Entrepreneurship through Employee Mobility, Innovation, and Growth

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53rd Konstanz Seminar on
Monetary Theory and Monetary Policy
June 2022

Motivation

- Handful of high-quality, transformational entrepreneurs drive most of productivity growth.
- Recent literature emphasizes ex-ante differences at birth in entrepreneurs' quality/growth potential.
- What are the sources of these large quality differences at birth?
  - Improves our understanding of growth process and design of policies.

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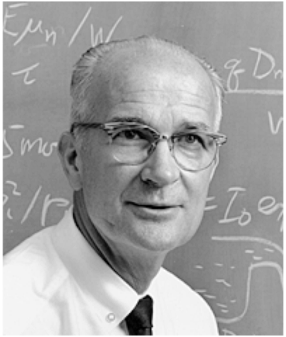
- What are the sources of these large quality differences at birth?
  - Improves our understanding of growth process and design of policies.
- Spinouts – new firms spawned by employees of existing incumbents – often distinctly high-quality.

Transformative Spinouts



William Shockley

In 1955, an inventor of the transistor, Stanford professor, and a Nobel prize winner William Shockley establishes "Shockley Transistors". Two years later, "The Traitorous Eight" scientists leave the company to found "Fairchild Semiconductors" – the leader of semiconductor industry and incubator of Sillicon Valley.

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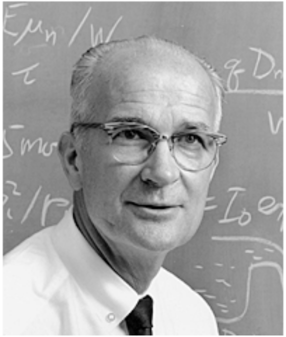

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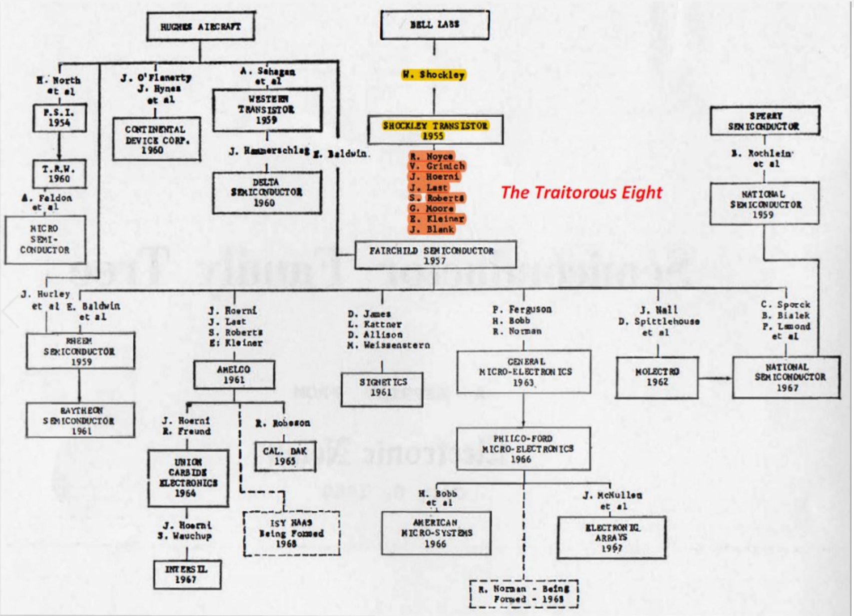

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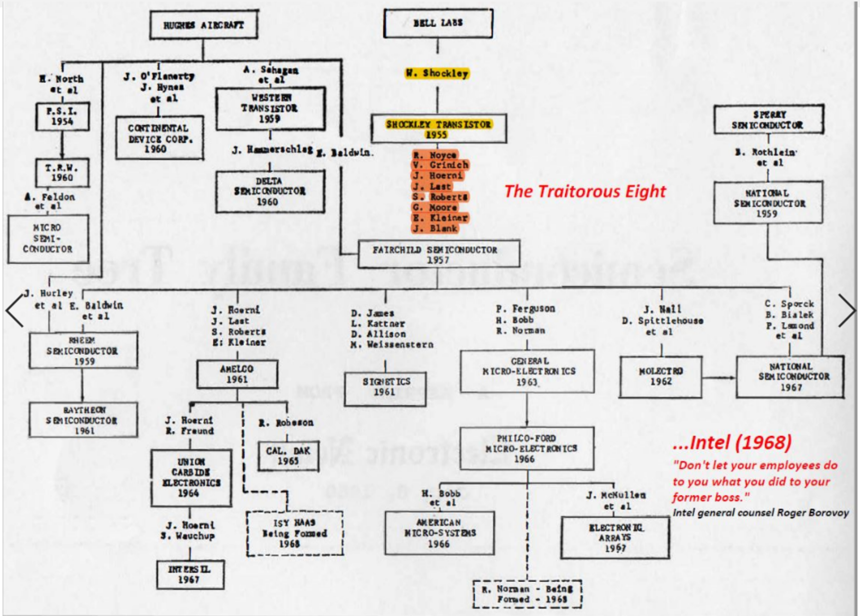

Motivation

- Spinout entry and knowledge diffusion through employee mobility may be essential for growth.
- However, tension between entrepreneurial spawning and employers' innovation incentives (appropriability problem).
- Indeed, many U.S. states enforce Non-Compete agreements:
  - Restrictions on employees moving and starting new business. Chilling effect.
  - Growing use over time; 25-60 million signed NCC.
  - Fight in DC: A NCL reform bill *(House Bill 2293, 2017-2018)* filed for strengthening NCL VS *Executive Order* on limiting NCL, President Biden, July, 2021.

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This paper:

* Study innovation and growth with spinout dynamics.

* Quantitatively explore optimal non-compete policies.

This Paper

- **Empirical Analysis**
  - Identify *innovating* spinouts using inventors and patents data.
  - Stylized empirical facts motivating the model.
- **Theoretical Analysis**
  - A new theory of innovation and firm dynamics with spinout dynamics.
- **Quantitative Analysis**
  - Quantitatively explore the mechanisms of the model.
  - Growth decompositions. Policy experiments.

Literature & Contribution

- Large *ex-ante* differences among firms (Schoar, 2010; Hurst & Pugsley (2011); Guzman & Stern (2019), Pugsley, Sedlacek, & Sterk (2020))
  ** *a* micro-foundation for ex-ante quality differences.

- Importance of knowledge diffusion for sustained growth (Lucas & Moll (2014); Perla & Tonetti (2014))
  ** quantify importance of knowledge diffusion through employee spinouts.

- Policies encouraging entrepreneurship and growth...
  - Non-compete laws (Garmaise (2009); Samila & Sorenson (2010); Franco & Mitchell (2008))
    ** quantify the effect of NCL policy for growth.

- Spinouts (Klepper (2002); Franco & Filson (2002); Klepper & Sleeper (2005))
  ** macro implications.

Motivating Empirical Facts

Data

Data

- **Patents data**: NBER patent database, 1976-2006 + **Compustat data** for public firms – R&D, employment, growth variables.
- **Inventors data**: disambiguated inventors database from Harvard Dataverse Network, 1975-2010.

  ↪ Track inventors' mobility and firm performance.

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- **Non-compete laws**: NCL index across states – Garmaise (2009), Starr et al. (2018).
  Scope, geographic area, length, time restriction.

Identifying Innovating Spinouts

- In the data, classify firms into "regular", "spinout", and "unknown" types.
- Due to truncation, firms present before 1981 are "unknown" type.
- Spinout firm – firm entering after 1981 and whose first patent(s) is filed by inventor(s) who moved from other firm(s).
- Regular firm – firm entering after 1981 and whose first patent(s) is not filed by inventor(s) moving from other firm(s).
- 2.5 million patents. 17,295 spinouts, 46,888 regular, 11,452 unknown-type firms → 25% entry happens through spinouts.
  - Validation: empirical patterns from other micro studies; external validation for hard disc drive industry (Franco & Filson, 2006).

Three empirical facts for motivation

Fact 1: *Spinout entrants outperform regular entrants.*

Fact 2: *Spinouts entering from tech leader parents perform better.*

Fact 3: *In states with stricter non-competes, spinout entry is lower.*

Spinouts vs Regular Firms

Fact 1: *Spinout entrants outperform regular entrant firms.*

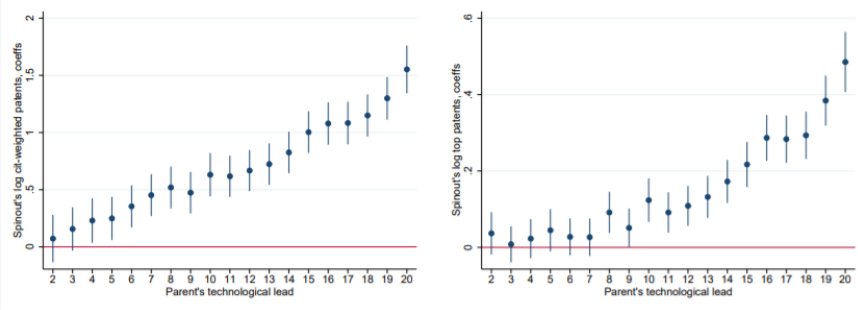
	Log Patents	Log Cit-Patents	Log Lifespan	Log Top Patents
-Panel A. Patent Data-				
Spinout entrant	0.376***	0.509***	0.176***	0.130***
	(0.009)	(0.013)	(0.008)	(0.005)
Cohort FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
State FE	YES	YES	YES	YES
Observations	64330	61419	64330	64330
Mean	0.713	3.103	0.767	0.193
-Panel B. Compustat + Patent Data-				
	log R&D/Empl	Mean growth	Cit-Patent/R&D	Top patent/R&D
Spinout entrant	0.172***	0.034**	177.682***	1.098***
	(0.051)	(0.014)	(34.821)	(0.222)
Cohort FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
State FE	YES	YES	YES	YES
Observations	2222	2552	2261	2261
Mean	3.133	0.251	160.612	0.952

Spinouts and Parents' Tech Lead

Fact 2: *Spinouts from tech leader parents perform better.*

$Y_j = \sum_{p=1}^{20} \beta_p Parent\ tech\ lead_j^p + nparents + npats\_parent + class + state + cohort\ f.e.$

$Parent\ tech\ lead_p$ - quintiles of citations-weighted patent counts in 5 years.



(a) Lifetime cit-patent count

(b) Lifetime top patent count

Fact 3: *In states with stricter non-competes, spinout entry is lower.*

	(1) Logit	(2) FE Logit	(3) Neg. Binomial	(4) FE Neg. Binomial
NCL index	-0.623***	-0.077*	-0.425**	-0.101***
	(0.1996)	(0.0416)	(0.1772)	(0.0341)
Year FE	YES	YES	YES	YES
Industry FE	YES	NO	YES	NO
State FE	YES	NO	YES	NO
Firm FE	NO	YES	NO	YES
Observations	179253	50153	179485	50465

Other controls: parent's number of patents and citation-adjusted patents, number of inventors, age, state-level competition over time, GDP per capita, and population.

Three empirical facts...
Motivating modeling assumptions

Fact 1: *Spinout entrants outperform regular entrants.*
$\hookrightarrow$ Model: firm type heterogeneity at entry. Spinouts more likely to be *high type*.

Fact 2: *Spinouts entering from tech leader parents perform better.*
$\hookrightarrow$ Model: knowledge inheritance. More likely to create high-type firm if parent firm innovates more.

Fact 3: *In states with stricter non-competes, spinout entry is lower.*
$\hookrightarrow$ Model: Policy parameter affecting cost of spinout formation.

Theoretical Model

Model Overview

Endogenous growth model with Schumpeterian dynamics + *occupation choice* problem.

- Skilled individuals are *entrepreneurs, R&D managers or outsiders*.
- Heterogeneous firms innovate employing R&D managers.
- Managers are employed in R&D and choose the intensity of separation – *spinout*.
- Knowledge inheritance: improves ideas for entrepreneurial ventures.
- Non-compete laws (NCL) govern cost of separation.
- Spinout entry and NCL affect innovation, competition, firm dynamics, and growth:
  - *Direct entry effect + disincentive effect + knowledge diffusion + markup composition.*

Consumers and Production

- The representative household:

$$U = \int_{0}^{\infty} e^{-\rho t} \ln C(t) dt,$$

ρ – discount rate. Measure L unskilled, $2 + S$ – skilled people.

- Final good production:

$$\ln Y_t = \int_0^1 \ln y(j,t) dj,$$

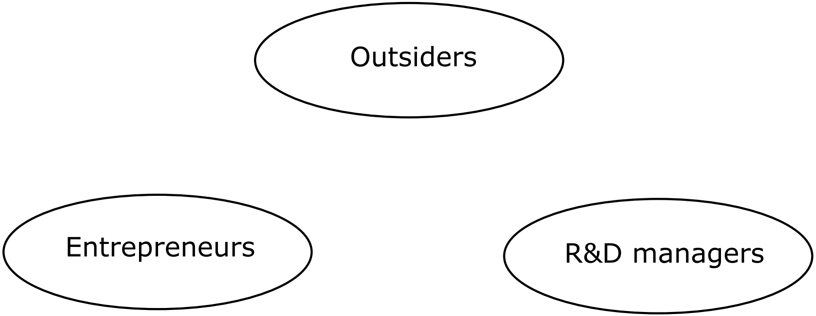
$y(j,t)$ is intermediate output produced in product line j at time t.

- Intermediate good j produced using linear technology:

$$y(j,t) = q(j,t) l(j,t),$$

$l(j,t)$ – unskilled labor and $q(j,t)$ – productivity.

Model Summary



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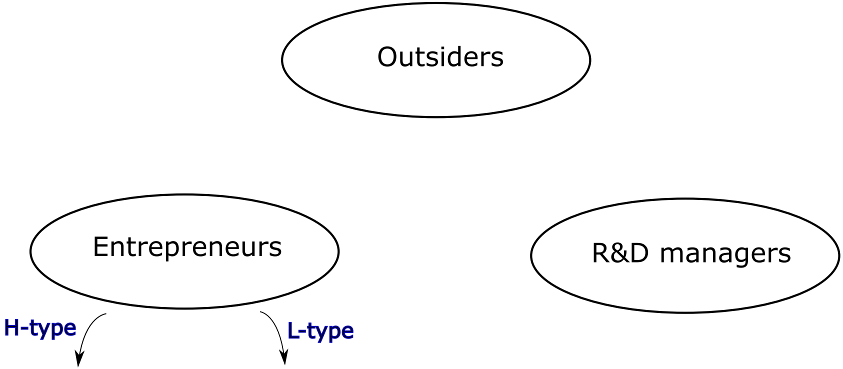


- Innovate: $q \uparrow$
- Climb up tech ladder: $n \uparrow$

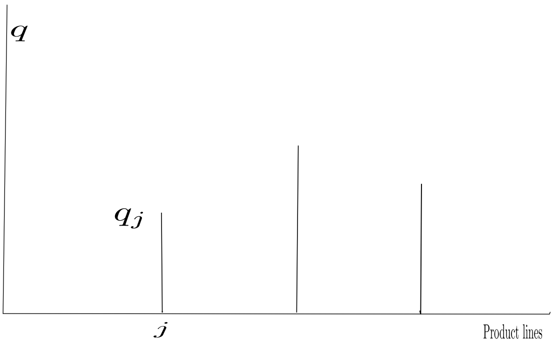
Innovation and firm heterogeneity

- Firms innovate to improve $q(j,t)$.
- Heterogeneity in firms' R&D efficiency.
- At entry, each firm draws its **permanent quality type** $\tau \in \{H, L\}$.
- R&D cost= R&D manager pay + variable cost:

$$\text{R\&D cost} = w^s(t) + \frac{z^\gamma(j,t)}{\gamma B^\tau} Y(t)$$

- $B^H > B^L$: **High-type** firms are more efficient at research than **Low-type** firms.

Productivity dynamics and technology gaps



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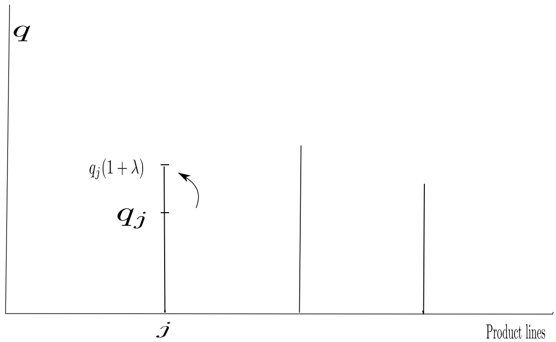

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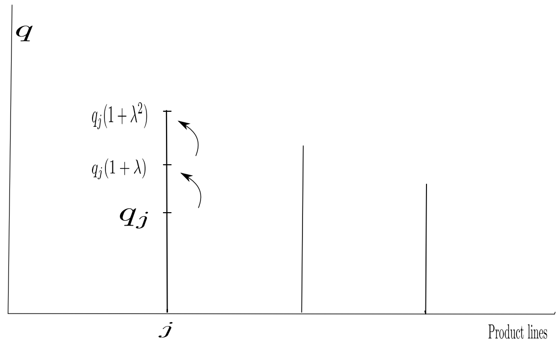

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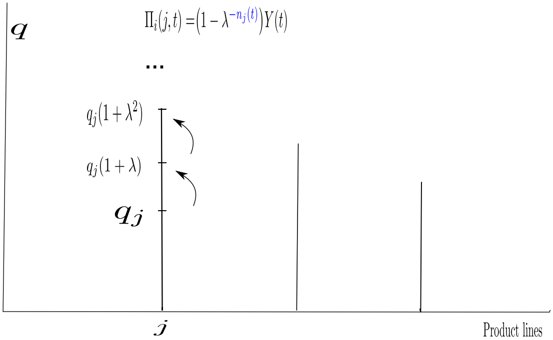
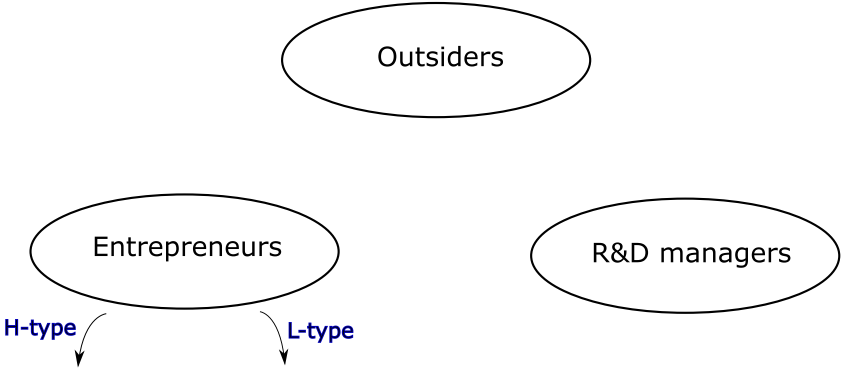


$n_j(t) \equiv n_{ij}(t) - n_{-ij}(t)$ – **technology gap** of an incumbent.

Model Summary



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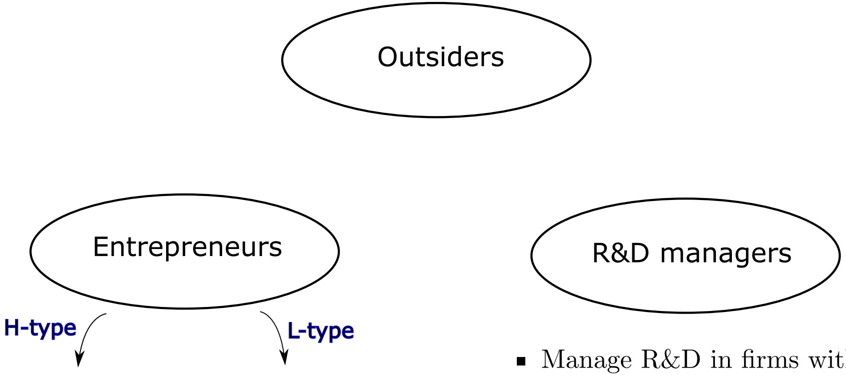
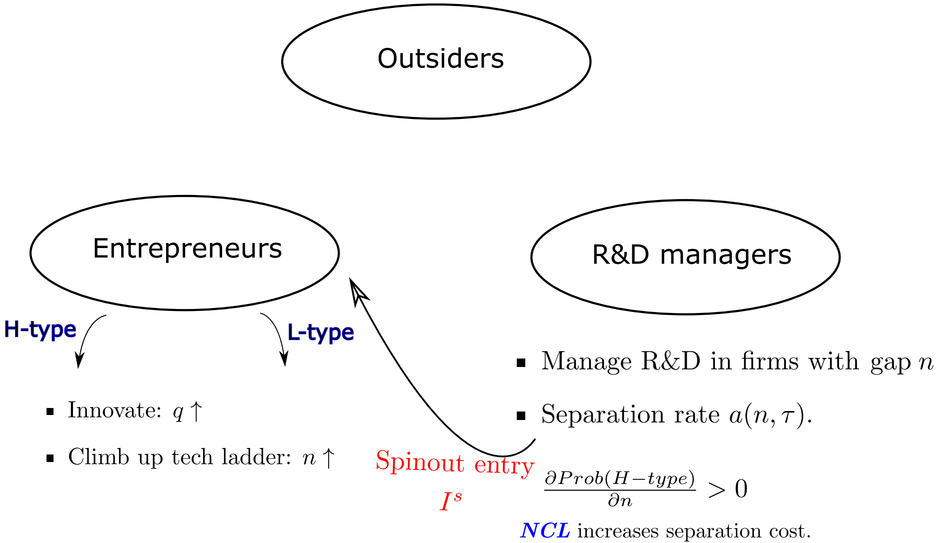


- Innovate: $q \uparrow$
- Climb up tech ladder: $n \uparrow$

- Manage R&D in firms with gap n

Model Summary



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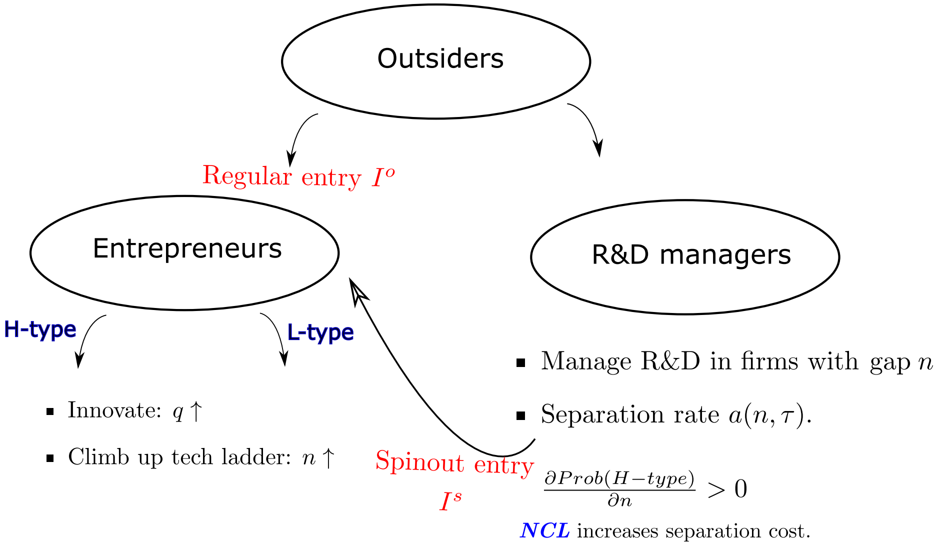

Growth and Welfare

- $\xi(n,\tau)$ – measure of firms with technology gap n and τ-type.

$$g = \ln \lambda (l^s + l^o + \sum_{n,\tau} \xi(n,\tau) z(n,\tau)).$$

$$\text{Welfare}(0) = \frac{\ln Q(0) - \ln \lambda \sum_{n,\tau} n \xi(n,\tau) - \ln \omega^u}{\rho} + \frac{g}{\rho^2} + \frac{\ln(1-l)}{\rho}$$

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Quantitative Analysis of the Model

Calibrated Parameters

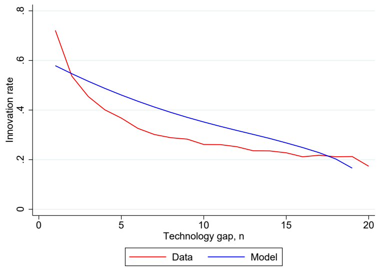
Parameter	Meaning	Value
	Externally Calibrated Parameters (24)	
ρ	Discount rate	0.04
γ	R&D cost curvature	2
β	R&D manager's bargaining weight	0.05
$\{\mu_n\}_{n=1}^{N}$	Prob. of H-type spinout entry from firm n	Figure 4
$\tilde{\mu}$	Prob. of H-type outside entry	0.20
	Internally Calibrated Parameters (8)	
B^H, B^L	R&D cost efficiency	2.74, 0.049
L, S	Skill composition	19, 0.60
e	Entry cost parameter	6.07
F	NCL parameter	0.60
κ	Separation cost parameter	12.52
λ	Step size of innovation	1.08

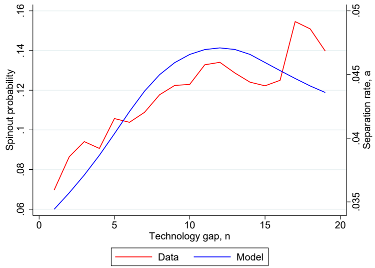
Moments

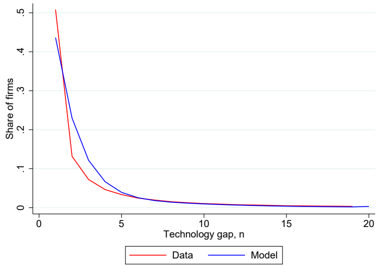
Moments: Model vs Data

Description	Data	Model
Growth rate	3.1%	3.08%
Average R&D intensity	0.127	0.096
Ratio of H- to L-type firm innovations	9.5	6.72
Wage ratio $\frac{\overline{w(n,\tau)}}{w^u}$	2.27	1.42
Percent of S&E in workforce	5%	5%
Average outside entry rate	7.8%	8.77%
Average spinout entry rate	3.2%	3.76%
Spinout entry rate with no NCL	4.31%	5.36%

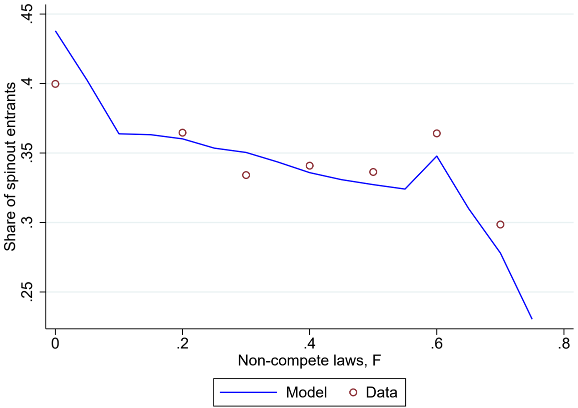
Innovation, Separation, and Firm Distribution. Validation







NCL and spinouts. Validation



Growth Decomposition

Aggregate growth: $g = 3.08\%$			
Entrants 23%		Incumbents 77%	
Spinout entrants 7%	Regular entrants 16%	High-type firms 46%	Low-type firms 31%
		Small firms ($n \leq 5$) 59%	Large firms ($n > 5$) 18%

Dynamic growth contribution of spinouts (entry & more high-type firms through knowledge diffusion)?

Policy Experiments

Policy Experiments

	Benchmark NCL	No NCL		
$z(1,\cdot)$	1.0790	1.0115		
$z(10,\cdot)$	0.8174	0.7797		
$\xi(1,\cdot)$	0.3180	0.3964		
$\xi(10,\cdot)$	0.0128	0.0088		
$\xi(\cdot,H)$	0.2816	0.2922		
Mean z	0.3534	0.3417		
$a(1,\cdot)$	0.0515	0.1059		
$a(10,\cdot)$	0.0926	0.1329		
I^s	0.0317	0.0560		
I^o	0.0706	0.0674		
w^u	0.0197	0.0205		
w^s	0.0848	0.0692		
g^*	3.08%	3.15%		
Welfare	120.0126	126.7576		

- *Direct entry effect; Markup composition; Knowledge diffusion; Disincentive effect.*

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$\xi(\cdot,H)$	0.2816	0.2922	0.2824	
Mean z	0.3534	0.3417	0.3513	
$a(1,\cdot)$	0.0515	0.1059	0	
$a(10,\cdot)$	0.0926	0.1329	0.0974	
I^s	0.0317	0.0560	0.0127	
I^o	0.0706	0.0674	0.0742	
w^u	0.0197	0.0205	0.0192	
w^s	0.0848	0.0692	0.0961	
g^*	3.08%	3.15%	2.96%	
Welfare	120.0126	126.7576	115.6200	

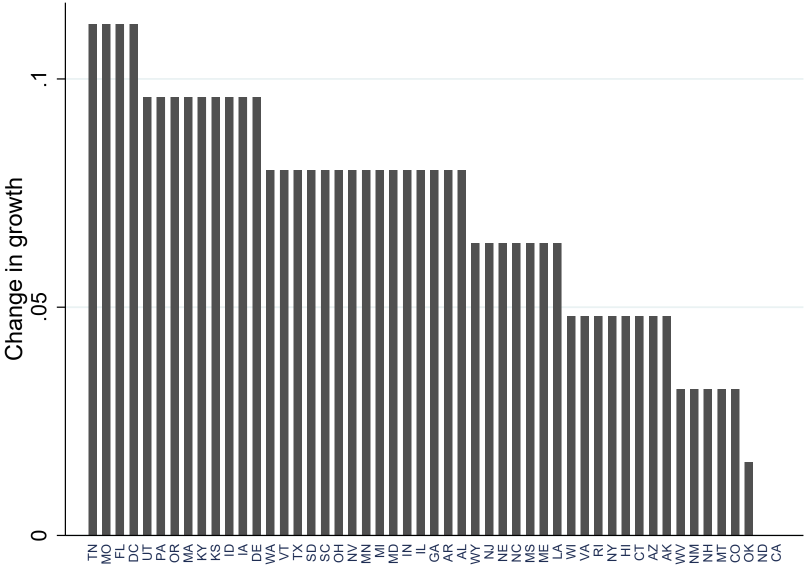
- *Direct entry effect; Markup composition; Knowledge diffusion; Disincentive effect.*

Policy Experiments

	Benchmark NCL	No NCL	Protection of Lower n	Protection of Higher n
$z(1,\cdot)$	1.0790	1.0115	1.1224	1.0395
$z(10,\cdot)$	0.8174	0.7797	0.7503	0.9034
$\xi(1,\cdot)$	0.3180	0.3964	0.2464	0.3798
$\xi(10,\cdot)$	0.0128	0.0088	0.0168	0.0101
$\xi(\cdot,H)$	0.2816	0.2922	0.2824	0.2765
Mean z	0.3534	0.3417	0.3513	0.3487
$a(1,\cdot)$	0.0515	0.1059	0	0.1081
$a(10,\cdot)$	0.0926	0.1329	0.0974	0.0761
I^s	0.0317	0.0560	0.0127	0.0504
I^o	0.0706	0.0674	0.0742	0.0687
w^u	0.0197	0.0205	0.0192	0.0201
w^s	0.0848	0.0692	0.0961	0.0745
g^*	3.08%	3.15%	2.96%	3.17%
Welfare	120.0126	126.7576	115.6200	123.4354

- *Direct entry effect; Markup composition; Knowledge diffusion; Disincentive effect.* "Trickle-down" effect.

GAINS FROM OPTIMAL POLICY ADOPTION ACROSS STATES



Conclusion

- New model of innovation-driven growth and spinout dynamics.
- Quantify the channels through which spinout formation affects innovation and productivity growth.
- Explore optimal non-compete policies.
  - No NCL protection is growth-maximizing.
  - IPR policy protecting IP accumulated by firms achieving high leadership is beneficial.
- tbd: Targeted entry subsidies (general entrants vs spinout entrants.)

Value function: Outsiders

- **Outsiders** $\rightarrow$ entrepreneurs or R&D managers: $v^{out} = \max\{v^{entry}, v^{work}\}$
- To become an *entrepreneur*, cost $\frac{e\nu^2}{2}$. If successful, replace incumbent through **creative destruction**.

$$\rho v^{entry} = \max_{\nu \geq 0} \left(-\frac{e\nu^2}{2} + \nu(\tilde{\mu} v^{Ent}(1, H) + (1 - \tilde{\mu}) v^{Ent}(1, L) - v^{entry}) \right)$$

back

Value function: Entrepreneurs

- An entrepreneur of (n, τ) firm decides on innovation intensity $z(n, \tau)$:

$$\rho v^{Ent}(n,\tau) = \max_{z(n,\tau)\geq 0} \left\{ \begin{aligned} &\pi(n) - \omega(n,\tau) - \frac{z(n,\tau)^{\gamma}}{\gamma B^{\tau}} + z(n,\tau)(v^{Ent}(n+1,\tau) - v^{Ent}(n,\tau)) \\ &+ (I^{s} + I^{o})(v^{out} - v^{Ent}(n,\tau)) + a(n,\tau)(v^{Ent}(1,\tau) - v^{Ent}(n,\tau)) \end{aligned} \right\}$$

  where $\pi(n) = 1 - \lambda^{-n}$ is the normalized flow profit.
  Spinout cost to the employer: technology embedded in the human capital/competition.

- FOC: $$z(n,\tau) = \max\left\{0, B^{\tau\frac{1}{\gamma-1}}(v^{Ent}(n+1,\tau) - v^{Ent}(n,\tau))^{\frac{1}{\gamma-1}}\right\}$$
  - Incremental value from innovation $\rightarrow$ innovation rates decline with n.
  - Appropriability problem from spinouts.

back

Value function: R&D Managers and Spinout Entry

- l^s – rate of creative destruction from spinouts.
- Value function of an R&D manager:

$$\rho v^{R\&D}(n,\tau) = \max_{a(n,\tau)\geq 0} \begin{cases} \omega(n,\tau) - \dfrac{ka^2(n,\tau)}{2} \\ + a(n,\tau)[\mu(n)v^{Ent}(1,H) + (1-\mu(n))v^{Ent}(1,L) - F - v^{R\&D}(n, \\ + (l^s + l^o)[v^{out} - v^{R\&D}(n,\tau)] \\ + z(n,\tau)[v^{R\&D}(n+1,\tau) - v^{R\&D}(n,\tau)] \end{cases}$$

- FOC:

$$a(n,\tau) = \max\left\{0, \frac{\mu(n)v^{Ent}(1,H)+(1-\mu(n))v^{Ent}(1,L)-F-v^{R\&D}(n,\tau)}{k}\right\}$$

  - Tradeoff between current entry and option to wait...

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Wage Determination

- R&D manager's wage $\omega(n, \tau)$ set through Nash bargaining in each period.
- Linear sharing rule:

$$\beta(v^{Ent}(n,\tau) - v^{Ent}(1,\tau)) = (1-\beta)(v^{R\&D}(n,\tau) - v^{out})$$

  β – R&D manager's bargaining weight.
- When $n = 1$, this implies:

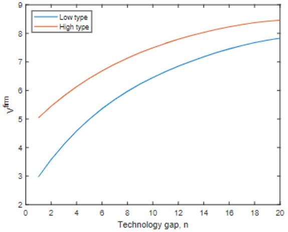
$$v^{R\&D}(1,H) = v^{R\&D}(1,L) = v^{out}$$

  - No incentives to re-search.
  - Managers "pay" for the possibility of better learning in H-type firms.

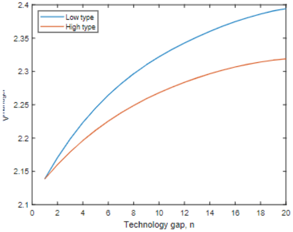
back

SOME EQUILIBRIUM PROPERTIES BACK

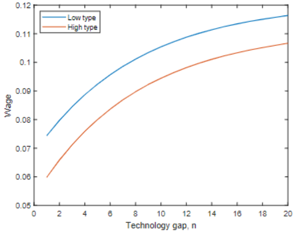
(a) Value function of the firm



(b) Value function of R&D manager



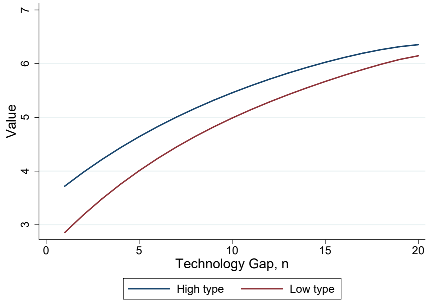
(c) Wages of R&D manager



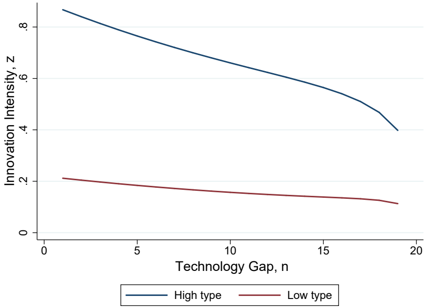
Solution Property I

Value Functions and Optimal Policies

Firm's value, $V(n, \tau)$



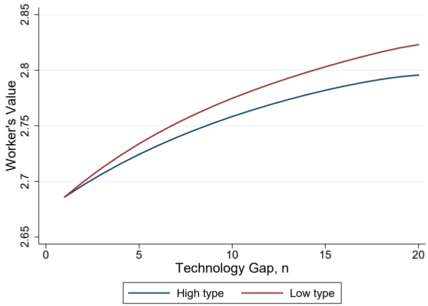
Firm's Innovation Rate, $z(n, \tau)$



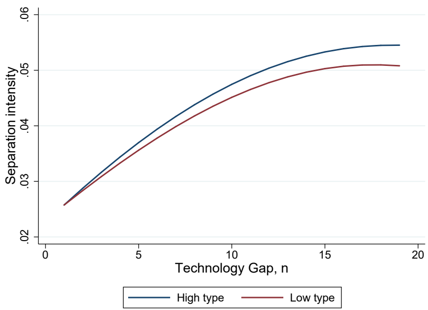
Solution Property II

Value Functions and Optimal Policies

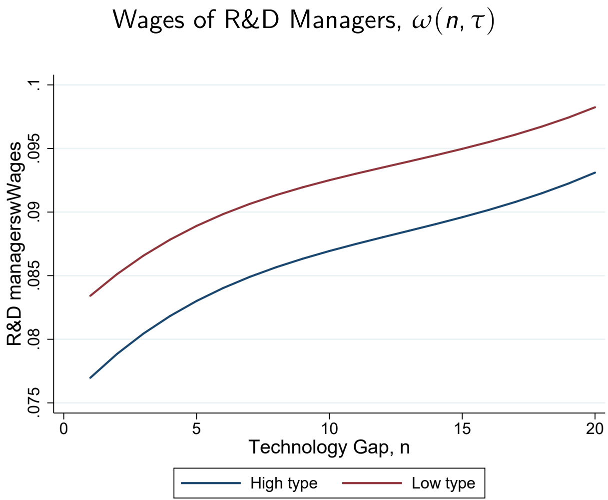
Worker's value, $S(n, \tau)$



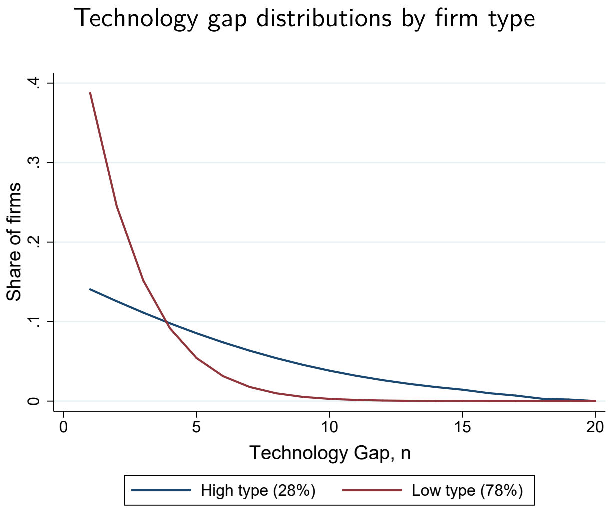
Worker's Separation Rate, $a(n, \tau)$



Solution Property III



Solution Property IV



back

3. Spinout Separation and Parent Characteristics

Fact 3: *Tech leader firms are more likely to spawn spinouts.*

	(1) Logit	(2) FE Logit	(3) Neg. Binom	(4) FE Neg. Binom
-Panel A: Patent data				
Log patents	-0.089***	-0.065	-0.105***	-0.184***
	(0.0230)	(0.0583)	(0.0214)	(0.0513)
Log cit-patents	0.141***	0.155***	0.139***	0.145***
	(0.0123)	(0.0337)	(0.0115)	(0.0299)
Log inventors	0.559***	0.859***	0.583***	0.938***
	(0.0201)	(0.0544)	(0.0189)	(0.0497)
Log Firm age	-0.241***	-0.175***	-0.248***	0.017
	(0.0112)	(0.0320)	(0.0103)	(0.0294)
Year FE	YES	YES	YES	YES
Industry FE	YES	NO	YES	NO
State FE	YES	NO	YES	NO
Firm FE	NO	YES	NO	YES
Observations	179313.000	50292.000	179547.000	50606.000

	(1) Logit	(2) FE Logit	(3) Neg. Binom	(4) FE Neg. Binom
-Panel B: Patent + Compustat data				
Log patents	0.307***	0.346***	0.202***	0.156
	(0.0798)	(0.1308)	(0.0648)	(0.0974)
Log cit-patents	0.092*	0.193**	0.158***	0.204***
	(0.0492)	(0.0927)	(0.0392)	(0.0717)

4. Spinout Separation and Non-Compete Laws

***Fact 4:** Stricter NCL hinder spinouts' creation.*

	(1) Logit1	(2) Logit2	(3) Neg. Binom1	(4) Neg. Binom2
NCL	-0.623***	-0.077*	-0.425**	-0.101***
	(0.1996)	(0.0416)	(0.1772)	(0.0341)
Log patents	-0.110***	-0.150**	-0.103***	-0.168***
	(0.0232)	(0.0593)	(0.0214)	(0.0512)
Log cit-patents	0.143***	0.154***	0.140***	0.143***
	(0.0124)	(0.0341)	(0.0115)	(0.0299)
Log inventors	0.583***	0.966***	0.581***	0.908***
	(0.0203)	(0.0560)	(0.0189)	(0.0495)
Log Firm age	-0.241***	0.003	-0.249***	-0.018
	(0.0113)	(0.0355)	(0.0103)	(0.0291)
State comp.	-0.059	0.248**	0.060	0.131
	(0.1407)	(0.1090)	(0.1251)	(0.0855)
Log GDP pc	-1.135***	-1.527***	0.114	-1.341***
	(0.1029)	(0.1375)	(0.2924)	(0.1020)
Log population	-1.176***	-0.327***	-0.968***	-0.224**
	(0.3505)	(0.1204)	(0.3141)	(0.0923)
Year FE	YES	YES	YES	YES
Industry FE	YES	NO	YES	NO
State FE	YES	NO	YES	NO
Firm FE	NO	YES	NO	YES
Observations	179253	50153	179485	50465