

Innovation Booms, Easy Financing, and Human Capital Accumulation

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Motivation

- Intense technological change often comes with financial speculation

⇒ Easy financing for innovative firms

... can pay high wages and attract talent

⇒ Reallocation of high-skill workers to booming innovative sector

...exposes their human capital to new technologies

- Examples: current AI boom, late 1990s tech bubble, etc.

Questions

Effect of innovation booms and easy financing on human capital?

1. Effect of **joining** a booming new technology sector on skilled workers' human capital?
 2. Role of **financial capital flows**?
 - **Allocative effect**: across-firm correlation between capital flow and impact on human capital?
 - **Direct effect** of easy financing on human capital?
- Matters for **aggregate labor productivity**

Effect on human capital ex ante unclear

- Potential **upside**
 - Exposure to new technologies \Rightarrow workers acquire **valuable skills**
 - \approx Growth-enhancing tech bubbles (Olivier 2000; Caballero Farhi Hammour 2006)
- Potential **downside**

Effect on human capital ex ante unclear

- Potential **upside**
 - Exposure to new technologies \Rightarrow workers acquire **valuable skills**
 - \approx Growth-enhancing tech bubbles (Olivier 2000; Caballero Farhi Hammour 2006)
- Potential **downside**
 - Skills rapidly **lose value**
 - Skills linked to **rapidly evolving technology** \Rightarrow “vintage-specific human capital”
(Chari Hopenhayn 1991; Deming Noray 2020)
 - Easy financing \Rightarrow **lower quality projects**

Empirical design

- **Episode:** Information and Communications Technology (ICT) late 1990s boom
 - Large
 - Plausibly accompanied by speculative capital flows
 - Possible to study long-run effects
- **Data:** Administrative employer-employee panel data for France (1994–2015)
 - Track workers from when they start in a sector
 - Compare cohorts of workers starting in ICT sector vs. other sectors

This paper

1. Sizeable **reallocation** of K and skilled L to ICT sector during boom
 - **1/3 of new cohorts** of skilled workers start in ICT during boom

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2. Wage pattern for these workers fifteen years out:

- **6% lower**
 - **Not** explained by **demand effects**
 - **Not** explained by **selection effects**
- ⇒ Lower value of **human capital**

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 - **Not** explained by **selection effects**
 - ⇒ Lower value of **human capital**
3. Easy financing **amplifies** the effects
4. Mechanism: accelerated **skill obsolescence**

Contribution to the Literature

- 1. Financing cycles and trajectory of innovation.** Quantity (Kortum and Lerner, 2000; Brown, Fazzari, and Petersen, 2009; Bernstein, 2015) Composition and risk (Nanda and Rhodes-Kropf 2013, 2017; Townsend 2015; Howell, Lerner, Nanda, and Townsend 2021; Bernstein, McQuade, Nanda, and Roth 2019) human capital overvaluation (Fedyk and Hodson, 2022)
- 2. Role of financing booms and wage premia across sectors on the talent allocation and long-run productivity growth.** (Baumol, 1990; Philippon, 2010; Gupta and Hacamo, 2022) – Growth enhancing bubbles (Olivier, 2000; Caballero, Farhi, and Hammour, 2006)
- 3. Sectoral allocation and human capital accumulation.** Mostly low skill sectors (Charles, Hurst, and Notowidigdo, 2018 Carrillo, 2020; Choi, Lou, and Mukherjee, 2022)
- 4. Technological vintages** Chari and Hopenhayn, 1991; Violante, 2002; Deming and Noray, 2020; Kogan, Schmidt, and Seegmiller, 2022; Ma, 2022

Roadmap

The ICT Boom

Wage Dynamics

Role of Financial Capital

Mechanism

Wrap-up

Data

1. Employment: matched employer-employee data for random 1/24th of employees
 - **Skilled workers**: “executives and higher intellectual professions” (STEM content + management/business content)
2. Firm data: universe of tax files
 - **ICT sector** defined by industry

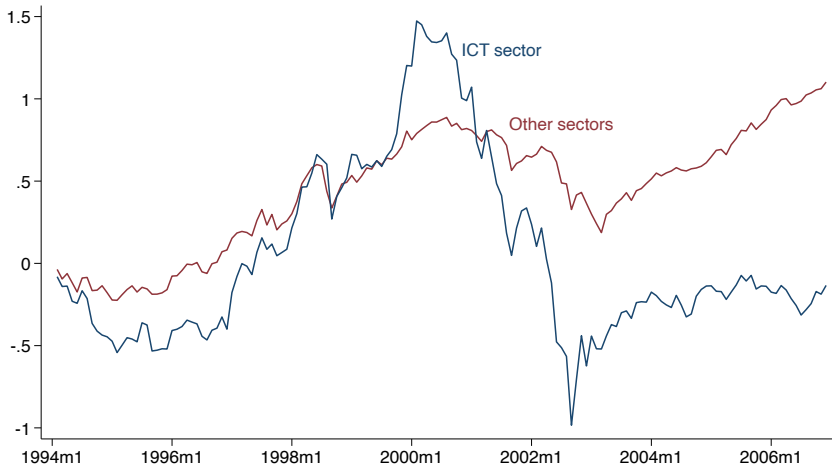
The Information and Communication Technology (ICT) Sector

ICT industries	Share of total employment (%)	Share of skilled employment (%)
ICT: Services	1.9	7.8
IT consultancy	0.7	3.4
Software	0.7	3.2
Data processing	0.3	0.8
Maintenance computers	0.1	0.2
Other data/computer-related services	0.1	0.2
ICT: Telecommunications	1.4	2.2
Telecommunications	1.4	2.2
ICT: Manufacturing	1.7	3.7
Electronic/communication equipment	0.8	1.8
Measurement/navigation equipment	0.5	1.2
Accounting/computing equipment	0.2	0.7
Insulated wire and cable	0.1	0.1
ICT: Wholesale	0.5	1.2
Computers, electronics, telecoms	0.5	1.2
ICT: Total	5.4	14.9

OECD (2002) definition, Universe of matched employer-employee data in France (1994–2008)

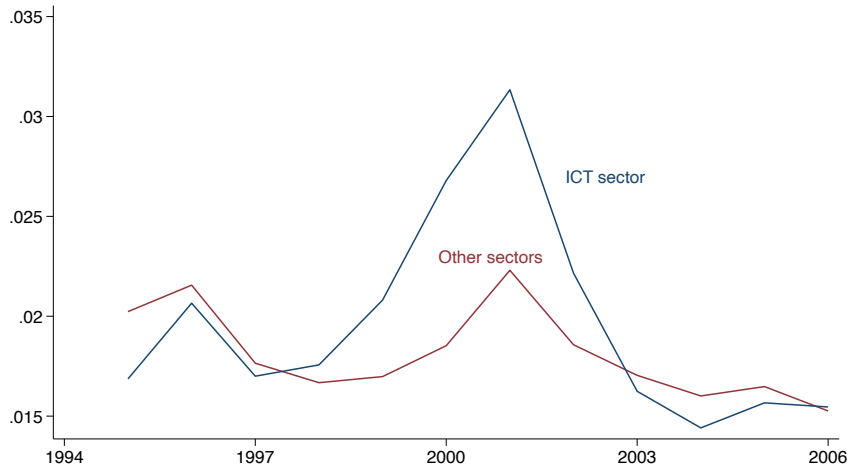
ICT boom: equity valuation

- Cumulative stock return: boom / bust / normalization
- (Similar pattern for stock price/sales)



ICT boom: capital reallocation

- Equity issuance/Total assets for universe of listed+private firms
- Similar pattern for firm creation rate



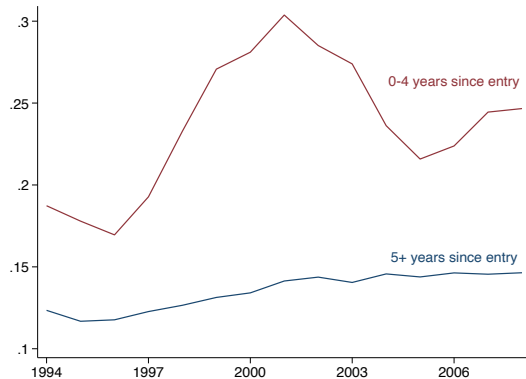
Labor reallocation: the role of extensive margin

- Reallocation of skilled workers to ICT sector (% skilled employment in ICT)



Labor reallocation: the role of extensive margin

- Reallocation of **skilled workers** to **ICT sector** (% skilled employment in ICT)
- Dynamics driven by workers **starting their career** (= extensive margin)

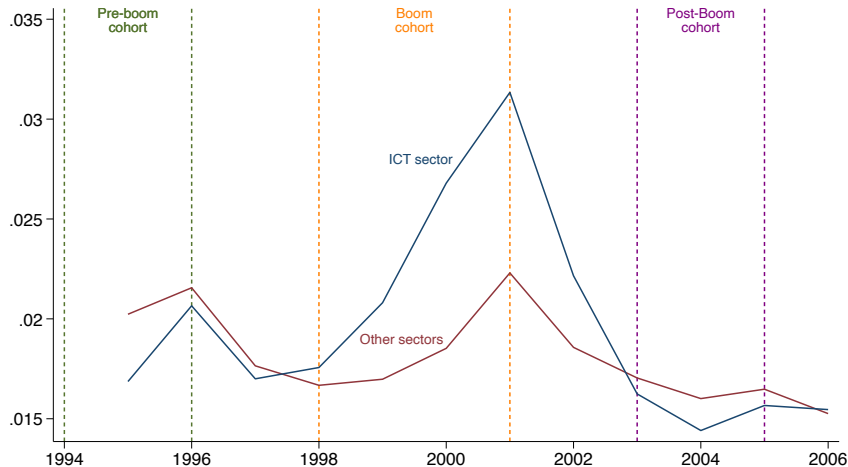


ICT boom: taking stock

1. Large **reallocation** of K & skilled labor
2. **Three** distinct cohorts of workers: pre-boom, boom, post-boom

Different exposure to the boom across cohorts

Equity issuance/Total assets



(Similar pattern for labor market entry)

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Graphical evidence

Regressions & robustness

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Wage differences: across workers within boom cohort

- Sample: Skilled workers starting between 1998 and 2001
- Baseline regression:

$$\log(wage_{i,t}) = \beta_t \cdot ICT_{i,0} + \delta_t + \delta_t \times X_i + \epsilon_{i,t}$$

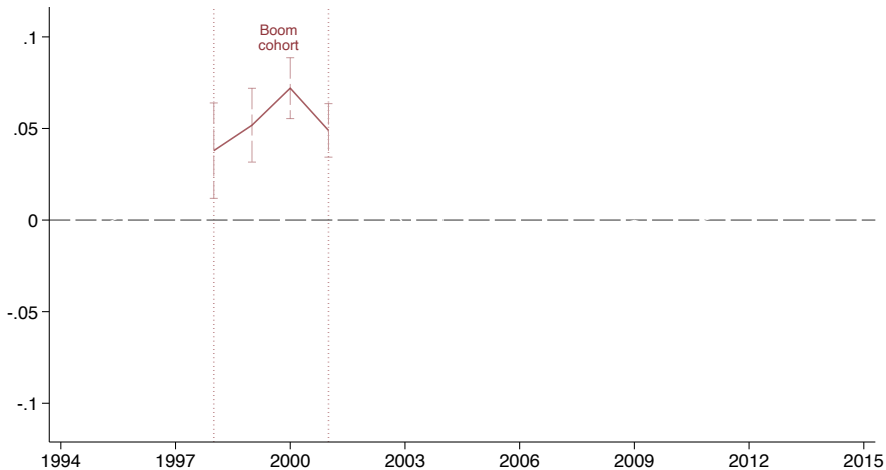
$ICT_{i,0} = 1$ if worker i starts career in ICT sector

→ wage premium can reflect sector reallocation post entry

X_i = entry year, sex, age, age squared, two-digit occupation at entry

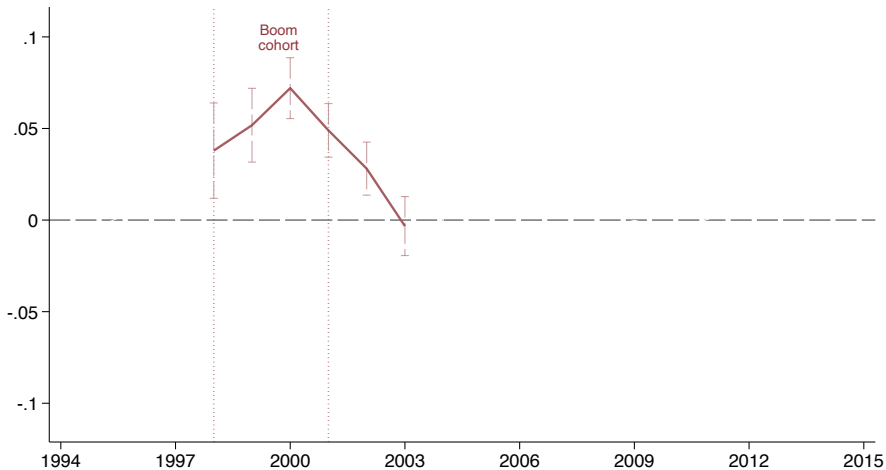
Wage dynamics of boom cohort

- 5% higher entry wage



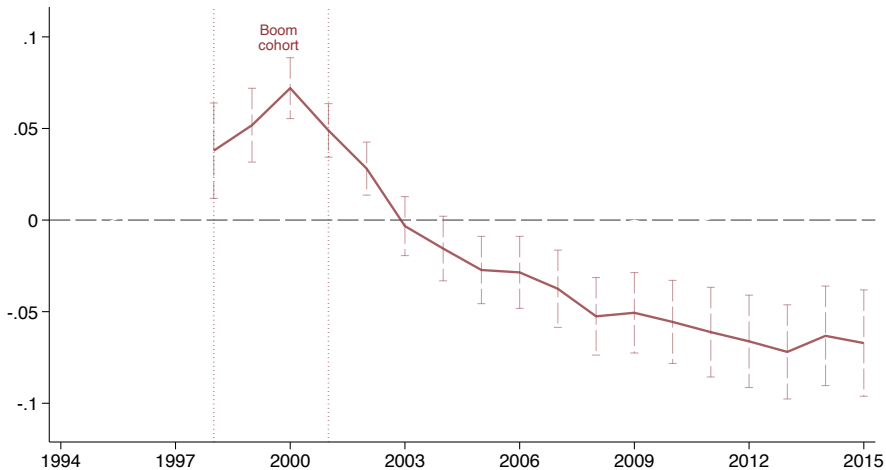
Wage dynamics of boom cohort

- No premium after boom → standard boom-bust



Wage dynamics of boom cohort

- 6% lower wage fifteen years out



Candidate explanations

Key ingredients of the model

- **Heterogeneous** workers (productivity and preferences) choose sector **at entry**
- **Human capital** has **two** components:
 - **Fixed** component (\approx education, ability)
 - **On-the-job** accumulation / depreciation (sector specific)
- Two types of **sectoral shocks**:
 - **Demand** shocks \Rightarrow *sector specific (all cohorts)*
 - **Technological** shocks \Rightarrow *sector-cohort specific*

Wage Dynamics Differential

Δ wage between two sectors for cohort c at time t has three components:

$$\Delta \bar{w}_{c,t} = \sum_{\tau=c+1}^t \Delta dh_{c,\tau} + \Delta w_t + \Delta \bar{\theta}_c$$

accumulated demand / worker quality
human capital supply shock (selection)

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accumulated demand / worker quality
human capital supply shock (selection)

- Tighter identification (**across** cohorts) rules out **demand** and **selection**

Ruling out labor market demand / supply shocks

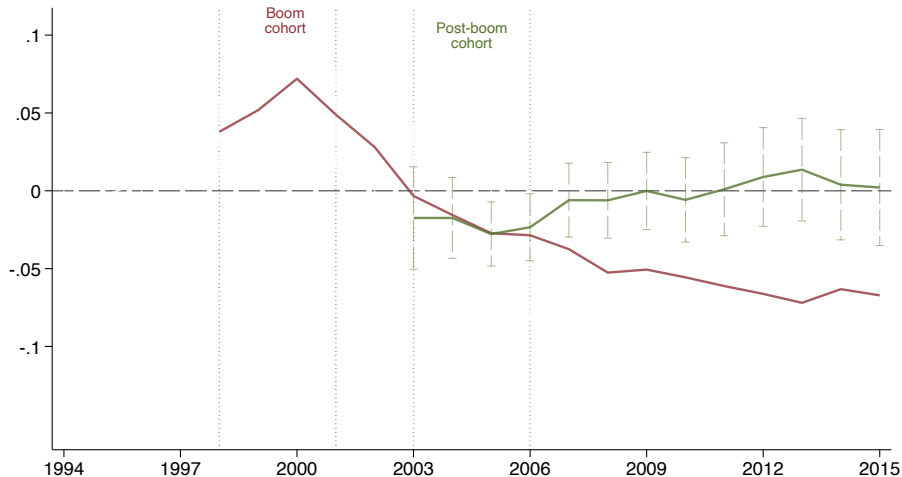
$$\Delta \bar{w}_{c,t} = \sum_{\tau=c+1}^t \Delta dh_{c,\tau} + \Delta \mathbf{w}_t + \Delta \bar{\theta}_c$$

accumulated demand / worker quality
human capital supply shock (selection)

- Hypothesis: low labor demand / high labor supply in ICT post boom
- Implication: post-boom cohort should also experience wage decline

Wage dynamics of **post-boom** cohort (2003–2005)

- Inconsistent with labor supply / demand shock
- Test statistical difference



Ruling out selection

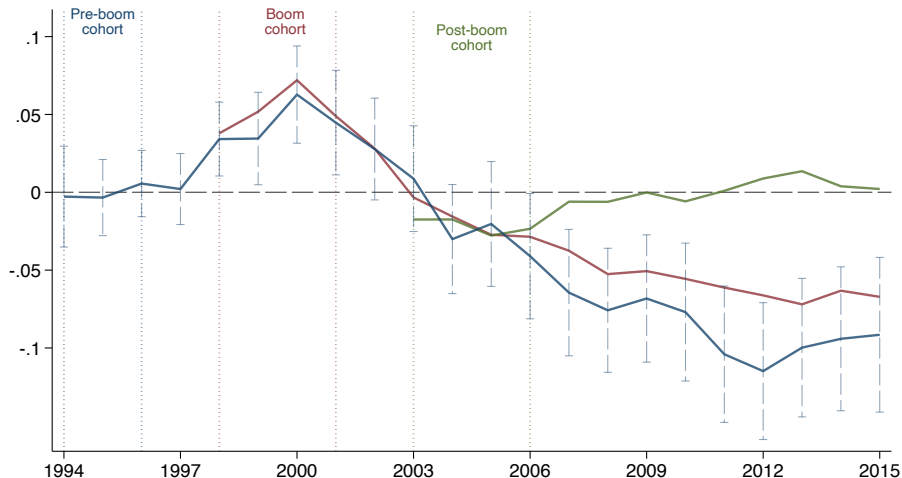
$$\Delta \bar{w}_{c,t} = \sum_{\tau=c+1}^t \Delta dh_{c,\tau} + \cancel{\Delta w_t} + \Delta \bar{\theta}_c$$

accumulated demand / worker quality
human capital supply shock (selection)

- Hypothesis: boom attracts less able workers
- Implication: pre-boom cohort should not display wage decline

Wage dynamics of pre-boom cohort (1994–1996)

- **Inconsistent** with **selection** Test statistical difference
- **Consistent** with HK depreciation for **all** cohorts **experiencing the boom**



Taking stock

What explains the wage discount?

$$\Delta \bar{w}_{c,t} = \sum_{\tau=c+1}^t \Delta dh_{c,\tau} + \cancel{\Delta w_t} + \cancel{\Delta \bar{\theta}_c}$$

accumulated demand / worker quality
human capital supply shock (selection)

Roadmap

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Graphical evidence

Regressions & robustness

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Main specification: across sectors + across cohorts

- Sample: boom cohort (1998–2001) + post-boom cohort (2003–2005)
- Estimating equation

$$\log(\text{wage}_{i,c,t}) = \beta_t \cdot \text{ICT}_{i,0} \times \text{BoomCohort}_c + \delta_t \times \text{ICT}_{i,0} \\ + \alpha_i + \gamma_c \times \delta_t \times X_{i,0} + \epsilon_{i,t}$$

- β_t = wage premium in year t

...of workers starting in ICT sector vs. in other sectors (first difference)

...of workers starting during the boom vs. after boom ends (second difference)

Main specification: across sectors + across cohorts

- Sample: boom cohort (1998–2001) + post-boom cohort (2003–2005)
- Estimating equation

$$\log(wage_{i,c,t}) = \beta_t \cdot ICT_{i,0} \times BoomCohort_c + \delta_t \times ICT_{i,0} + \alpha_i + \delta_t \times \gamma_c \times X_{i,0} + \epsilon_{i,t}$$

- $\delta_t \times ICT_{i,0}$ = ICT specific shocks (labor supply/demand)
- $\delta_t \times \gamma_c \times X_{i,0}$ = Cohort & worker characteristics time-varying shocks

Long-term wage decline

- Starting in ICT during boom (98-01) \Rightarrow **7% slower** long-term wage growth from 2003 to 2015

	log(wage)
$ICT_0 \times \text{BoomCohort} \times 2003-05$	0.001 (0.013)
$ICT_0 \times \text{BoomCohort} \times 2006-10$	-0.035** (0.014)
$ICT_0 \times \text{BoomCohort} \times 2011-15$	-0.073*** (0.019)
Worker controls	✓
$ICT_0 \times \text{Year FE}$	✓
$\text{Cohort} \times \text{Year FE}$	✓
Worker FE	—
Observations	93,304

Long-term wage decline

- Starting in ICT during boom (98-01) \Rightarrow **7% slower** long-term wage growth from 2003 to 2015
- **Worker FE** \rightarrow control for **non-random attrition** + selection on **levels**

	log(wage)	
ICT ₀ \times BoomCohort \times 2003-05	0.001 (0.013)	ref.
ICT ₀ \times BoomCohort \times 2006-10	-0.035** (0.014)	-0.048*** (0.010)
ICT ₀ \times BoomCohort \times 2011-15	-0.073*** (0.019)	-0.077*** (0.015)
Worker controls	✓	✓
ICT ₀ \times Year FE	✓	✓
Cohort \times Year FE	✓	✓
Worker FE	—	✓
Observations	93,304	92,901

Robustness to possible confounding factors

- Robust to:
 - Controlling for **workers' characteristics**: city, education
 - Controlling for **job termination**
 - Controlling for **firm characteristics**: productivity, age, size, future growth
 - **Measurement of earnings**: account for participation in firm profit
 - **Excluding finance** from the control group
 - Restricting the sample to **US firms** (e.g., Microsoft France) → not a French firm phenomenon

First take-away of the paper

- 1/3 of high-skill labor market entrants go to ICT sector during the boom
 - ...and experience long-term human capital depreciation
- ⇒ Labor reallocation during the boom weighs on aggregate HK accumulation

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If easy financing making things worse?

Do capital flows amplify the negative effect on aggregate HK?

1. **Allocative effect:** depends on which ICT firms receive the most capital

- Firms whose workers' HK depreciate the most? The least?

→ $\text{Cov}[\text{Capital flow, HK accumulation}]?$

(K flow versus L flow)

2. **Direct effect:** easy financing may worsen average project quality

- Reduces individual-level HK accumulation?

Allocative effect: capital flows to firms with largest HK depreciation

- Wage discount **only** in firms with above-median capital availability
- $\text{Cov}[\text{Capital flow, HK accumulation}] < 0 \Rightarrow \text{aggregate labor productivity} \downarrow$

Proxy of capital availability:	log(Wage)		
	1999 return (Industry level)	1999 P/S (Industry level)	Equity issuance (Industry×geo ×entry year level)
	(1)	(2)	(3)
$\text{ICT}_0 \times \text{Boom cohort} \times 2011-15$	0.022 (0.044)	0.007 (0.042)	-0.029 (0.025)
$\text{ICT}_0 \times \text{Capital availability} \times \text{Boom cohort} \times 2011-15$	-0.129*** (0.049)	-0.113** (0.047)	-0.081*** (0.031)
$\text{ICT}_0 \times \text{Year FE}$	✓	✓	✓
$\text{Worker controls} \times \text{Cohort} \times \text{Year FE}$	✓	✓	✓
Worker FE	✓	✓	✓
Observations	60,420	60,420	85,128

Direct effect: does capital flow **cause** faster HK depreciation?

- $\text{Cov}[\text{Capital flow, HK depreciation}]$ may reflect causal relation
- ...or both are driven by omitted factor: technology change \Rightarrow capital flow and HK depreciation
- Test: re-estimate correlation holding technology fixed (within narrow sectors)

Direct effect: capital flow causes faster HK depreciation?

- Industry×Cohort×Year FE = within industry, across geography → control for technology shocks

	log(Wage)	
	Equity issuance (Industry×geo×entry year level)	
Proxy of capital availability:	(3)	(4)
ICT ₀ × Boom cohort × 2011-15	-0.029 (0.025)	— —
ICT ₀ × Capital availability × Boom cohort × 2011-15	-0.081*** (0.031)	-0.083** (0.035)
ICT ₀ × Year FE	✓	✓
Worker controls×Cohort×Year FE	✓	✓
Worker FE	✓	✓
Industry×Cohort×Year FE	—	✓
Observations	85,128	85,128

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What drives human capital depreciation?

- Skill obsolescence

- Skills are **vintage** specific → made obsolete by technological change
- Worsened by easy financing if lower quality technologies are funded
- Test: compare jobs with different level **technological content**

What drives human capital depreciation?

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- Worsened by easy financing if lower quality technologies are funded
- Test: compare jobs with different level **technological content**

- Winner-take-all

- VC/technology-related investors prefer projects with small probability of large success ⇒ positive **right tail** of wage growth
- Test: quantile regressions

- ~~Job loss~~

Skill obsolescence

- Universe of workers by occupation level: high / middle / low skill
- Wage decline **largest** in **high skill** occupations

	log(Wage)					
	High-skill		Middle-skill		Low-skill	
	(1)	(2)	(3)	(4)	(5)	(6)
ICT ₀ × Boom cohort × 2011-15	-0.077*** (0.015)	-0.029 (0.025)	-0.068*** (0.014)	-0.039* (0.023)	-0.022 (0.020)	-0.027 (0.040)
ICT ₀ × Capital availability × Boom cohort × 2011-15		-0.081*** (0.031)		-0.033 (0.029)		-0.004 (0.041)
Worker controls×Cohort×Year FE	✓	✓	✓	✓	✓	✓
Worker FE	✓	✓	✓	✓	✓	✓
Observations	92,901	85,128	206,918	186,477	250,620	218,927

Skill obsolescence

- Universe of workers by occupation level: high / middle / low skill
- Wage decline **largest** in **high skill** occupations
- ... particularly so if **large inflow of capital**

	log(Wage)					
	High-skill		Middle-skill		Low-skill	
	(1)	(2)	(3)	(4)	(5)	(6)
ICT ₀ × Boom cohort × 2011-15	-0.077*** (0.015)	-0.029 (0.025)	-0.068*** (0.014)	-0.039* (0.023)	-0.022 (0.020)	-0.027 (0.040)
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Worker controls×Cohort×Year FE	✓	✓	✓	✓	✓	✓
Worker FE	✓	✓	✓	✓	✓	✓
Observations	92,901	85,128	206,918	186,477	250,620	218,927

Winner-take-all?

- Quantile regressions
- Entire wage distribution shifts to the left

	Wage quantiles				
	P10	P25	P50	P75	P90
$ICT_0 \times \text{Capital availability} \times \text{Boom cohort} \times 2011-15$	-0.056 (0.036)	-0.065** (0.026)	-0.077*** (0.018)	-0.089*** (0.023)	-0.098*** (0.032)
Worker controls	✓	✓	✓	✓	✓
Cohort \times Year FE	✓	✓	✓	✓	✓
Worker FE	✓	✓	✓	✓	✓
Observations	93,306	93,306	93,306	93,306	93,306

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Two main results:

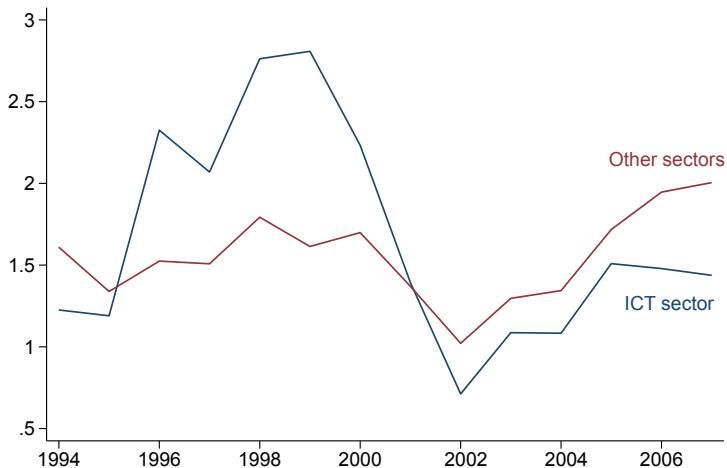
1. Skilled workers starting in booming tech sector **lose human capital**
 - Wage **6%–8% lower fifteen years out**
 - Not explained by labor market imbalance and selection
2. Human capital depreciation **amplified by easy financing**

Wrap-up

Implications:

- Skill-biased technological change?
 - **Our paper:** *within* skilled workers, those who develop and implement new technologies (who represent one-third of the boom cohort) lose out
- Growth enhancing financial speculation?
 - Maybe positive externalities, **but**
 - Capital allocated to firms that do not enhance their workers' human capital → lower aggregate labor productivity

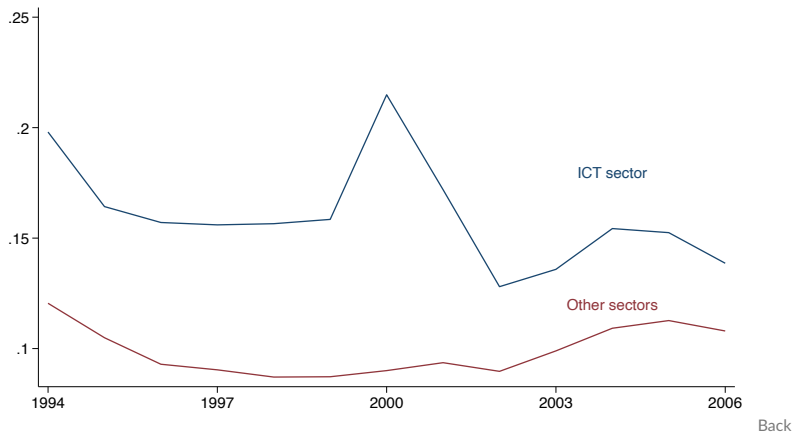
ICT boom: stock price/sales per share



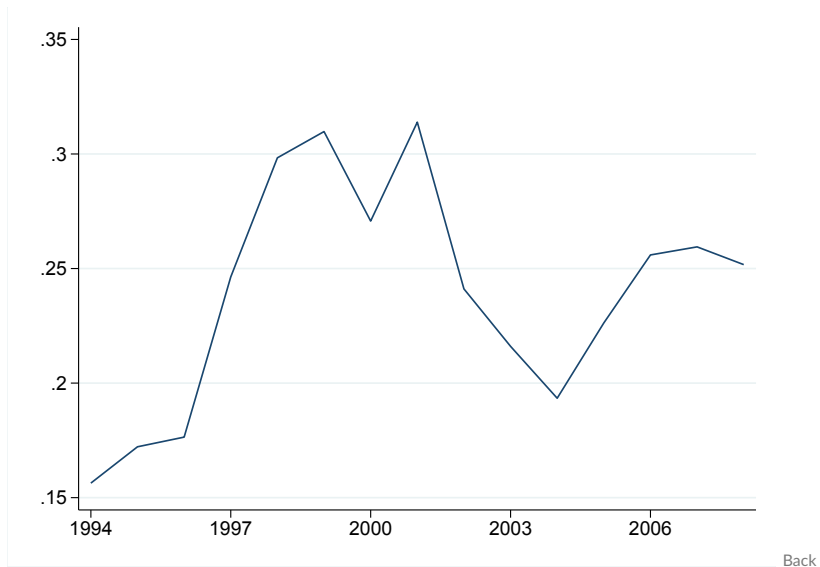
ICT boom: firm entry/stock of firms



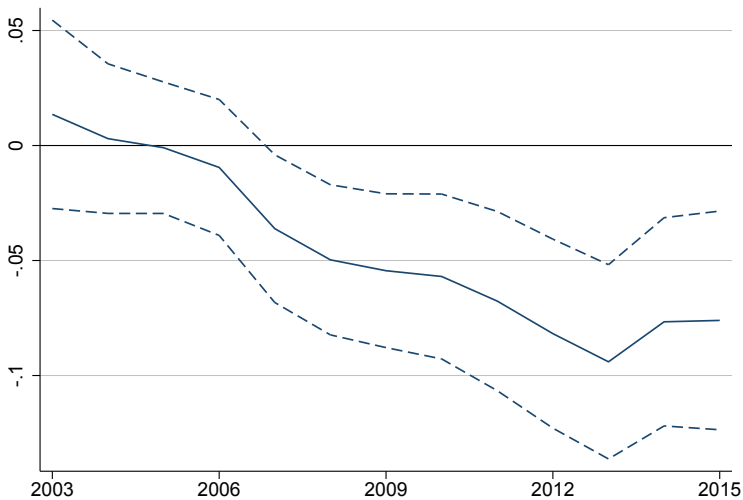
ICT boom: capital reallocation



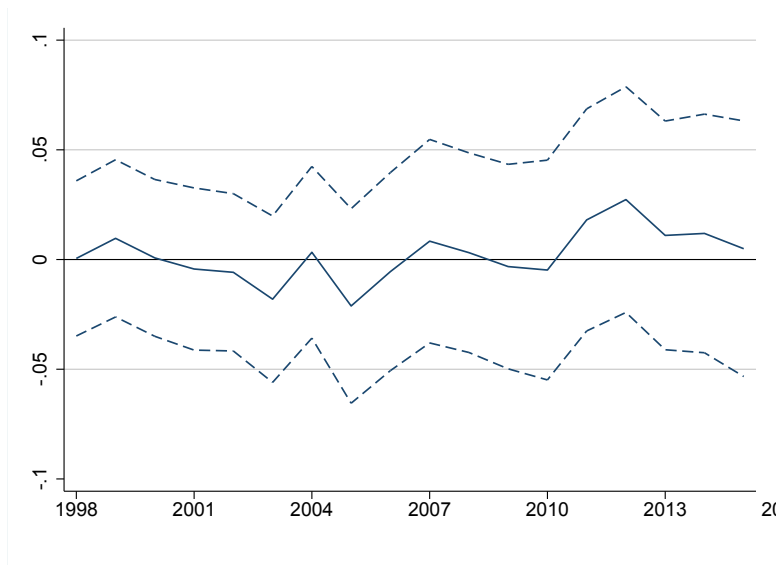
ICT boom: skilled labor market entrants



Wage premium: boom cohort vs. post boom cohort



Wage premium: boom cohort vs. pre boom cohort



Worker controls

	log(Wage)				
	(1)	(2)	(3)	(4)	(5)
$ICT_0 \times \text{Boom cohort} \times 2006-10$	-0.035** (0.014)	-0.048*** (0.010)	-0.043*** (0.010)	-0.041*** (0.011)	-0.045*** (0.013)
$ICT_0 \times \text{Boom cohort} \times 2011-15$	-0.073*** (0.019)	-0.077*** (0.015)	-0.075*** (0.015)	-0.067*** (0.016)	-0.078*** (0.019)
Worker controls×Cohort×Year FE	✓	✓	✓	✓	✓
Worker FE	—	✓	✓	✓	✓
Entry wage quintile×Cohort×Year FE	—	—	✓	—	—
Commuting zone×Cohort×Year FE	—	—	—	✓	—
Four-digit sector×Year FE	—	—	—	—	✓
Observations	93,304	92,901	92,901	92,719	91,343

Firm controls

- 250 pseudo firms: quintiles of employment, firm age, labor productivity, and whether the firm belongs to a conglomerate ($5 \times 5 \times 5 \times 2 = 250$)
- 5-year growth rate = $[S_{t+5} - S_t] / [(S_{t+5} + S_t) \times 0.5]$

	log(Wage)		
	(1)	(2)	(3)
ICT ₀ × Boom cohort × 2011-15	-0.065*** (0.016)	-0.070*** (0.018)	-0.074*** (0.024)
Worker controls×Cohort×Year FE	✓	✓	✓
Worker FE	✓	✓	✓
Commuting zone×Cohort×Year FE	—	—	✓
Entry wage quintile×Cohort×Year FE	—	—	✓
Four-digit sector×Year FE	—	—	✓
Pseudo firm FE×Year FE	✓	✓	✓
Sales growth ($t \rightarrow t + 5$) Quintile FE×Year FE	—	✓	✓
Observations	92,714	90,473	88,586

Job losses explain a tiny part of the wage decline

- Control for **forced job loss** within first four years after entry → **wage discount constant**

(i) ↓ employment at initial employer > 10% — (ii) transition to next job → wage cut

Control for:	log(Wage)	
	—	Job loss
	(1)	(2)
ICT ₀ × Boom cohort × 2011-15	-0.029 (0.025)	-0.026 (0.025)
ICT ₀ × Capital availability × Boom cohort × 2011-15	-0.081*** (0.031)	-0.082*** (0.031)
Worker controls×Cohort×Year FE	✓	✓
Job loss×Year FE	—	✓
Job loss×Cohort×Year FE	—	—
Worker FE	✓	✓
Observations	85,128	85,128

Job losses explain a tiny part of the wage decline

- Control for **forced job loss** within first four years after entry → **wage discount constant**
 - (i) ↓ employment at initial employer > 10% – (ii) transition to next job → wage cut
- Same if job loss during a **sectoral bust**

Control for:	log(Wage)		
	—	Job loss	Job loss ×ICT ₀ ×BoomCoh.
	(1)	(2)	(3)
ICT ₀ × Boom cohort × 2011-15	-0.029 (0.025)	-0.026 (0.025)	-0.019 (0.028)
ICT ₀ × Capital availability × Boom cohort × 2011-15	-0.081*** (0.031)	-0.082*** (0.031)	-0.083** (0.035)
Worker controls×Cohort×Year FE	✓	✓	✓
Job loss×Year FE	—	✓	—
Job loss×Cohort×Year FE	—	—	✓
Worker FE	✓	✓	✓
Observations	85,128	85,128	85,128

Robustness: account for “stock options”

- Use net income from tax file, merge with matched employer-employee

	log(Wage)		log(Wage+Cap.income)	
	Excl. finance (1)	US firms (2)	Capital income assigned to CEOs (3)	Skilled workers (4)
ICT ₀ × Boom cohort × 2006-10	-0.049*** (0.010)	-0.033 (0.032)	-0.051*** (0.011)	-0.052*** (0.011)
ICT ₀ × Boom cohort × 2011-15	-0.079*** (0.015)	-0.074* (0.044)	-0.076*** (0.015)	-0.081*** (0.016)
Worker controls×Cohort×Year FE	✓	✓	✓	✓
Worker FE	✓	✓	✓	✓
Observations	87,522	11,359	92,901	92,901

Robustness: focus on US firms

- Use firm ownership structure → identify US firms

	log(Wage)		log(Wage+Cap.income)	
	Excl. finance (1)	US firms (2)	Capital income assigned to CEOs (3)	Skilled workers (4)
ICT ₀ × Boom cohort × 2006-10	-0.049*** (0.010)	-0.033 (0.032)	-0.051*** (0.011)	-0.052*** (0.011)
ICT ₀ × Boom cohort × 2011-15	-0.079*** (0.015)	-0.074* (0.044)	-0.076*** (0.015)	-0.081*** (0.016)
Worker controls×Cohort×Year FE	✓	✓	✓	✓
Worker FE	✓	✓	✓	✓

Robustness: remove workers starting in finance

	log(Wage)		log(Wage+Cap.income)	
	Excl. finance	US firms	Capital income assigned to CEOs	Skilled workers
	(1)	(2)	(3)	(4)
ICT ₀ × Boom cohort × 2006-10	-0.049*** (0.010)	-0.033 (0.032)	-0.051*** (0.011)	-0.052*** (0.011)
ICT ₀ × Boom cohort × 2011-15	-0.079*** (0.015)	-0.074* (0.044)	-0.076*** (0.015)	-0.081*** (0.016)
Worker controls×Cohort×Year FE	✓	✓	✓	✓
Worker FE	✓	✓	✓	✓

Capital flow versus labor flow

