intensity of the economy up by 0.8 (case 2) or 0.3 (case 3) p.p.

Aggregate productivity

Log change	10 years		Long run	
	$\phi = -1.6$	$\phi = 0.96$	$\phi = -1.6$	$\phi = 0.96$
1. Exogenous productivity	0	0	0	0
2. Endogenous entry				
No business stealing	0.024	0.020	0.03	1.92
With business stealing	0.009	0.007	0.03	1.92
3. Endogenous entry and incumbents				
No business stealing	0.030	0.026	0.04	2.45
With business stealing	-0.017	-0.015	-0.04	-2.46

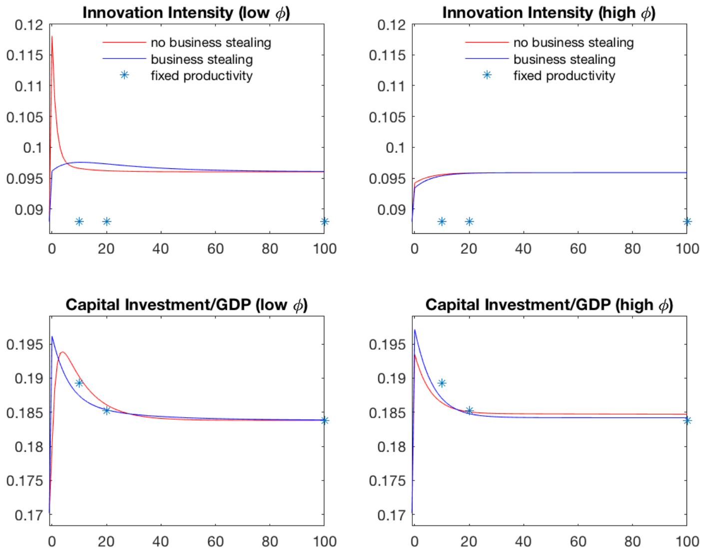
Aggregate output

Log change	10 years		Long run	
	$\phi = -1.6$	$\phi = 0.96$	$\phi = -1.6$	$\phi = 0.96$
1. Exogenous productivity	0.019	0.019	0.026	0.026
2. Endogenous entry				
No business stealing	0.034	0.029	0.05	2.58
With business stealing	0.016	0.017	0.07	2.60
3. Endogenous entry and incumbents				
No business stealing	0.047	0.040	0.07	3.28
With business stealing	0.002	0.002	-0.03	-3.26

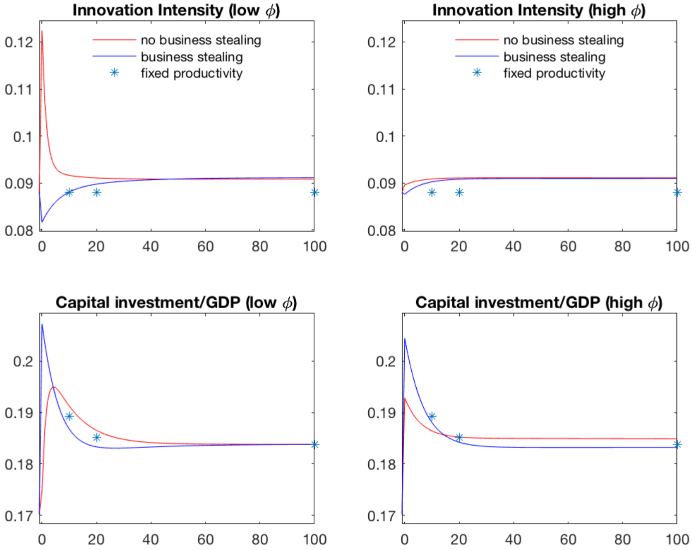
Welfare (equivalent variation)

	$\phi = -1.6$	$\phi = 0.96$
1.Exogenous productivity	0.004	0.004
2.Endogenous entry		
No business stealing	0.03	0.17
With business stealing	0.02	0.07
3. Endogenous entry and incumbents		
No business stealing	0.04	0.22
With business stealing	-0.04	-0.11

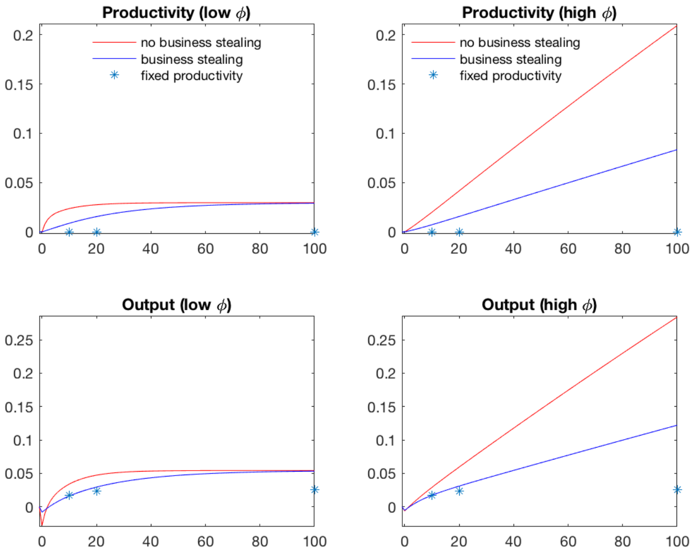
Endogenous entry



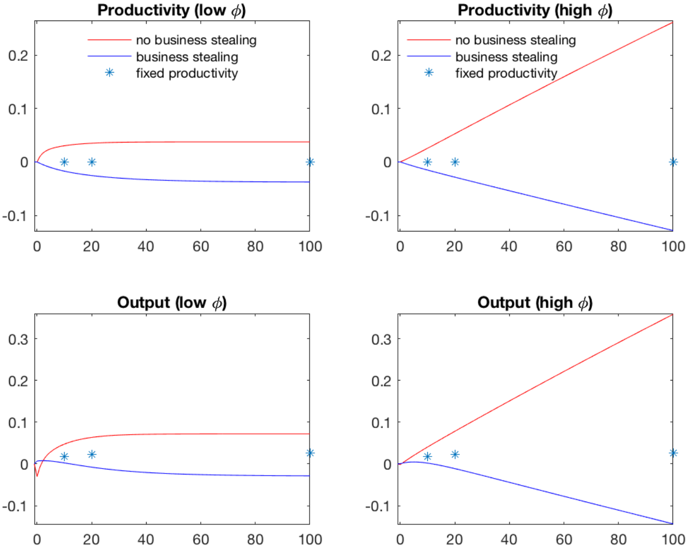
Endogenous entry and incumbents



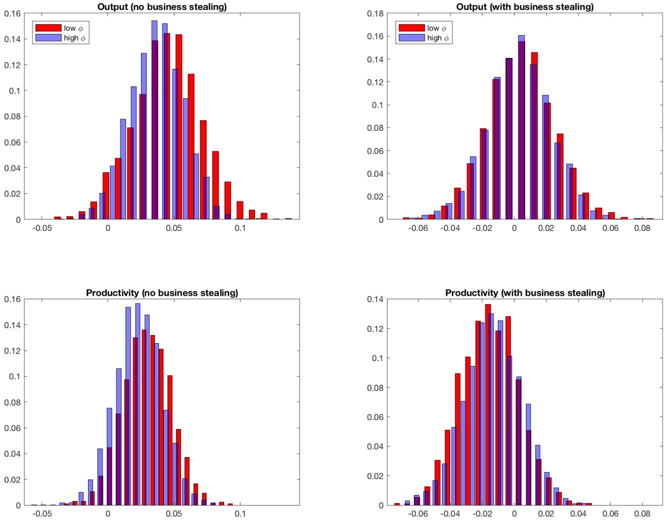
Endogenous entry



Endogenous entry and incumbents



Endogenous entry and incumbents



Summary

- How do consideration of the impact of corporate profits taxes on firms' incentives to invest in innovation shape the model's predicted response of aggregate output?
- Ten-year horizon: response not very different (in absolute terms) compared to e.g. business cycle variation
- Long-run: can make a big difference, depending on:
  - intertemporal knowledge spillovers
  - is there too much or too little entry in the initial equilibrium (due to business stealing and ex-ante differential expensing)?

Investments by incumbents and productivity growth

Product-level technologies:

1. New products by entrants, $x_{et} M_t$, fraction δ_e stolen, $\mathbb{E}\exp(z')^{\rho-1} = \eta_e \frac{Z_t^{\rho-1}}{M_t}$
2. New products by incumbent firms, $h(x_{mt}) M_t$, δ_m stolen, $\mathbb{E}\exp(z')^{\rho-1} = \eta_m \frac{Z_t^{\rho-1}}{M_t}$
3. Improvements of incumbents' products, if continue, $\mathbb{E}\exp(z')^{\rho-1} = \zeta(x_{ct}) \frac{Z_t^{\rho-1}}{M_t}$

Total measure of products

$$M_{t+1} = \left[(1 - \delta_{ct}) + h(x_{mt}) + x_{et}\right] M_t$$

Evolution of aggregate productivity

$$Z_{t+1}^{\rho-1} = \left[(1 - \delta_{ct}) \zeta(x_{ct}) + \eta_m h(x_{mt}) + \eta_e x_{et}\right] \frac{Z_t^{\rho-1}}{M_t} M_t$$

Product exit

$$\delta_{ct} = \delta_0 + \delta_m h(x_{mt}) + \delta_e x_{et}$$

Back

Welfare

Suppose undistorted physical capital Euler

Consumption Equivalent Welfare

$$\log \xi \approx (1-\tilde{\beta}) \sum_{t=0}^{\infty} \tilde{\beta}^t \frac{\bar{Y}}{\bar{C}} \left[\left(\log Z_t' - \log \bar{Z}_t \right) + (1-\alpha) \left(\log L_{pt}' - \log \bar{L}_p \right) \right]$$

$$\tilde{\beta} = \frac{\exp(\bar{g}_Y)}{1+R}$$

Socially Optimal Research Intensity

$$i_r^* = \frac{\tilde{\beta}\Theta}{1-\tilde{\beta}\left[1-(1-\phi)\Theta\right]}$$

Back