The Impact of Regulation on Innovation

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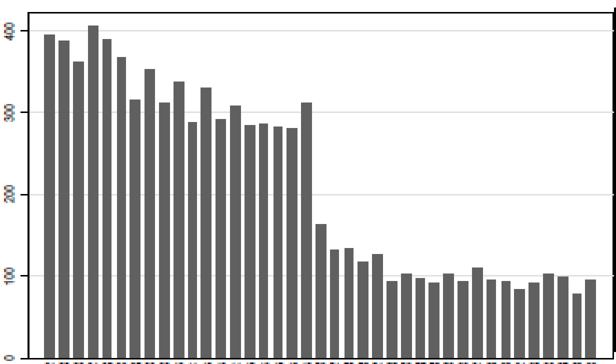
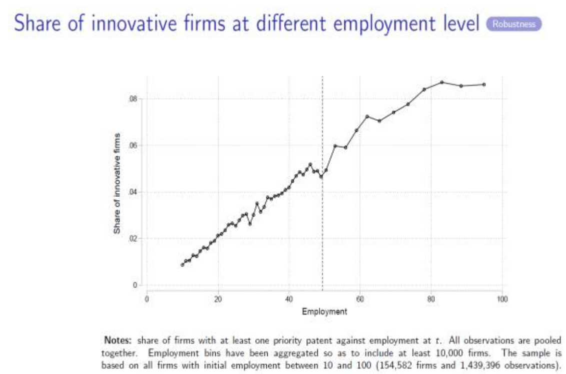


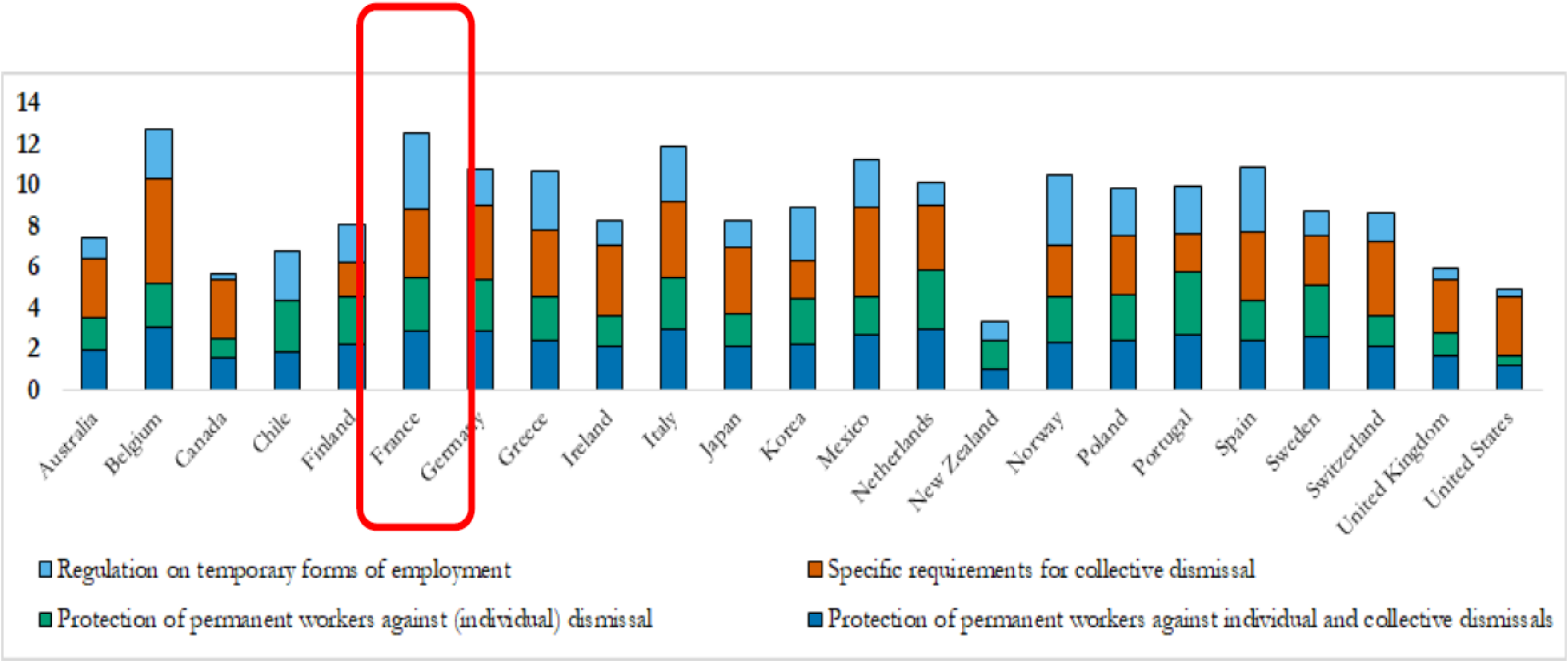


Introduction

- Long-standing question: how does regulation affect economic performance?
  - In particular, does labor regulation inhibit innovation?

- We develop a heterogeneous firm macro framework with endogenous R&D to study how regulation affects joint distribution of firm innovation & size.

France has tough Employment Protection Laws, but do these really cause economic problems?



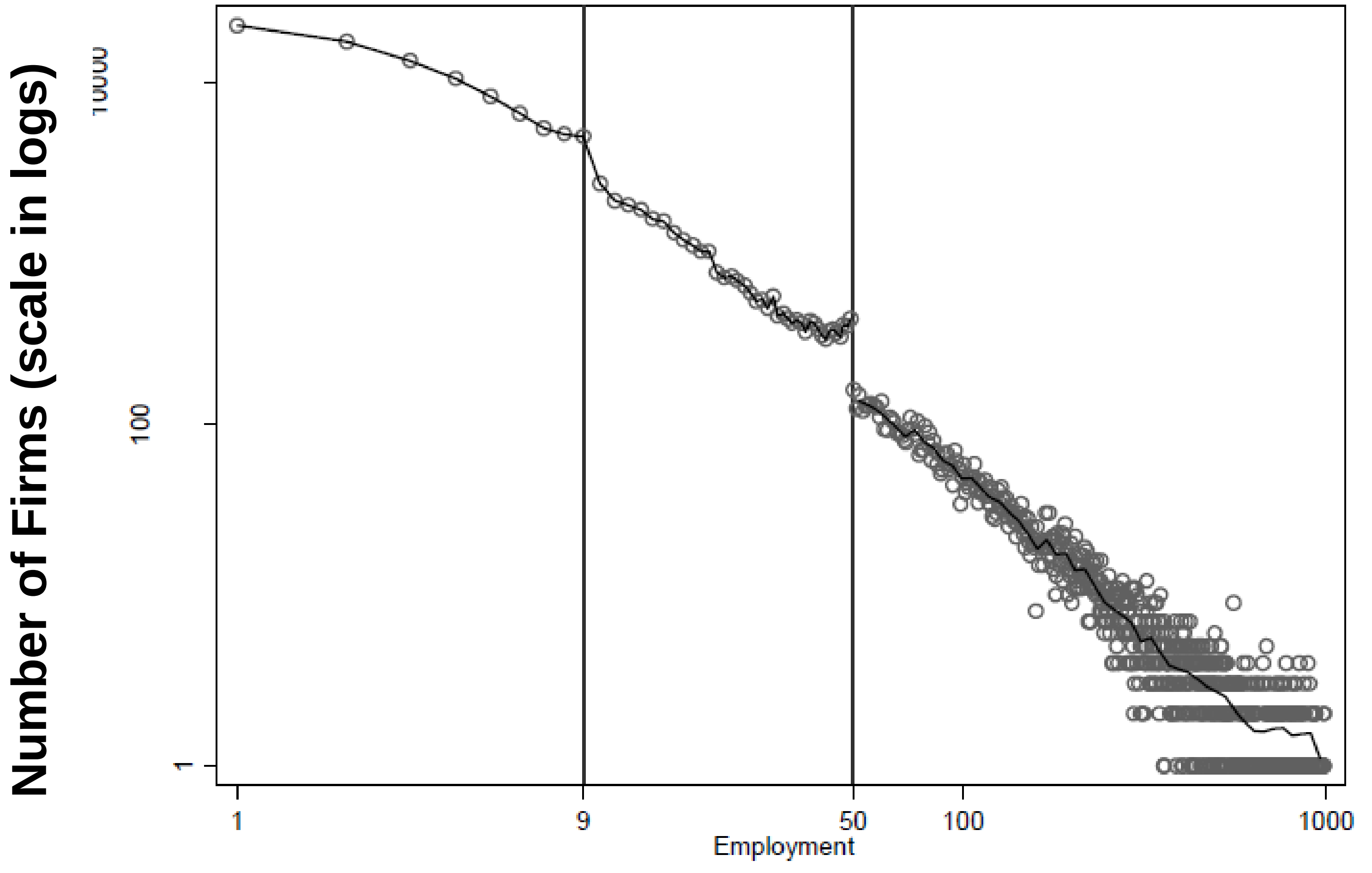
Source: OECD (2019)

Reform isn't easy (even on Bastille Day)

Empirical Contribution

- Many regulations are dependent on firm size & this creates discontinuities that are helpful for identification
- In France many important labor regulations begin at 50 employees
  - Creation of "work council" ("comité d'entreprise")
  - Firm has to offer union representation
  - Health & safety committee
  - Profit sharing scheme
  - Guaranteed minimum spending on training
  - Collective dismissal requires "social plan" to facilitate re-employment through training, job search, etc. Negotiated/monitored by unions & Labor Ministry

<u>Firm Size</u> Distribution (log scale) follows "broken power law" at regulatory thresholds



Note: Population FICUS data. Both axes on log scale. Another (smaller) increase in regulations at 10 employees, so we focus on 10+ sample.

Summary of Paper (1/2)

- Consistent with the qualitative predictions of the theory, in the data we find evidence that regulation **discourages** innovation through an implicit tax when crossing threshold:
  - **Non-parametric analysis**
    - See “innovation valley” in innovation-firm size relationship just before the threshold
    - See a fall in the slope of in innovation-firm size relationship after crossing threshold
  - **Dynamic parametric analysis:** Exploit exogenous export market size shocks. These stimulate innovation, but much less so for firms just below regulatory threshold

Summary of Paper (2/2)

- Structurally quantifying model parameters, we find that:
  - Aggregate Innovation is **~4.5%** lower due to regulation (robustness: 2% to 7%)
  - Decompose aggregate effect into components
    - Vast majority of this effect due to less innovation per firm, but some contribution from shifting size distribution to left (misallocation) & lower entry

- **Caveat:** Our effect mainly via reducing incremental innovations. Extend theory to allow for different types of R&D. For firms just below threshold, if they innovate, they “Swing for the fence” with radical innovation

SOME RELATED LITERATURE

- **Labor Regulation & Innovation:** Acharya et al (2013a,b); Griffith and Macartney (2014); Garcia-Vega et al (2019); Mukoyama & Osotimehin (2019)
- **Labor laws, Technology adoption & Productivity:** Braguinsky et al (2011); Ceci-Renaud & Chevalier (2011); Gourio & Roys (2014); Kahn (2007); Samariego (2006); Bartelsman et al (2016); Boeri et al (2017); Autor et al (2007), Alesina et al (2018), Haltiwanger et al (2014)
- **Size-related Distortions & Productivity:** Restuccia & Rogerson (2008); Hopenhayn (2014); Hsieh & Klenow (2009)
- **Tax:** Chetty et al (2011), Kleven & Waseem (2013); Akcigit et al (2019); Akcigit & Stantcheva (2020)
- **Labor Unions and Innovation:** Menezes-Filho et al (1998); Addison & Hirsch (1986); Grout (1984); Manning (1984)

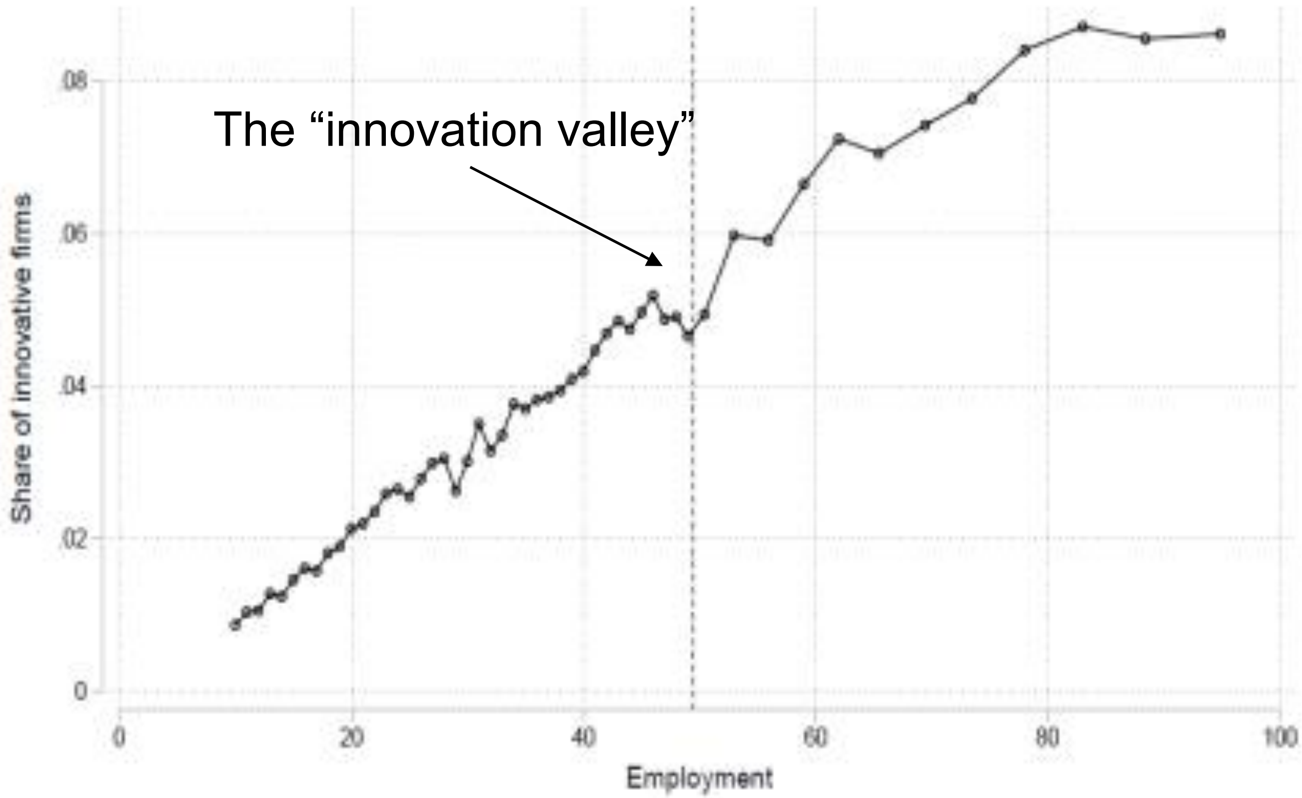
OUTLINE

1. **Data and Basic Facts**
2. Model
3. Empirical Strategy
4. Results
5. Extensions

Data

- Universe of French firms between 1994 - 2007
  - Mandatory fiscal returns of all firms ("FICUS").
- EPO PATSTAT 80 patent offices. Match to French firms using supervised Machine Learning algorithm (Lequien et al, 2018). Priority applications
- Customs data on all exports (with origin-destination product-country) 1994-2012 matched to firm level. UN COMTRADE

Share of innovative firms at different firm sizes: Innovation valley & flattening after threshold



Notes: share of firms with at least one priority patent against employment at t. All observations are pooled together. Employment bins have been aggregated so as to include at least 10,000 firms. The sample is based on all firms with initial employment between 10 and 100 (154,582 firms and 1,439,396 observations).

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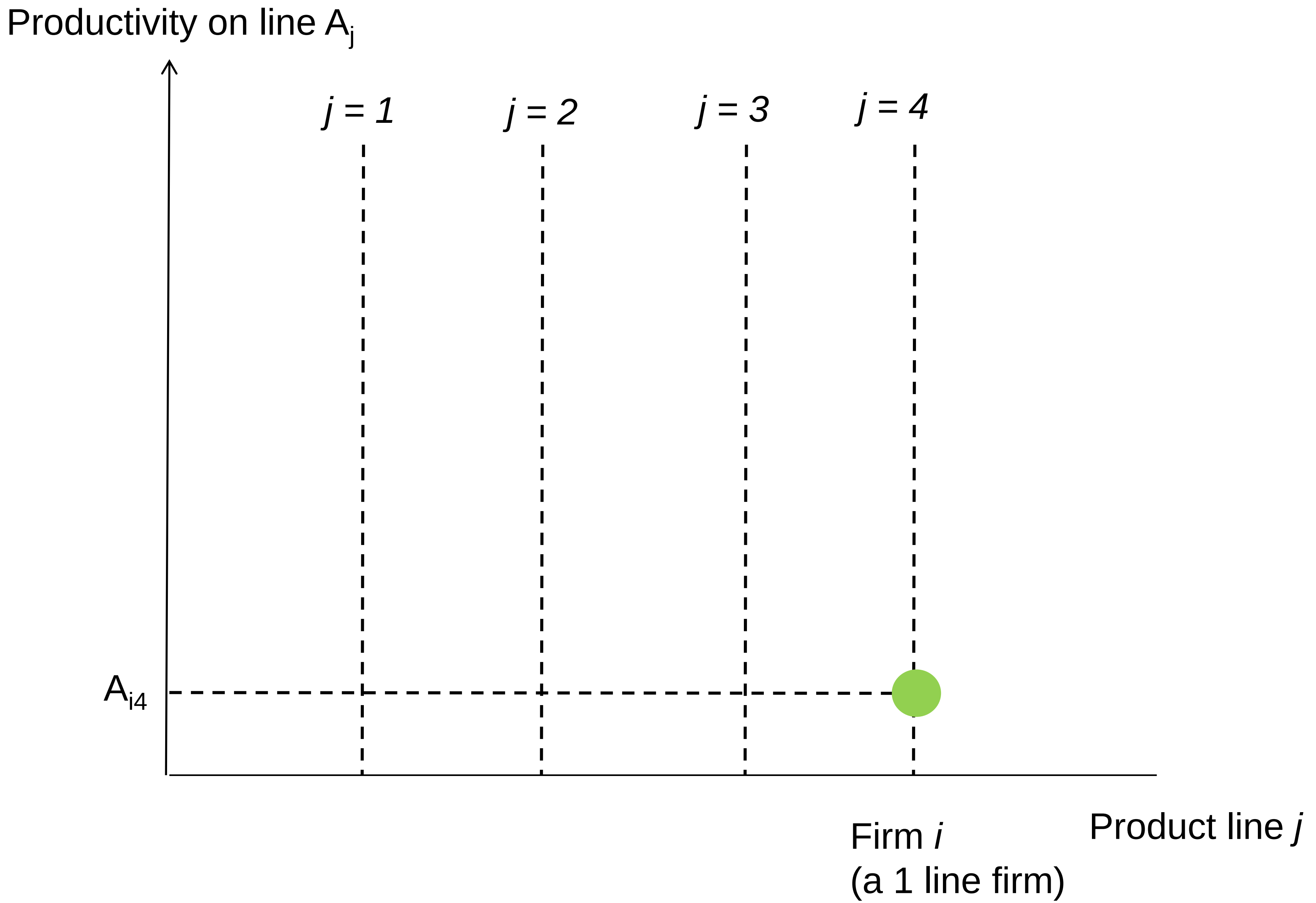
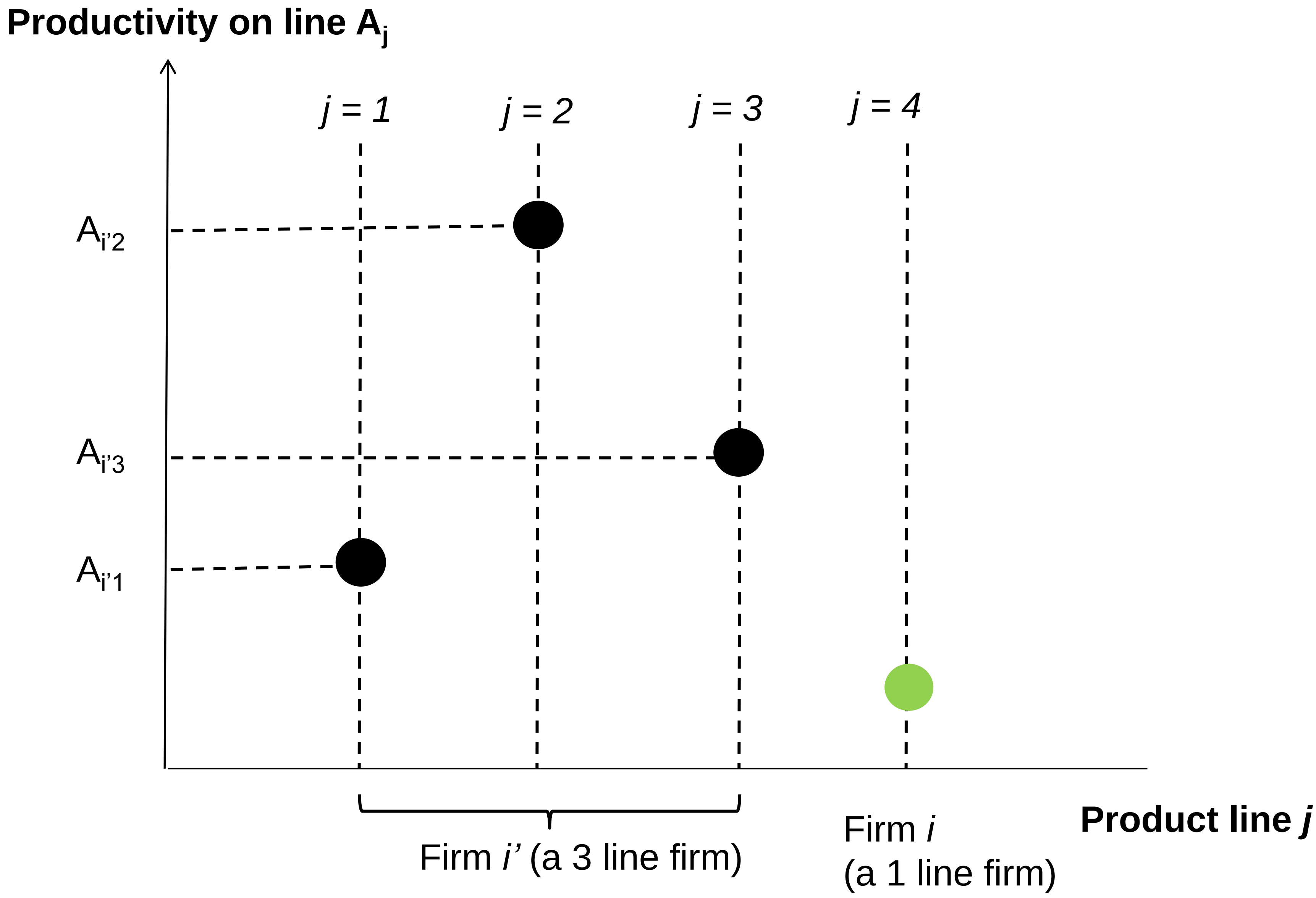
Basic Framework

- Schumpeterian growth model with Klette-Kortum (2004) firm dynamics. Add in regulatory marginal tax, τ, for firms > 49 workers.
- Continuum of product lines/varieties, *n*, indexed by *j*
- Each intermediate good (line) produced monopolistically (limit pricing) by the most recent innovator on line *j* using labor
- Firm's innovation (Z_i, Poisson arrival rate) depends on its R&D choice (and knowledge stock reflected in in size, n_i)
- Each of a firm's *n* lines is subject to risk of creative destruction at probability *x* by new entrants (z_e) & incumbents innovating
- An innovating firm improves productivity by $\gamma > 1$ over existing technology on one random product (now produces $n + 1$ lines)

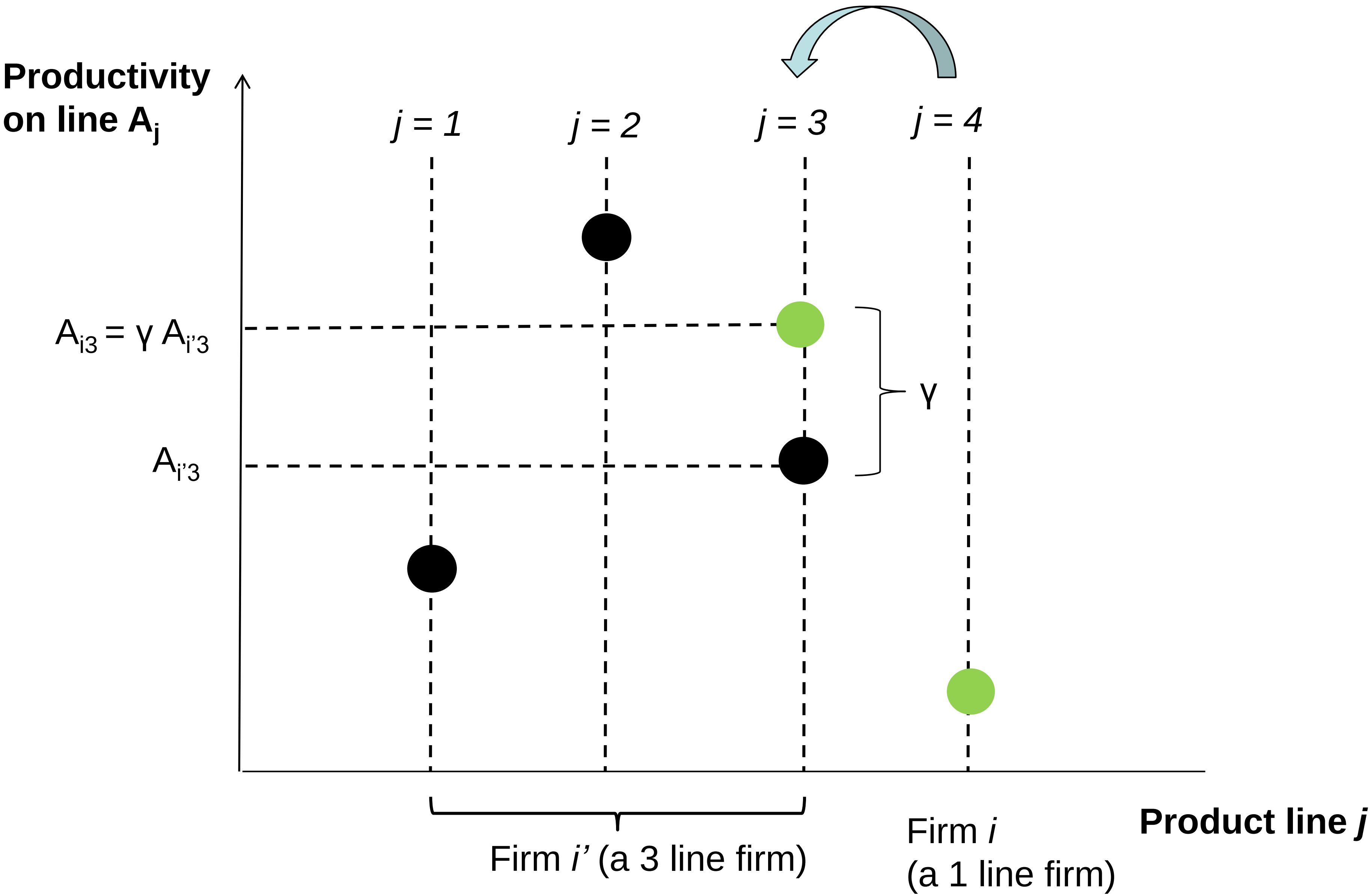
Firm *i* produces single line (*j*=4) with productivity A_{i4}



Firm *i'* has 3 lines (j = 1,2,3) with productivities ($A_{i'1}, A_{i'2}, A_{i'3}$)



Firm *i* innovates and enters line *3* with productivity $A_{i3} = \gamma A_{i'3}$



Creative destruction: Firm *i* limit prices at firm *i*'s marginal cost displacing firm *i'* on line *j* = 3

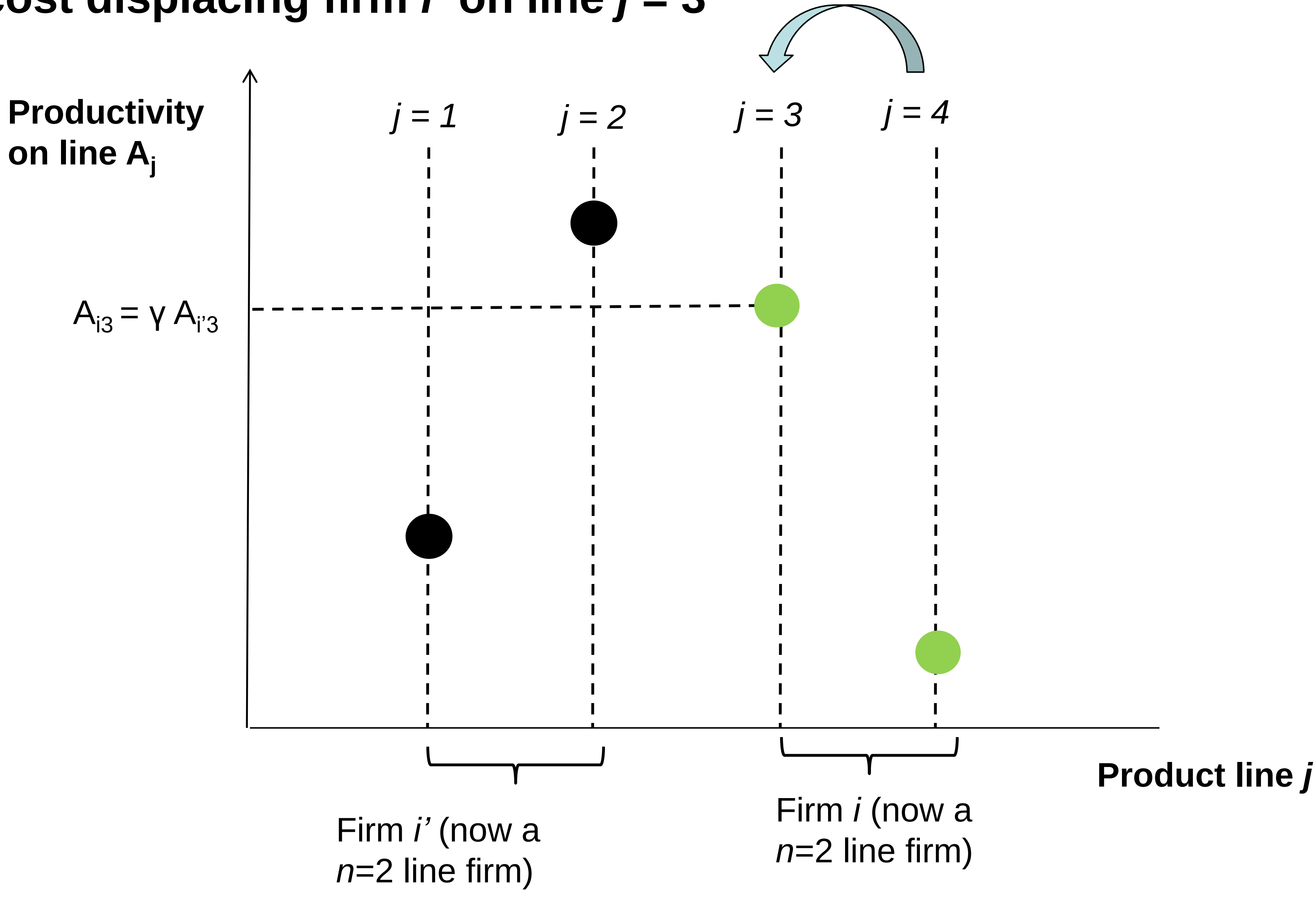
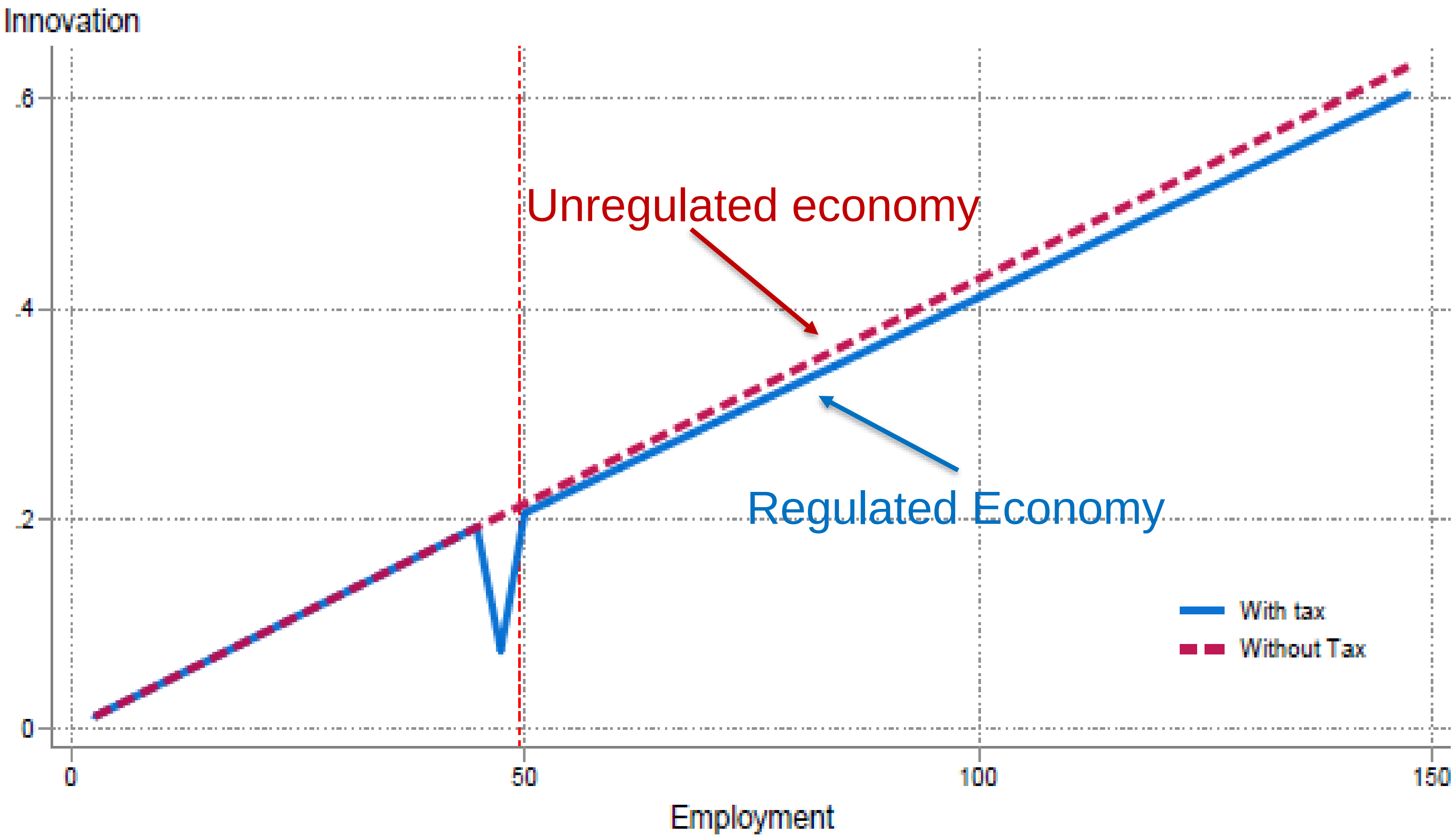
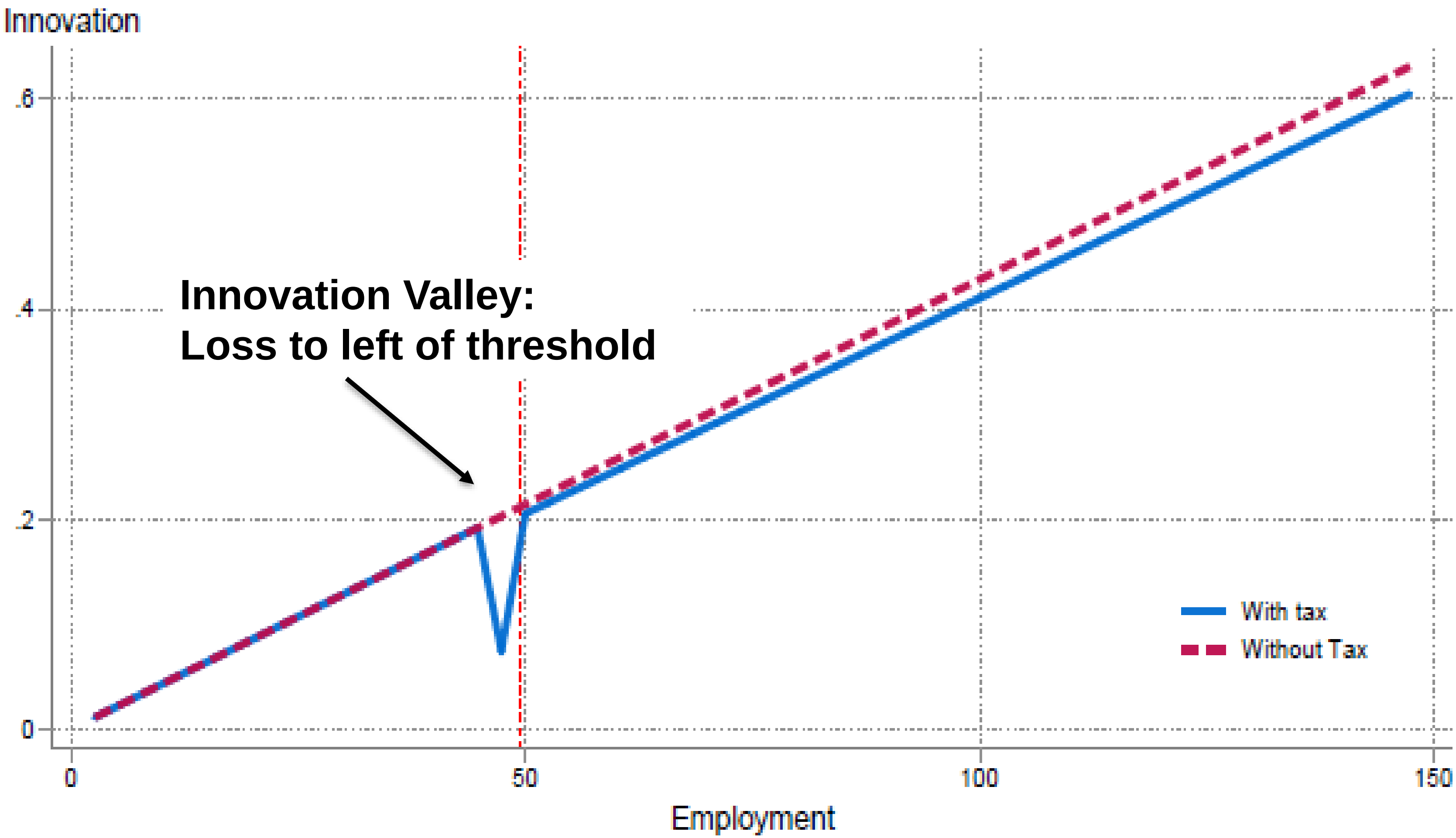


Fig. 3(a): Firm Innovation and Firm employment



Two types of firm-level Innovation losses



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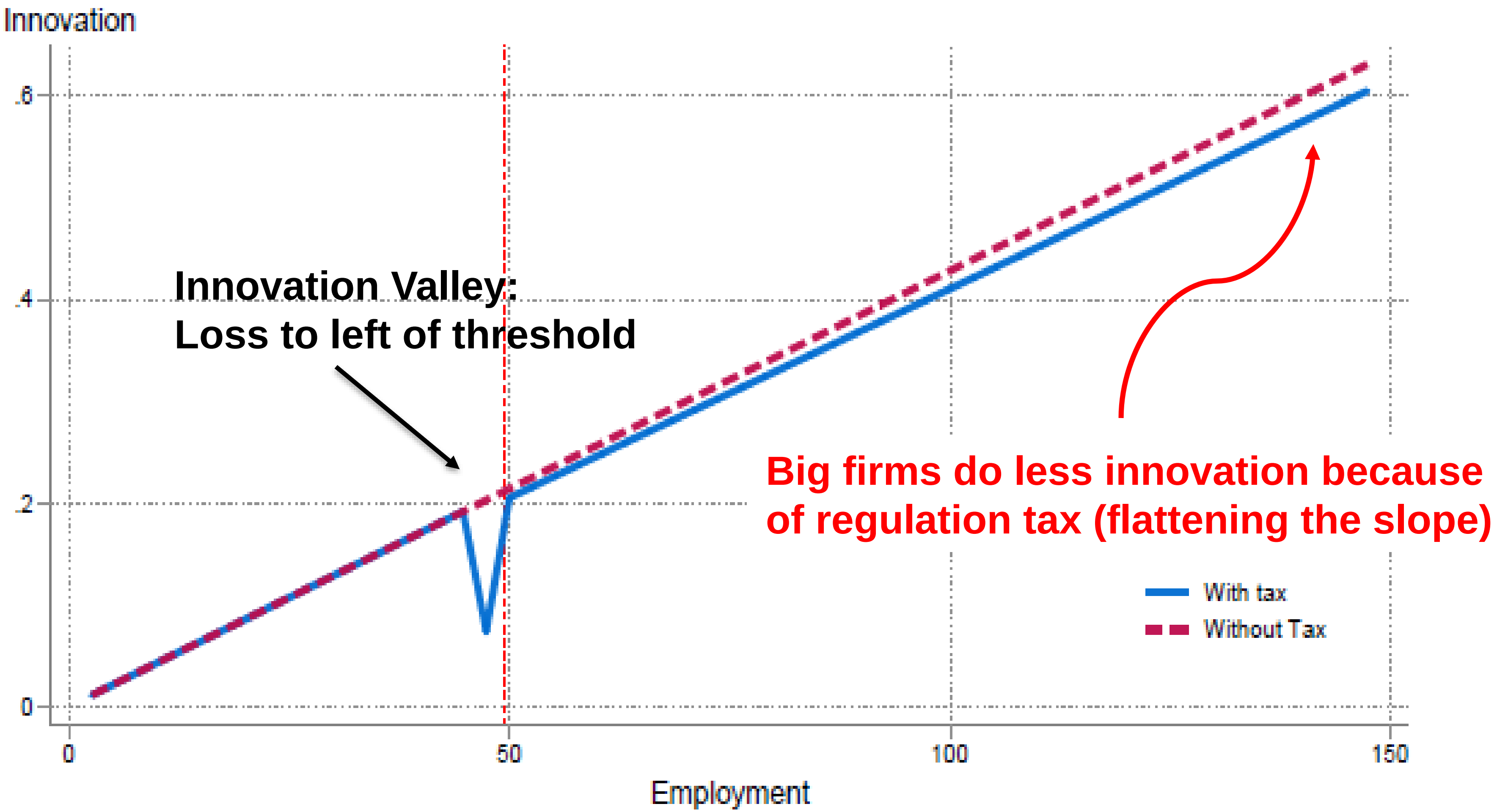
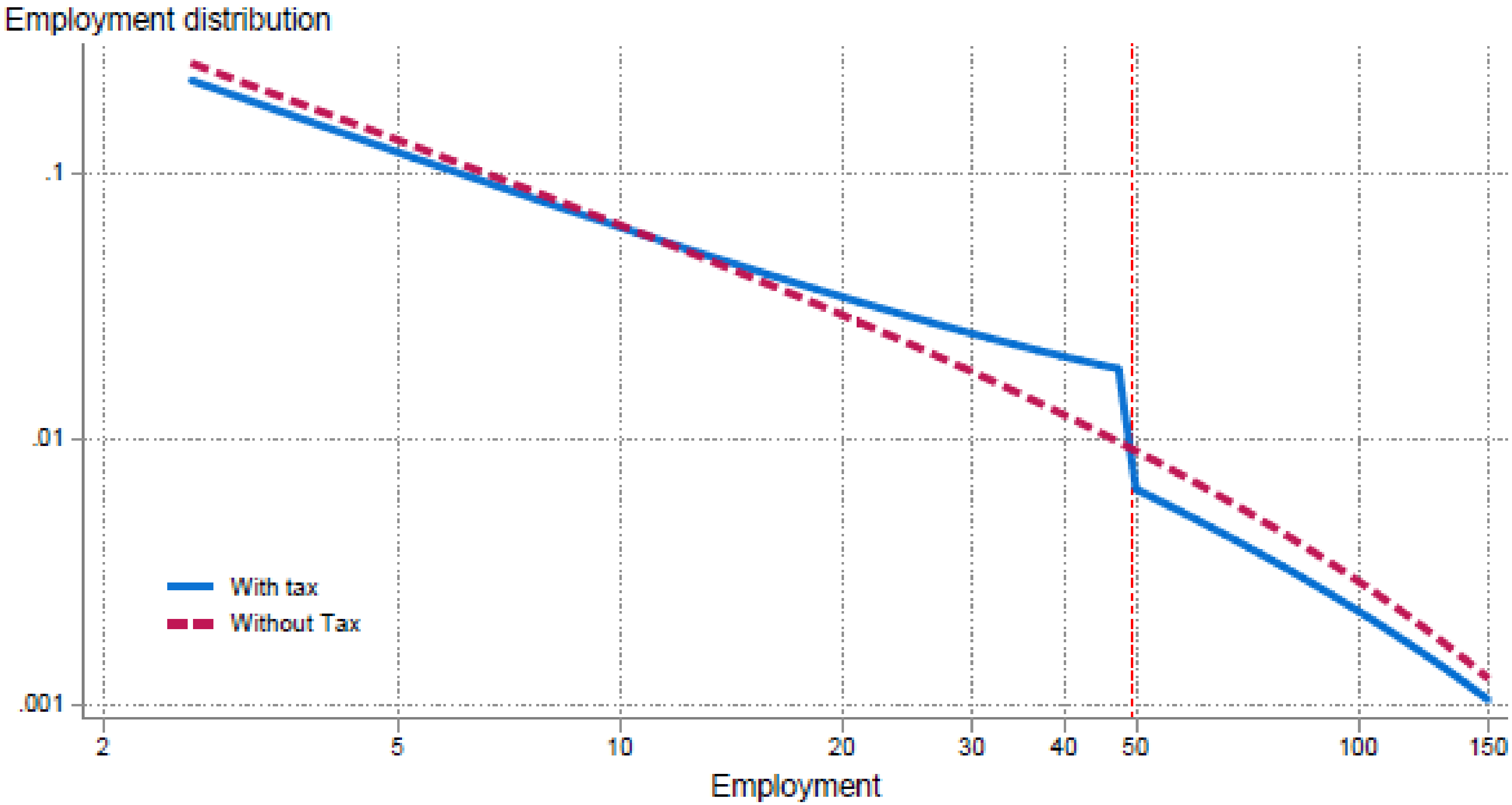
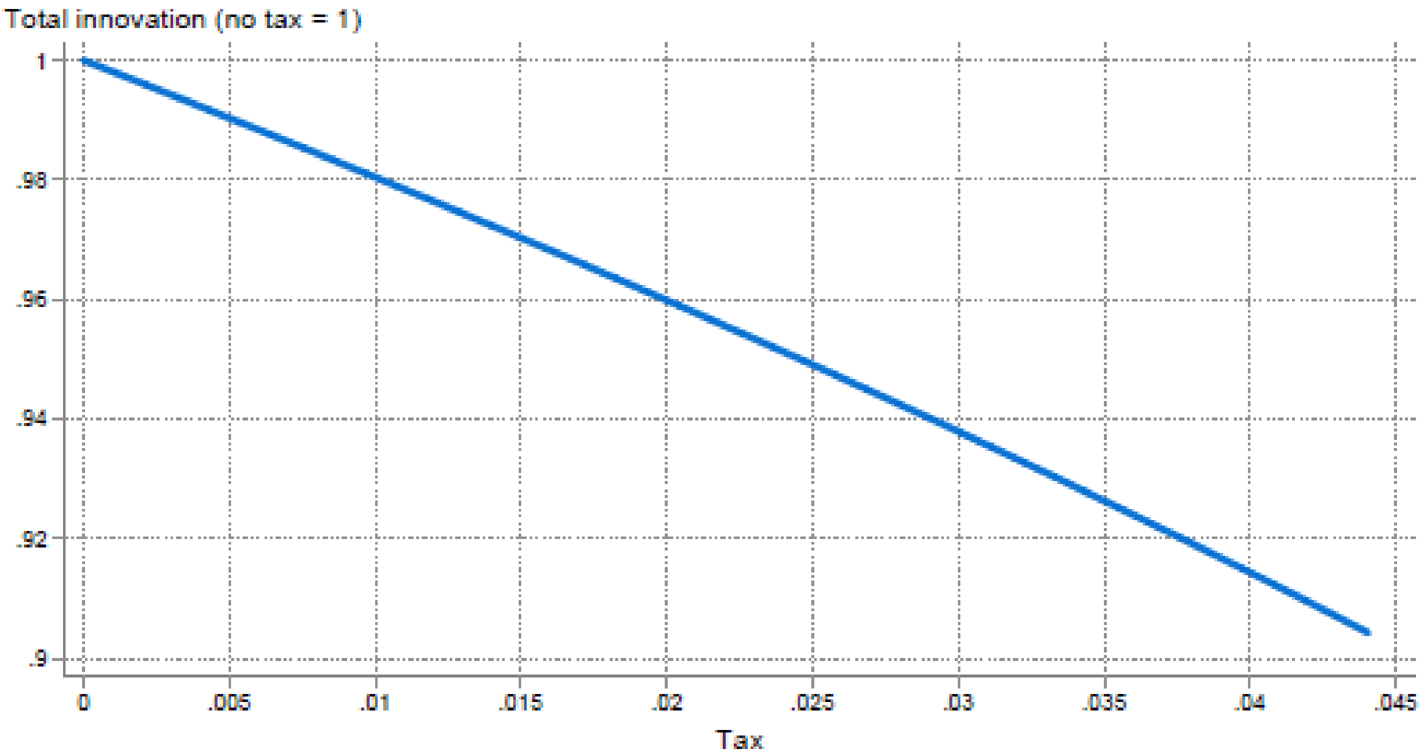


Steady State Firm Size distribution with and without regulation



Putting it all together: aggregate Loss of Innovation as a function of the regulation



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Measuring exogenous shock to market size

- **Market size & innovation:** Barlevy (2007); Acemoglu & Linn (2004); Schmookler (1966); Shleifer (1986);
- Construct demand shock based on growth of firm's overseas market size (Hummels et al, 2014):
- French customs data gives us exports of all **firm** *i*'s (HS6) **products** *s* to destination **country** *j* at **time** *t*
- Firm's export share in base year t_0 is $\omega_{i,s,j,t0}$
- We interact this weight with growth in imports (*I*) of this country-product (excluding France), to construct the IV

$$\Delta S_{it} = \sum_{s,j \in \Omega(i,,t_0)} \omega_{i,s,j,t_0} \tilde{\Delta} I_{s,j,t}$$

Patent Growth Equation

$$\tilde{\Delta} Y_{i,t} = \boxed{\delta\left[\Delta S_{i,t-2} * L^*_{i,t-2}\right]} + \alpha \Delta S_{i,t-2} + \beta L^*_{i,t-2}$$
$$+\gamma[\Delta S_{i,t-2} * P\left(\log(L_{i,t-2})\right)] + \psi_{s(i,t)} + \tau_t + \varepsilon_{it}$$

- L^* = 1 if firm has between 45 and 49 employees & zero otherwise; L = firm employment;
- $P\left(\log(L_{i,t-2})\right)$ polynomial to flexibly control for size
- $\psi_{s(i,t)}$ = industry dummies; τ_t = year dummies
- <u>**Key Hypothesis is $\boldsymbol{\delta < 0}$:**</u> firms increase innovation by less to a positive shock when just below the threshold
- Patent growth in "DHS" form:

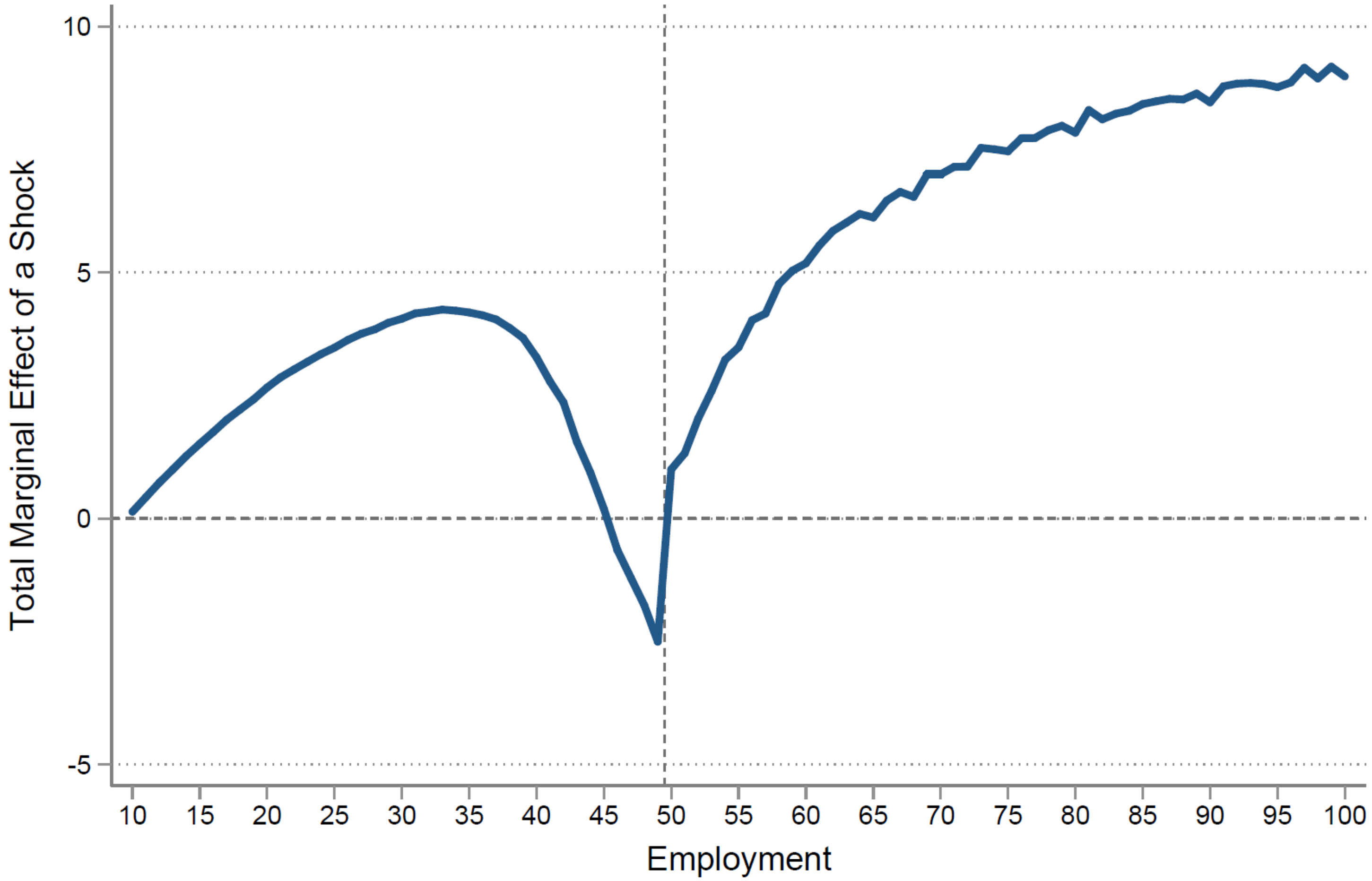
$$\tilde{\Delta} Y_{i,t} = \begin{cases} \frac{Y_t - Y_{t-1}}{Y_t + Y_{t-1}} & \text{if } Y_t + Y_{t-1} > 0 \\ 0 & \text{otherwise} \end{cases}$$

Tab 2: Demand shocks have weaker effects on innovation just below the regulatory threshold

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$Shock_{t-2} \times L^{\star}_{t-2}$				-11.910**	-13.924**	-13.135**	-15.673**
				(5.806)	(5.880)	(5.874)	(6.379)
$L^{\star}_{t-2}$				0.045	0.066	0.066	0.118
				(0.138)	(0.147)	(0.146)	(0.229)
$Shock_{t-2}$	2.912**	-8.160*	13.046	3.732***	-9.333*	10.467	-9.077*
	(1.172)	(4.173)	(9.728)	(1.182)	(4.185)	(9.652)	(4.617)
$log(L)_{t-2}$		-0.036	0.012		-0.040	0.008	-0.199**
		(0.027)	(0.104)		(0.031)	(0.102)	(0.083)
$Shock_{t-2} \times log(L)_{t-2}$		3.270**	-10.853		3.898***	-9.281	3.857**
		(1.374)	(7.524)		(1.392)	(7.490)	(1.552)
$log(L)^2_{t-2}$			-0.008			0.156	
			(0.019)			(0.151)	
$Shock_{t-2} \times log(L)^2_{t-2}$			2.182*			2.031	
			(1.291)			(1.287)	
$\Delta log(L)_{t-2}$							
Fixed Effects							
Sector	✓	✓	✓	✓	✓	✓	✓
Year	✓	✓	✓	✓	✓	✓	✓
Firm							✓
Number Obs.	186,337	186,337	186,337	186,337	186,337	186,337	186,337

Note: SE clustered by 3 digit industry. All models include 3 digit industry dummies and year effects

Implied Marginal effect of demand shocks on innovation by firm size



Note: These are based on the specifications in column (5) of Table 2

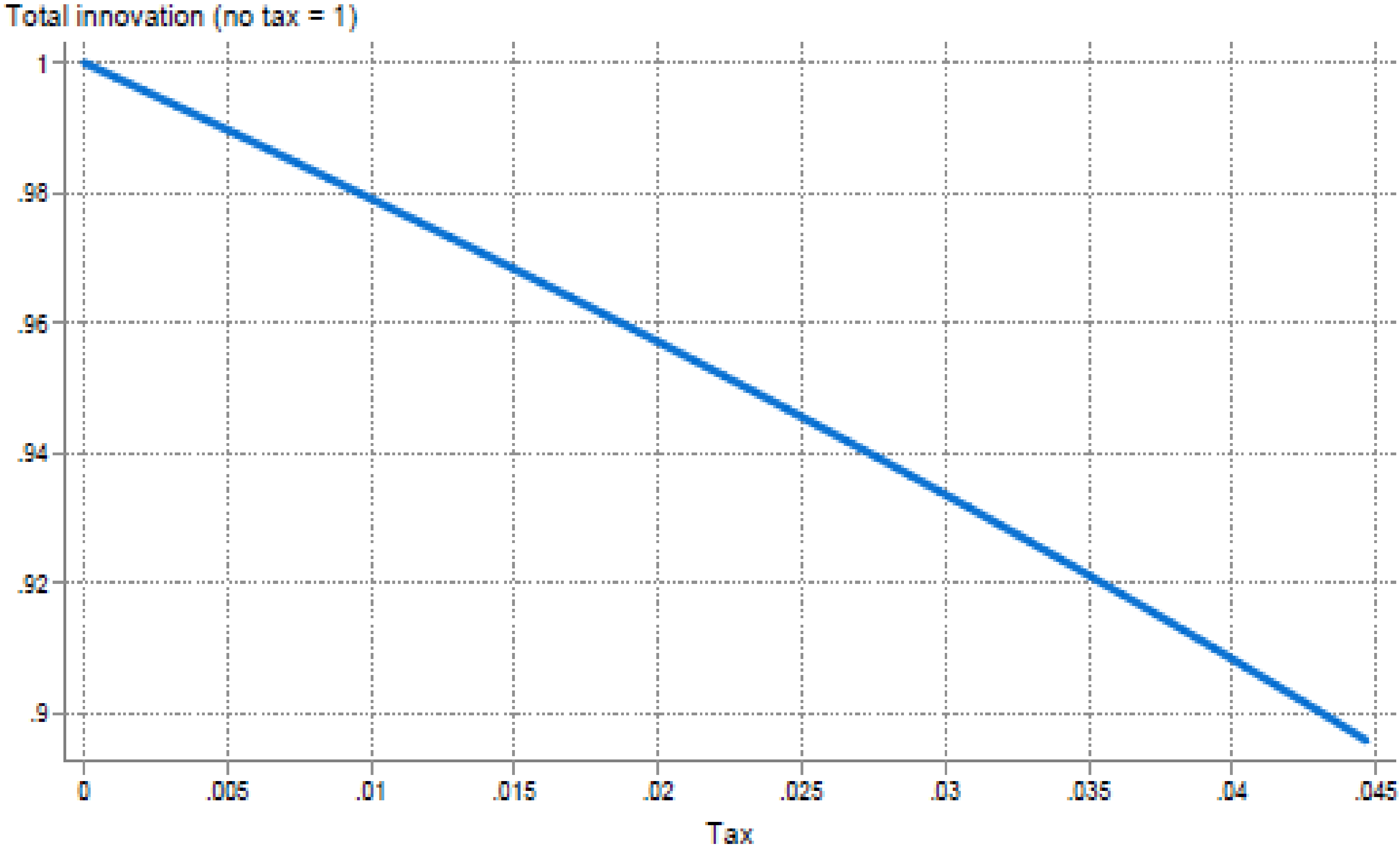
Aggregate Effects

- So far, checked the qualitative implications of the model
- Can also use model to calculate regulation effects on aggregate innovation
- Calibrate parameters from literature, moments form French data, etc.

Quantifying Parameters (Table 3)

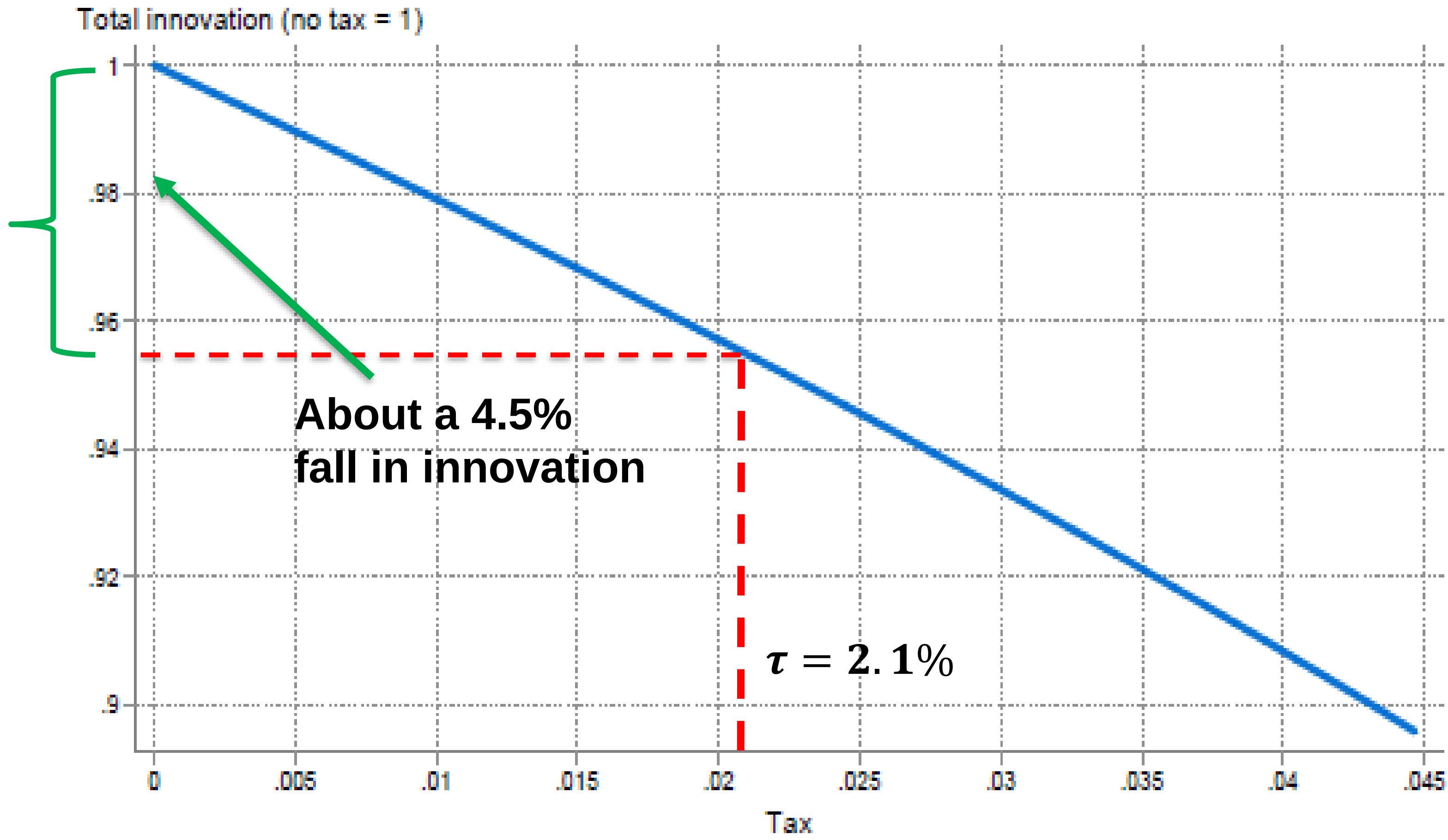
Name	**Parameter**	**Baseline Value (*sensitivity*)**	**Source**
Concavity of the innovation cost function	η	1.5 *(1.3,2.0)*	Dechezlepretre et al (2016). Function of Elasticity of patents with respect to R&D
Innovation step size	γ	1.3 *(1.05,1.5)*	Aghion et al (2019a). Aggregate price-cost mark-up
Regulatory implicit tax	τ	*0.021 (0.01,0.03)*	Fall in slope of innovation-firm size relationship for big firms (after threshold) compared to small firms (given η)
Output adjusted wage	ω	0.29 *(0.25,0.34)*	Firm size distribution (slope of power law steeper in log-log space when ω larger)
Discount factor/scale parameter	β/ζ	0.13	Function of slope of the innovation-size relationship for large firms (given η, γ, τ)

Aggregate Innovation falls by about 4.5% (estimated tax of 2.1%)



Note: Model uses parameters as estimated in Table 3.

Aggregate Innovation falls by about 4.5% (estimated tax of 2.1%)



Note: Model uses parameters as estimated in Table 3. In sensitivity tests range of innovation losses are between 2% and 7%.

Decomposing aggregate effects (shift share relative to unregulated economy)

$$
\begin{aligned}
Z(\tau) - Z(0) &= \sum_{n>0} \left(Z(n,\tau) - Z(n,0) \right) \mu(n,0) \\
&+ \sum_{n>0} \left(\mu(n,\tau) - \mu(n,0) \right) Z(n,0) \\
&+ \sum_{n>0} \left(\mu(n,\tau) - \mu(n,0) \right) \left(Z(n,\tau) - Z(n,0) \right) \\
&+ z_e(\tau) - z_e(0),
\end{aligned}
$$

Lower firm innovation (evaluated at unregulated firm size distribution)

Shift in firm size (evaluated at unregulated firm innovation)

Interaction

Entry

80% of the aggregate effect is the first row: lower innovation by incumbent given firm size distribution

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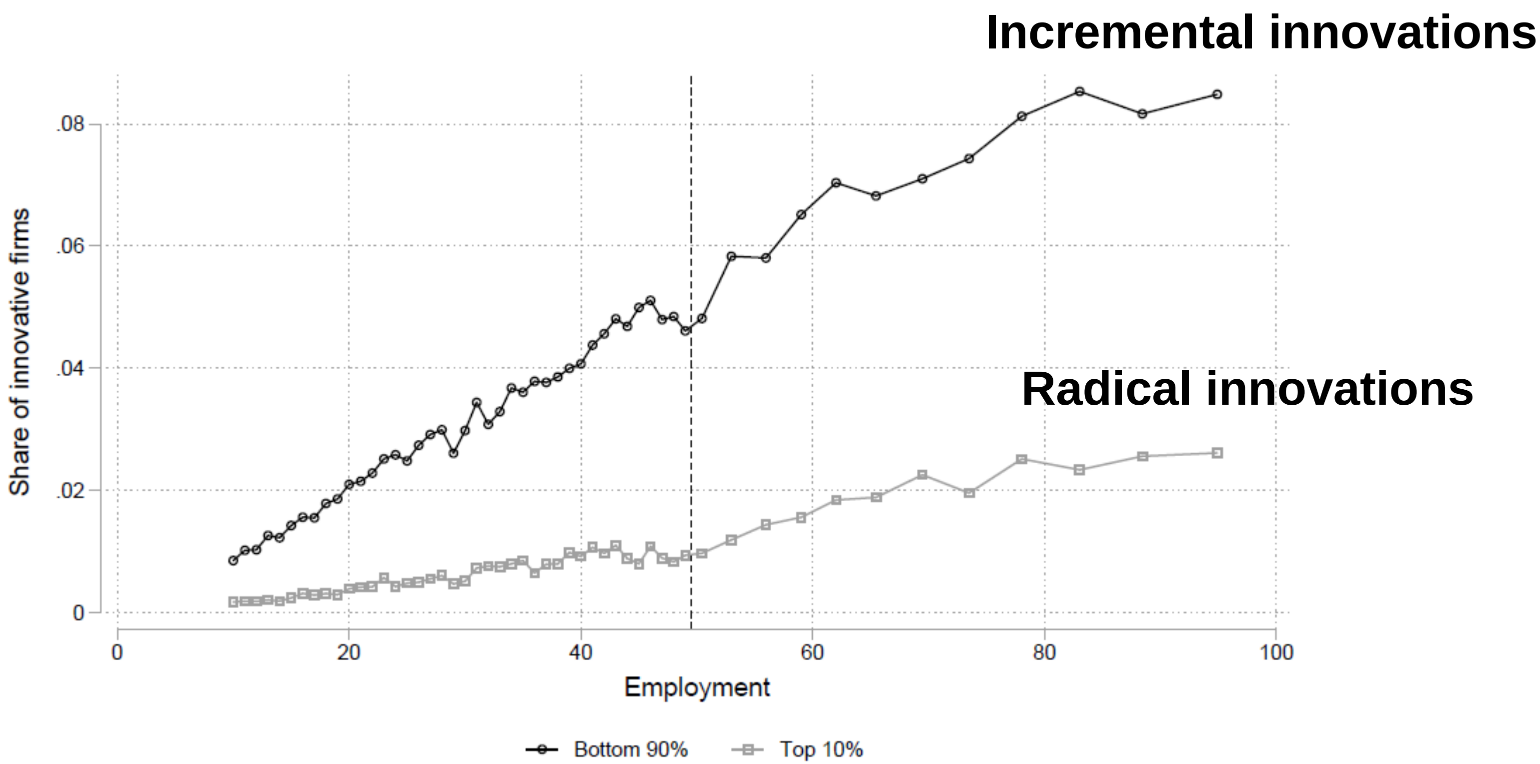
   - **Incremental & radical innovation**
   - Empirical robustness
   - Generalizing theory: infinitely lived firm owners; R&D as scientists

Extension to two types of innovation: incremental and radical

- We extend the model to allow for two types of innovation
  - Regular "incremental" innovation as before
  - Radical ("big") innovation which allows the firm to increase by $k>1$ product lines, but is more costly

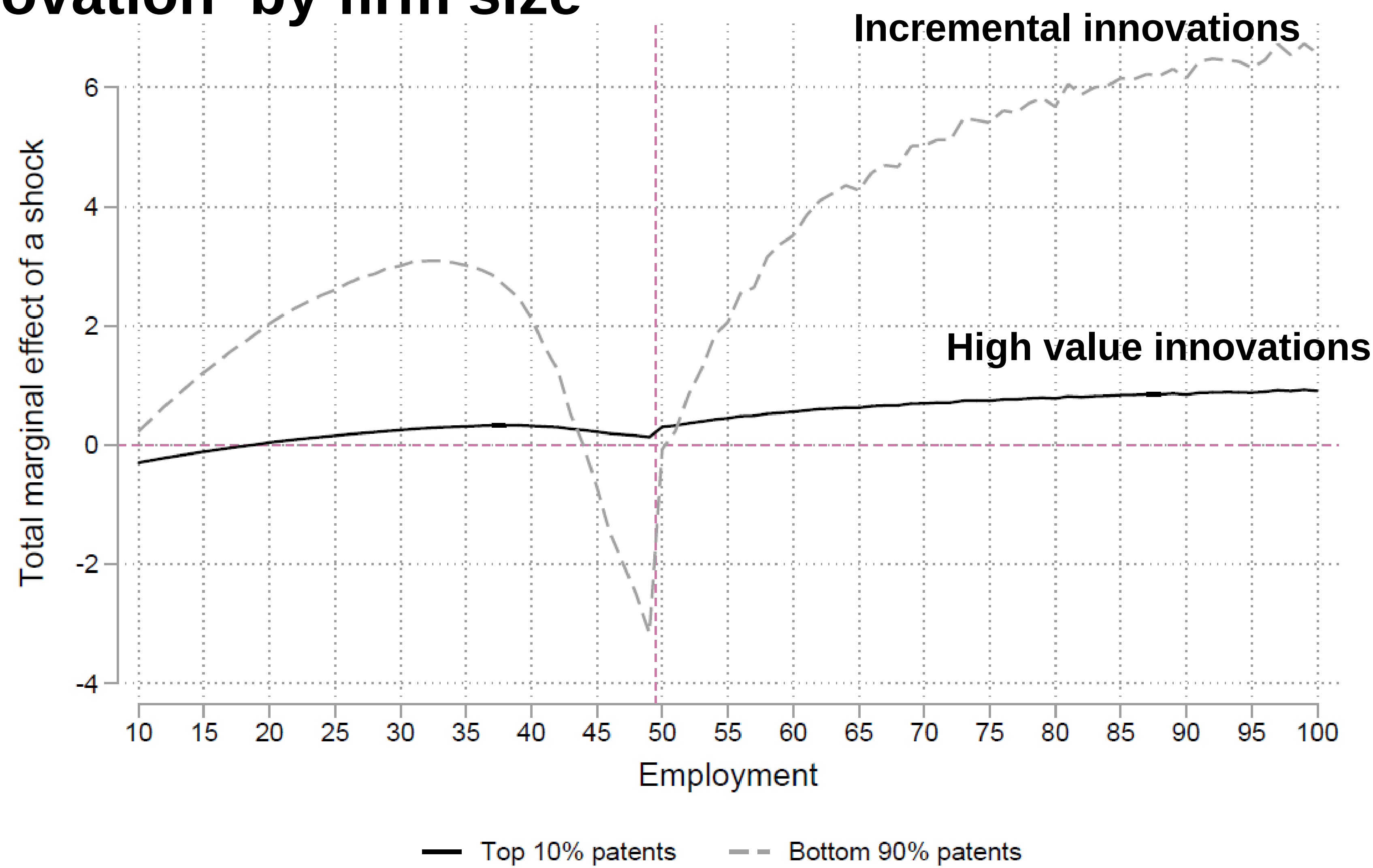
- Intuitively, if a firm is going to innovate, then those just below the threshold will much prefer radical to incremental innovation

The valley is only for low quality (“incremental”) innovators not high quality (“radical”) innovators (top 10% of future citations distribution)



Notes: share of firms with at least one priority patent in the top 10% most cited (grey line) and the share of firms with at least one priority patent among the bottom 90% most cited in the year (black line). All observations are pooled together. Employment bins have been aggregated so as to include at least 10,000 firms. The sample is based on all firms with initial employment between 10 and 100 (154,582 firms and 1,439,396 observations).

Implied Marginal effect of demand shocks on innovation by firm size



Note: These are based on the estimates in columns (1) and (6) of Table 3

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   - **Empirical robustness**
   - Generalizing theory: infinitely lived agents; R&D as scientists

Robustness

- **Add firm FE (firm trends); Tab 2 col (7)**
- **Add non-manufacturing. Tab 2 col (8)**
- Add employment growth. Tab 2 col (9)
- Placebo looking at nonlinearities for 14 other size thresholds in bandwidths of 5 employees 10-14,…,75-79. Only find effect for the 45-49 below threshold. Tab D1
- Alternative functional form of dep. Var. to DHS: IHS; log differences, normalize on pre-sample patents. Tab D2
- Instead of using bandwidth of 10 to 100 employees use [10,500]; [0,100]. Table D2
- Restrict to 1994 exporters; include non-exporters. Tab D2
- Alternative timing to t-2 shock. Tab D2
- Tests of Bartik assumptions (e.g. Borusyak et al, 2020)

Conclusions - Summary

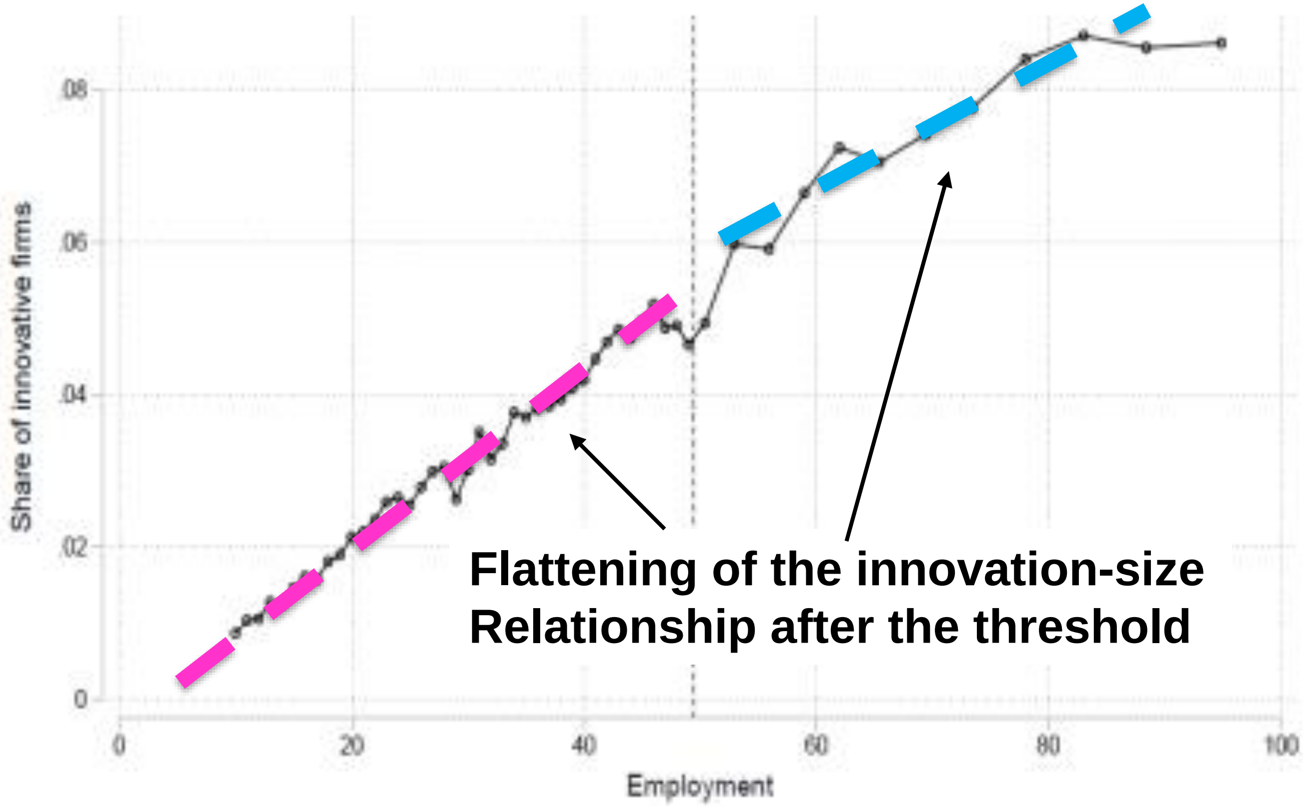
- Regulation has dynamic effects by affecting innovation incentives
- Theoretically and empirically, prospect of regulatory costs discourages innovation for firms just below the threshold
  - Evidence for this in static and dynamic analysis
- Aggregate effects look important: around 4.5% fall in innovation
- But both in cross section and using exogenous demand shocks in panel, the negative impact is confined to <u>incremental</u> (rather than radical) innovations

Conclusions - Discussion

- We have not quantified benefits in terms of insurance, security, investment in firm specific skills
  - Places a bound on these benefits.
  - And no wage change around threshold
- Does it matter that incremental innovation is discouraged
  - Are main market failures only for radical innovation? (estimating spillover effects for incremental vs. radical innovation using production functions)
- Methods: Beyond calibration to structural estimation

Back Up

Share of innovative firms at different firm employment levels



Notes: share of firms with at least one priority patent against employment at t. All observations are pooled together. Employment bins have been aggregated so as to include at least 10,000 firms. The sample is based on all firms with initial employment between 10 and 100 (154,582 firms and 1,439,396 observations).

Tab 3: Weaker effect of demand shocks below threshold only exist for incremental innovation

Quality	Top 10% (1)	Top 15% (2)	Top 25% (3)	Bottom 75% (4)	Bottom 85% (5)	Bottom 90% (6)
$Shock_{t-2} \times L^{\star}_{t-2}$	-0.825	0.953	-1.661	-15.475**	-12.982*	-16.117**
	(1.340)	(1.983)	(2.928)	(6.540)	(6.714)	(6.487)
$L^{\star}_{t-2}$	-0.051	-0.026	0.001	0.109	0.147	0.119
	(0.047)	(0.074)	(0.088)	(0.135)	(0.138)	(0.144)
$Shock_{t-2}$	-1.857	-3.710	-12.263***	-1.920	-7.715	-8.314*
	(2.059)	(3.222)	(4.614)	(5.156)	(4.929)	(4.588)
$log(L)_{t-2}$	0.015	-0.004	-0.045*	-0.037*	0.002	-0.056**
	(0.019)	(0.025)	(0.026)	(0.020)	(0.016)	(0.026)
$Shock_{t-2} \times log(L)_{t-2}$	0.624	1.198	3.825**	3.156*	1.553	3.414**
	(0.681)	(1.111)	(1.474)	(1.658)	(1.708)	(1.515)
Fixed Effects						
Sector	✓	✓	✓	✓	✓	✓
Year	✓	✓	✓	✓	✓	✓
Number Obs.	186,337	186,337	186,337	186,337	186,337	186,337

Notes: estimation results of the same model as in column 5 of Table 2. The dependent variable is the Davis and Haltiwanger (1992) growth rate in the number of priority patent applications between $t-1$ and t, restricting to the top 10% most cited in the year (column 1), the top 15% most cited in the year (column 2), the top 25% most cited in the year (column 3), the bottom 85% most cited in the year (column 4), the bottom 75% most cited in the year (column 5) and the bottom 90% most cited in the year (column 6). All models include a 3-digit NACE sector and a year fixed effects. Estimation period: 1997-2007. Standard errors are clustered at the 3-digit NACE sector level. ***, ** and * indicate p-value below 0.01, 0.05 and 0.1 respectively.

Robustness

Table 4: Sensitivity analysis

Robustness	**Loss in total innovation**
Baseline	-4.50%
$\gamma = 1.05$	-4.45%
$\gamma = 1.50$	-4.54%
$\eta = 2$	-2.29%
$\eta = 1.3$	-7.35%
$\omega = 0.25$	-4.46%
$\omega = 0.34$	-4.54%
$(\tau, \beta/\zeta)$	
	Percentile 75^{th}: -7.04% (corresponds to values: (0.032, 0.13))
	Percentile 25^{th}: -2.11% (corresponds to values: (0.010, 0.13))

Notes: baseline uses parameter values: ($\eta = 1.5$, $\gamma = 1.3$, $\tau = 0.021$, $\beta/\zeta = 0.13$ and $\omega = 0.29$), see Table 3. In the robustness where γ, η or ω are changed, we keep τ and β/ζ as in the baseline.

Lifecycle of a firm

- For expositional purposes, consider owner that lives 2 periods (firms can live forever)
  - Before period 1, the owner inherits a firm of size *n*
  - In period 1 she chooses her innovation intensity, *z*
  - In period 2, she chooses inputs & takes profits. Owner dies and successor takes over firm

- Therefore a firm cannot extend its size by more than 1 product line in a generation

- In general model we allow owners to live multiple periods (so allow infinitely lived firms) and same intuitions go through

Firm's problem

- If firm employment exceeds threshold $\bar{l}$ *(=49;* or equivalently produces more than $\bar{n}$ lines), it incurs a tax on profits, τ

- The firm chooses *z* (R&D per line) to maximize NPV:

$$\overbrace{\pi(n)}^{\textit{Flow profit per line today}} + \overbrace{\beta z[(n+1)\pi(n+1) - n\pi(n)]}^{\textit{Discounted Incremental profit from innovating (prob = z) \& producing n+1 lines}}$$

$$\underbrace{+\beta x[(n-1)\,\pi(n-1) - n\pi(n)]}_{\textit{Discounted Incremental loss from being replaced (prob = x) by another firm \& producing n -1 lines}} - \underbrace{\zeta z^{\eta}}_{\textit{R\&D cost}}$$

where $\pi(n) = 1 - \frac{1}{\gamma}$ if $n < \bar{n}$ and $\pi(n) = \left(1 - \frac{1}{\gamma}\right)(1-\tau)$ if $n \geq \bar{n}$

Firm's optimal innovation <u>per line</u>, *z(n)* = *(Z/n)*

Small firms
Well below threshold

$$\left(\frac{\beta(\gamma-1)}{\gamma\zeta\eta}\right)^{\frac{1}{\eta-1}} \quad if\ n < \bar{n}-1$$

Medium firms
Just below threshold

$$\left(\frac{\beta(\gamma-1)(1-\tau\bar{n})}{\gamma\zeta\eta}\right)^{\frac{1}{\eta-1}} \quad if\ n = \bar{n}-1$$

Big firms
above threshold

$$\left(\frac{\beta(\gamma-1))(1-\tau)}{\gamma\zeta\eta}\right)^{\frac{1}{\eta-1}} \quad if\ n \geq \bar{n}$$

$\bar{n}$ is the regulatory threshold