Can slow IT adoption explain productivity slowdown? Firm size and organizational change

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USA: Acceleration and deceleration of productivity (Fernald, 2014)

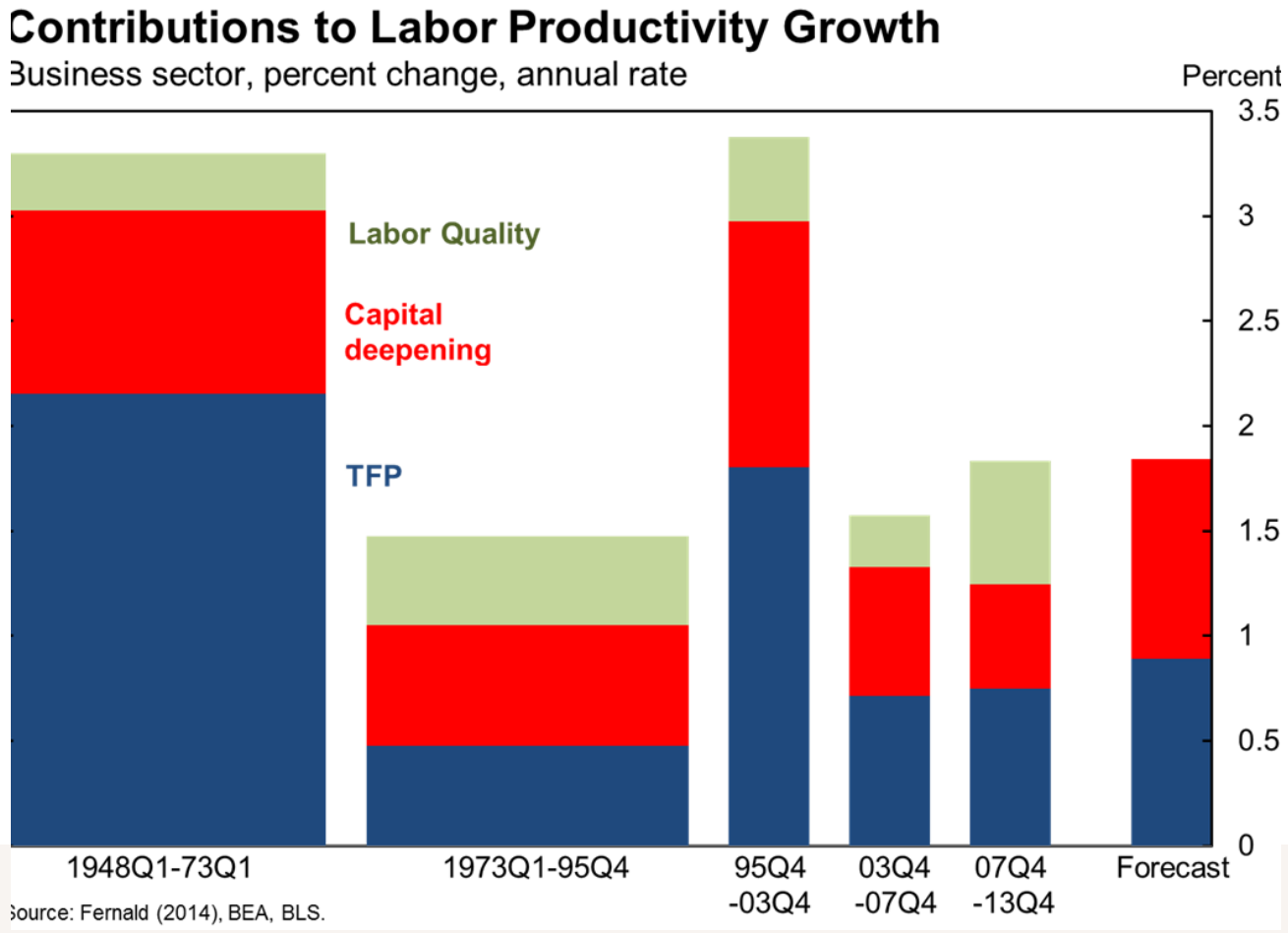
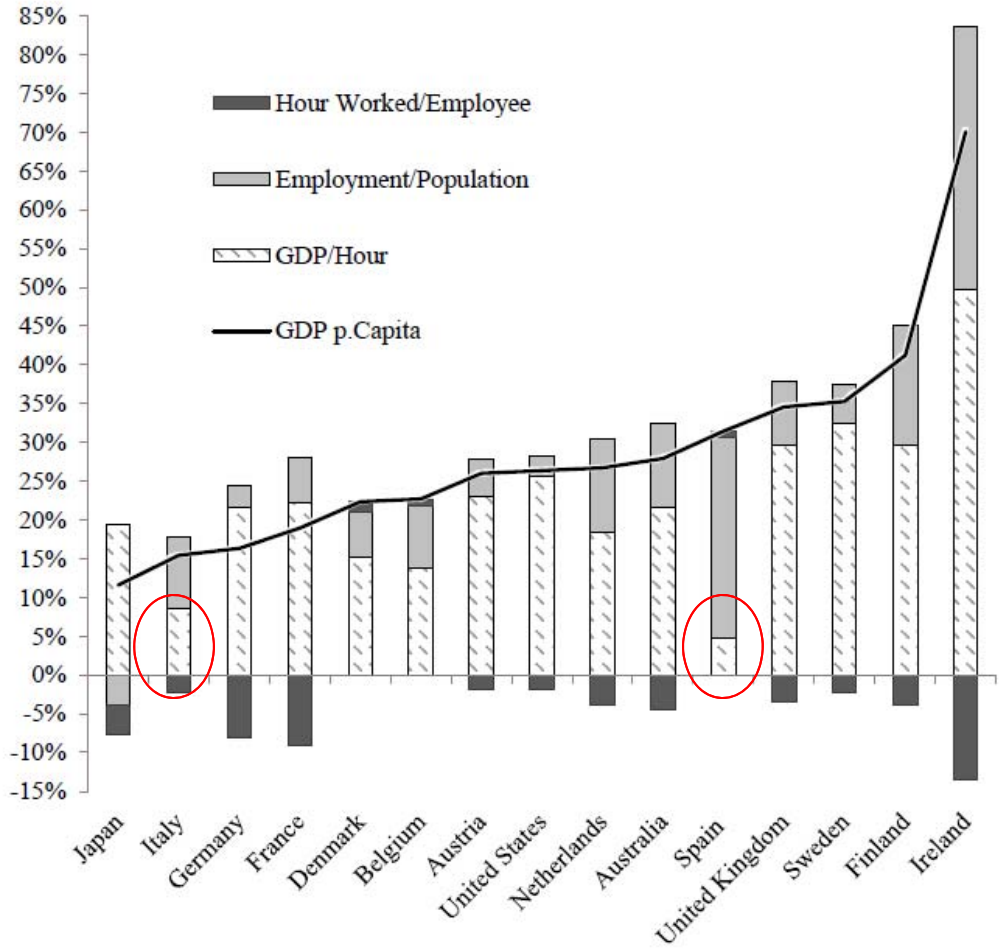


Figure 2. Growth in GDP / Capita (1994–2006)

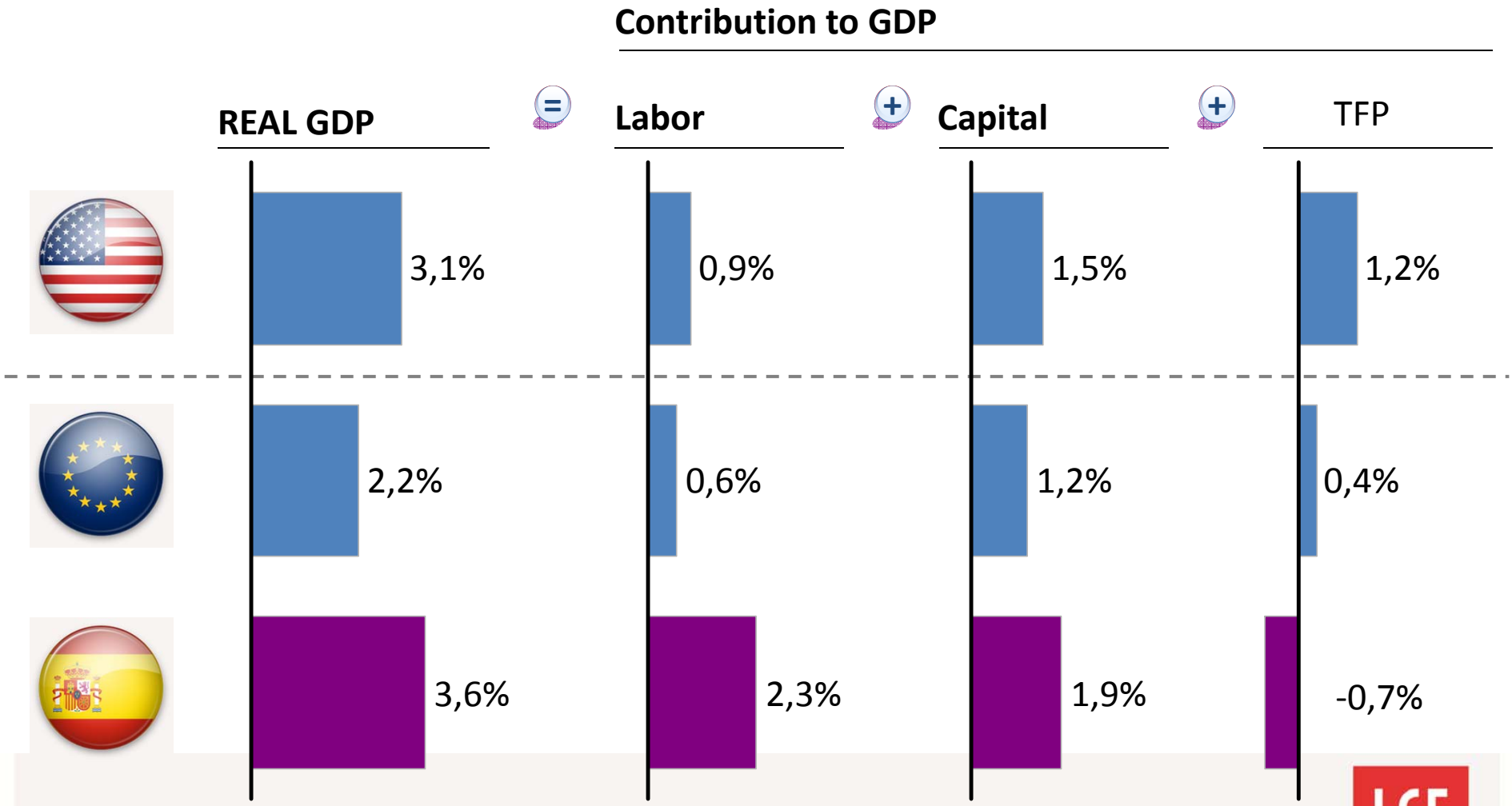
This chart shows the breakdown of log growth in GDP per capita at constant prices between 1994 and 2006 into 3 components. Data is sourced from the International Labor Comparisons program of the Bureau of Labor Statistics.



Source: Pellegrino and Zingales 2014 (my emphasis)

Spain: Growth Without Productivity

Average Annual Growth. 1995 – 2007



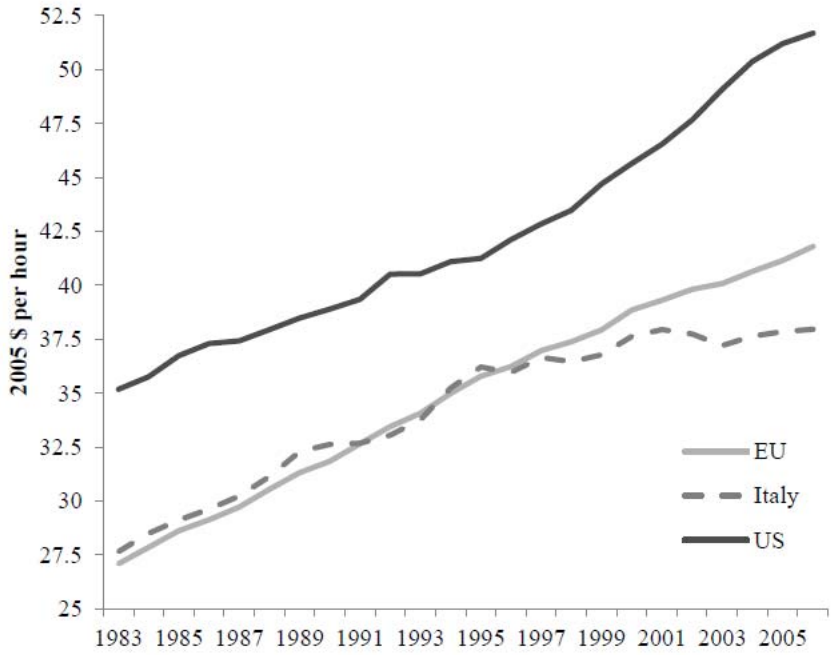
1 FOR EU 1995 – 2005 and only : AUT, BEL, DNK, ESP, FIN, FRA, GER, ITA, NLD & UK

Source: EU KLEMS, Fedea McKinsey 2009

Why? Italy´s case, Pellegrino & Zingales 2014

Figure 1. GDP per Hour Worked (2005 PPP$)

This chart shows the evolution of PPP-converted GDP per hour worked (in 2005 U.S. dollars) in the United States, Italy, and the EU15 (excluding Luxembourg, Greece and Portugal). Levels in 2005 International Dollars from Penn World Tables. Trend from EU KLEMS.



Usual Suspects:

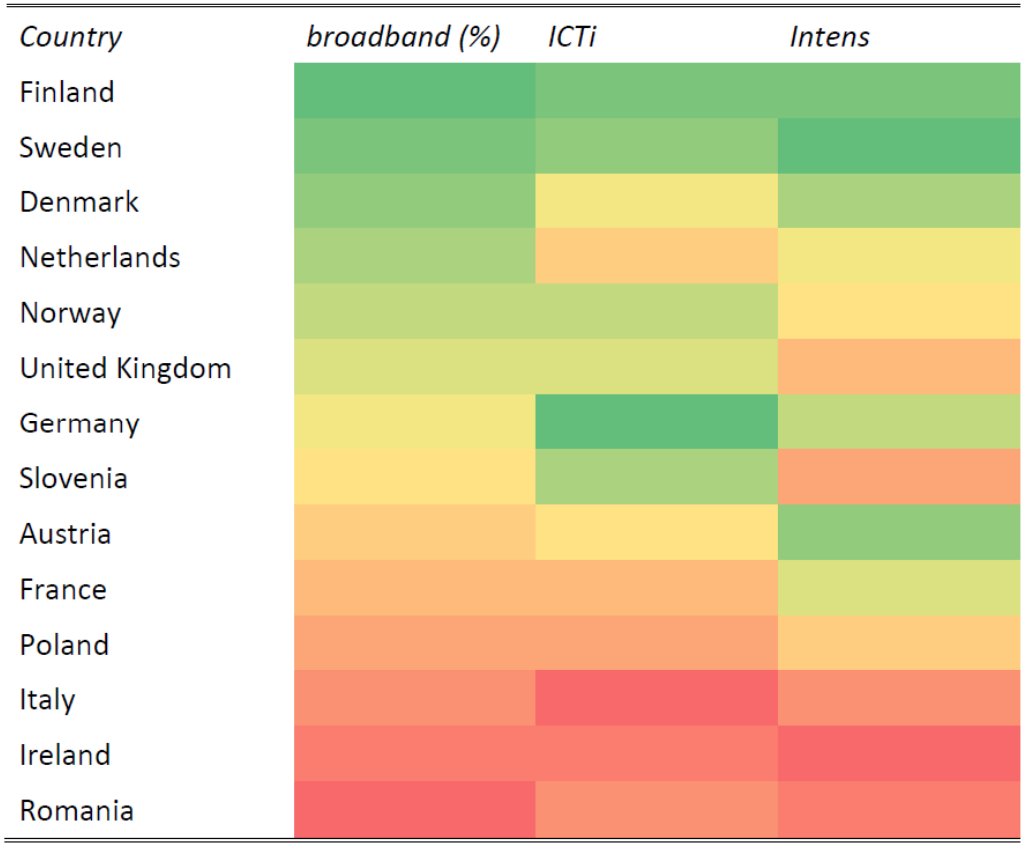
- Low tech sectors, NO!
  Mix predicts higher growth
- Govt efficiency, HK growth?
  Sectoral correlations wrong
  After all, true in 50s, 60s!

Things that changed:

Euro?/China?: though trade balance

- But no correlation between trade and productivity developments
- In fact more exposed sectors grow faster

Figure 5. Ranks of ICT intensity (ICTi and % of broadband enabled workers) by country (2009).



Country	*broadband (%)*	*ICTi*	*Intens*
Finland			
Sweden			
Denmark			
Netherlands			
Norway			
United Kingdom			
Germany			
Slovenia			
Austria			
France			
Poland			
Italy			
Ireland			
Romania			

Source: ESSLait Micro Moments Database

Bertelesman, Hagsten, Polder (2013)

Why? two arguments

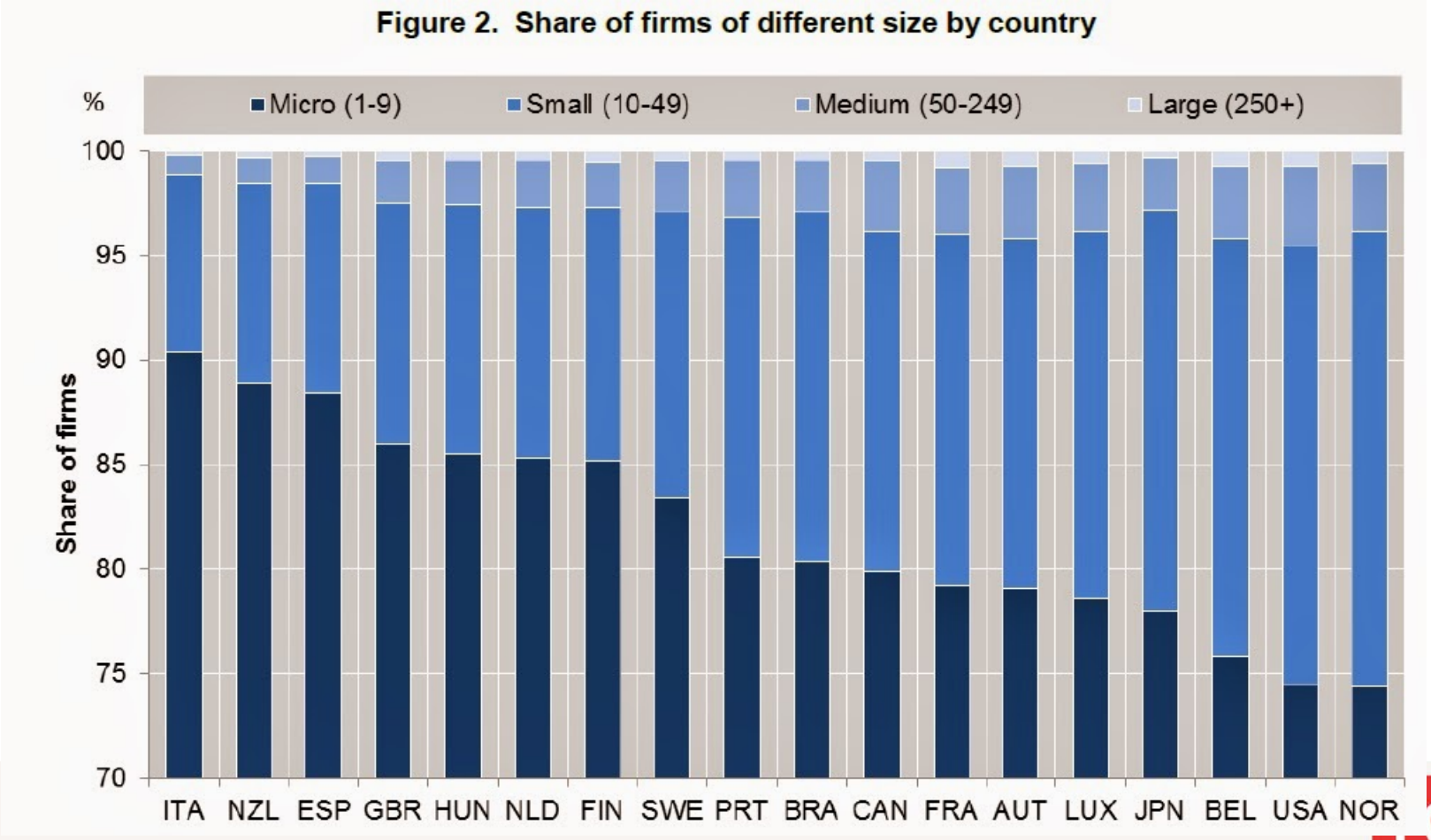
I. Size matters for ICT adoption
   And size dependent regulations distort European FSD (Garicano, Lelarge, Van Reenen, 2015)
II. The impact of IT on productivity is crucially mediated by management
   (1) Receiving the benefits of technology requires org change
      Will show a striking example: police and crime (Garicano Heaton 2010)
   (2) Will argue such org change is often subtle and unexpected, and depends on type
      Will show using data from Bloom and Van Reenen merged with ICT data (Bloom, Garicano, Sadun and Van Reenen, Forthcoming)

I. Size matters for ICT adoption

Tambe and Hitt (2012) show that returns for large firms are larger than for medium firms and that they improve over a larger period

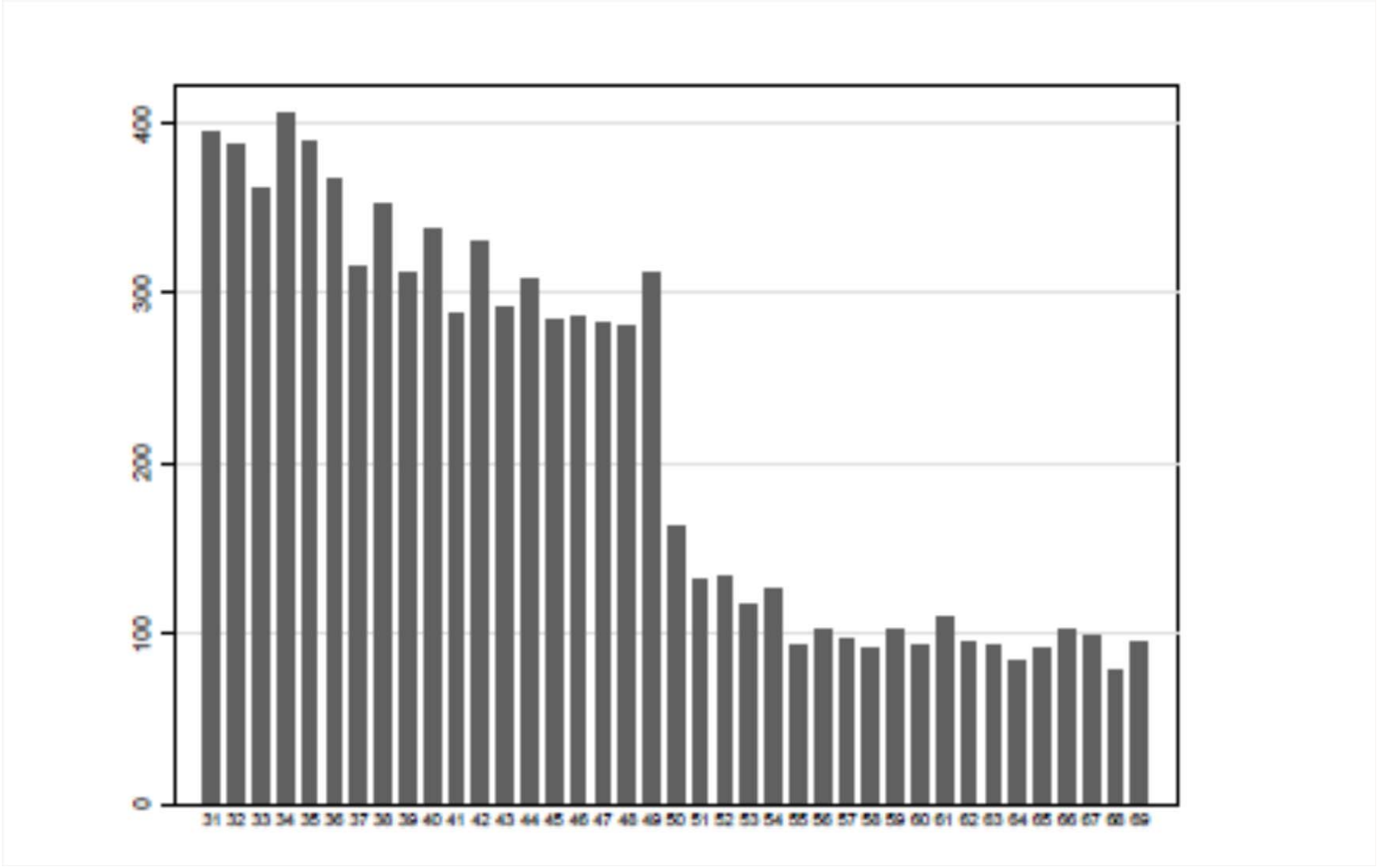
Giuri et al (2008): in Italian firms, complementarties between organization, ICT and skills only there for larger firms

And size is distorted for European firms



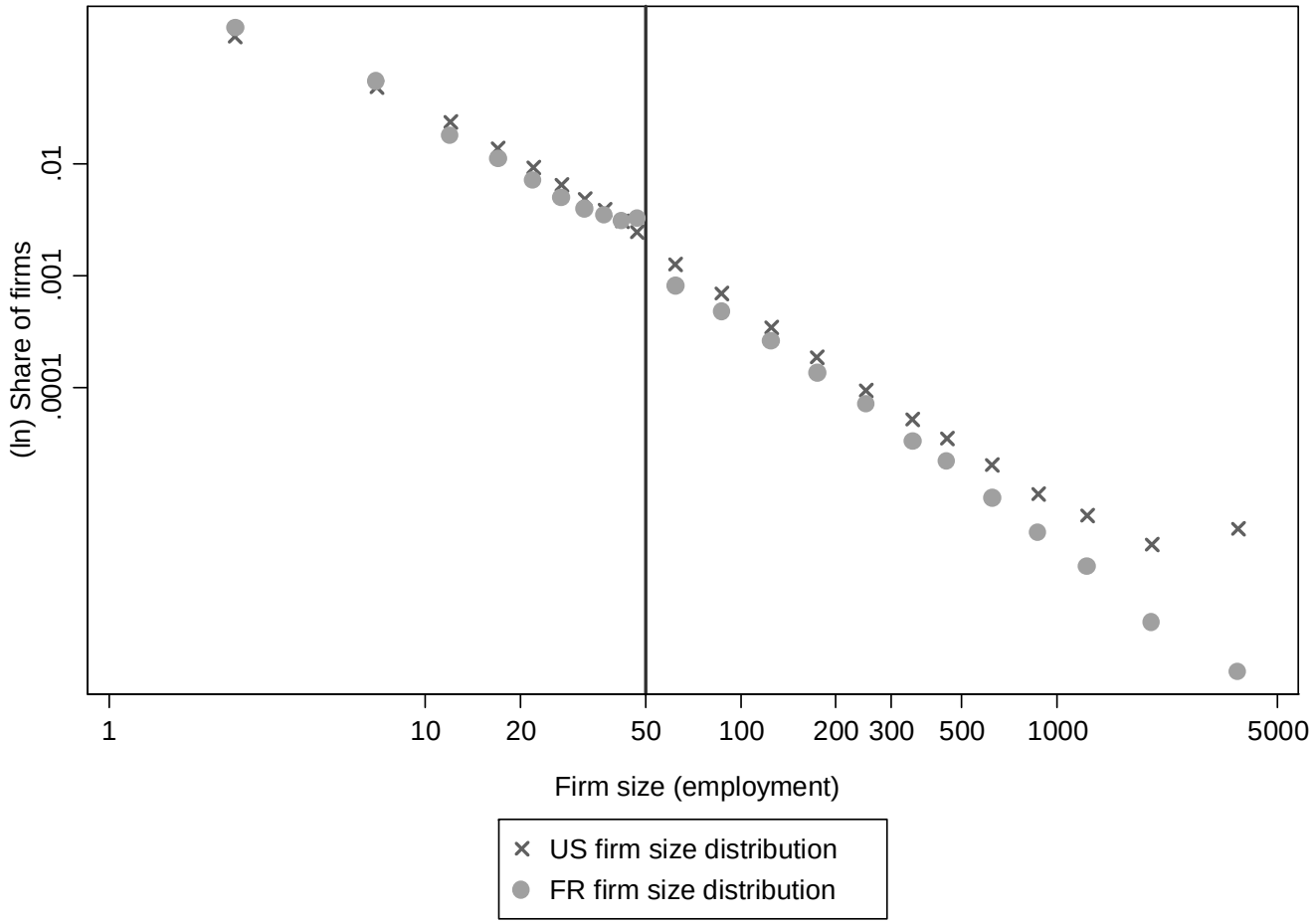
Criscuolo, Gal, Menon, 2014

Due to size related regulation: France



Source: Garicano, Lelarge, Van Reenen, 2015

Firm size distribution: USA and France (2003)



Source: Garicano, Lelarge, Van Reenen, 2015

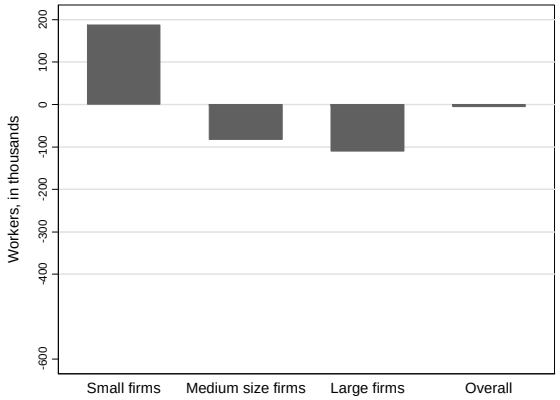
Why the break in the French case?
(Liaisons Sociales Quotidien 200/2010)

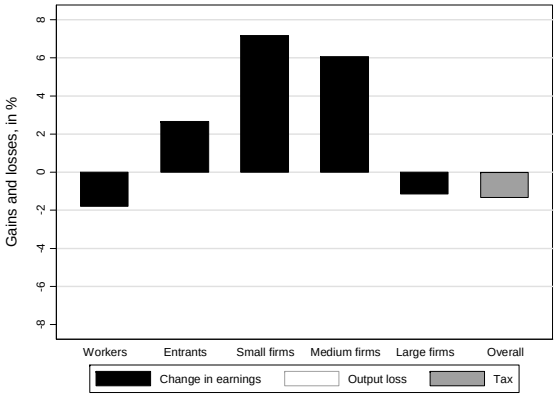
- Monthly reporting of the detail of all labor contracts to the administration
- Creation of a "firm council" ("comité d'entreprise") with minimum budget = 0.3% of total payroll.
- Obligation to establish a committee on health, safety and working conditions (CHSCT)
- A **union** representative (i.e not simply a local representative of the firm's workers) must be appointed if wanted by workers
- Obligation to establish a profit sharing
- Higher duties in case of an accident occurring in the workplace
- Obligation to do a formal "Professional assessment" for each worker older than 45.
    - *On top of that: accounting rules.*
    - *Firing Costs also increase after 50 (in case of collective dismissal of 10+ workers). An implicit tax on firm size (e.g. Bentolila & Bertola, 1990): makes firms reluctant to hire.*

Employment reallocations

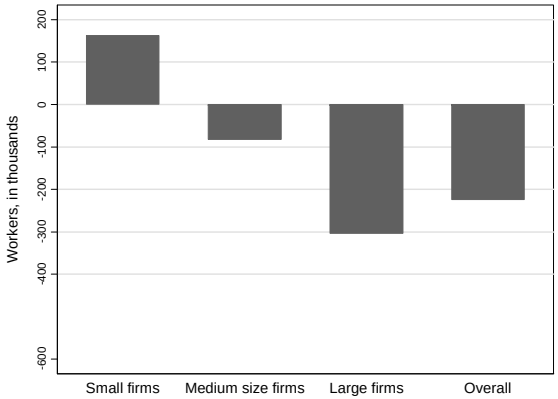
Changes in income (towards welfare…)

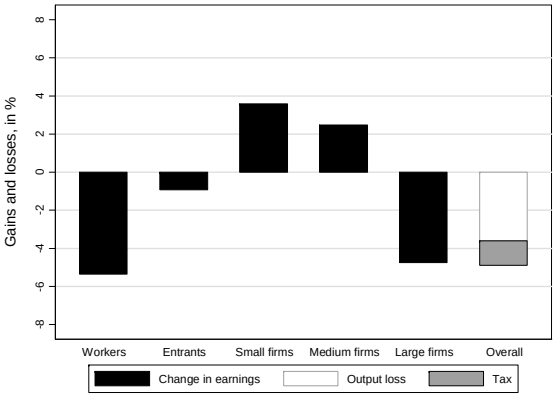
Fully flexible prices (100% adj.)



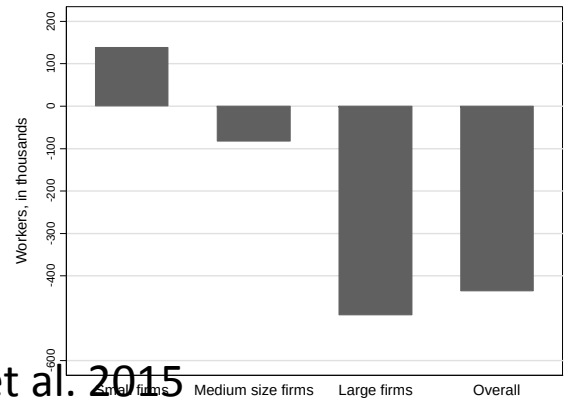


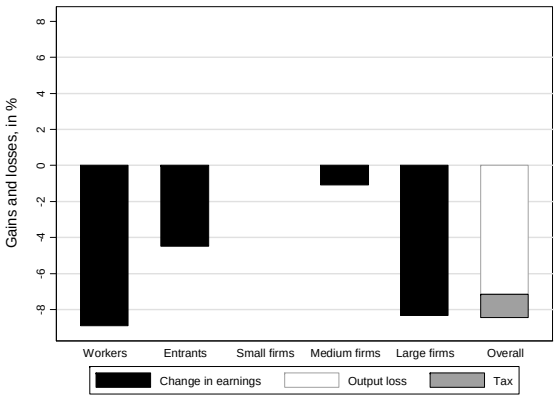
Partially flexible prices (50% adj.)





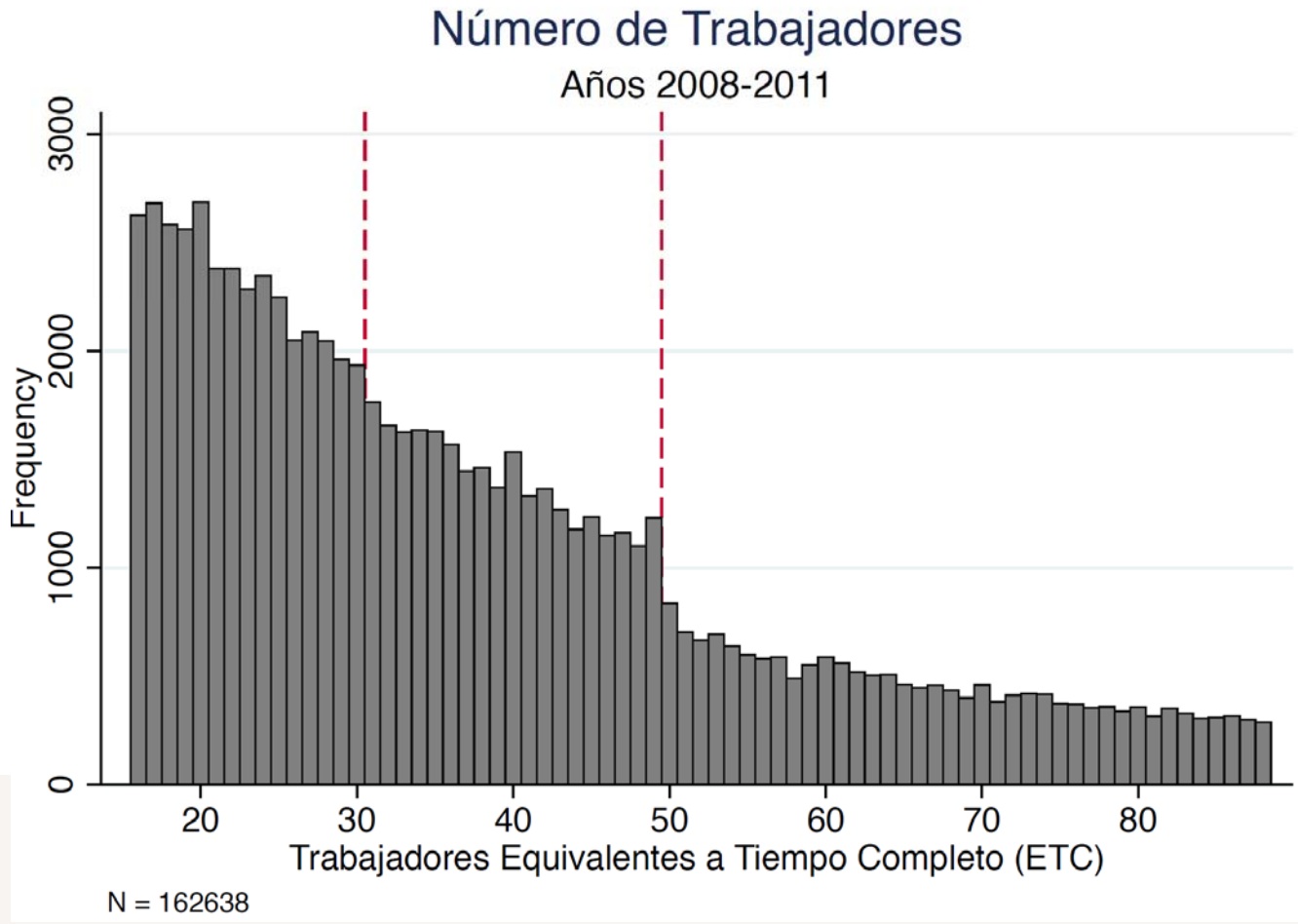
Fully rigid prices (0% adj.)



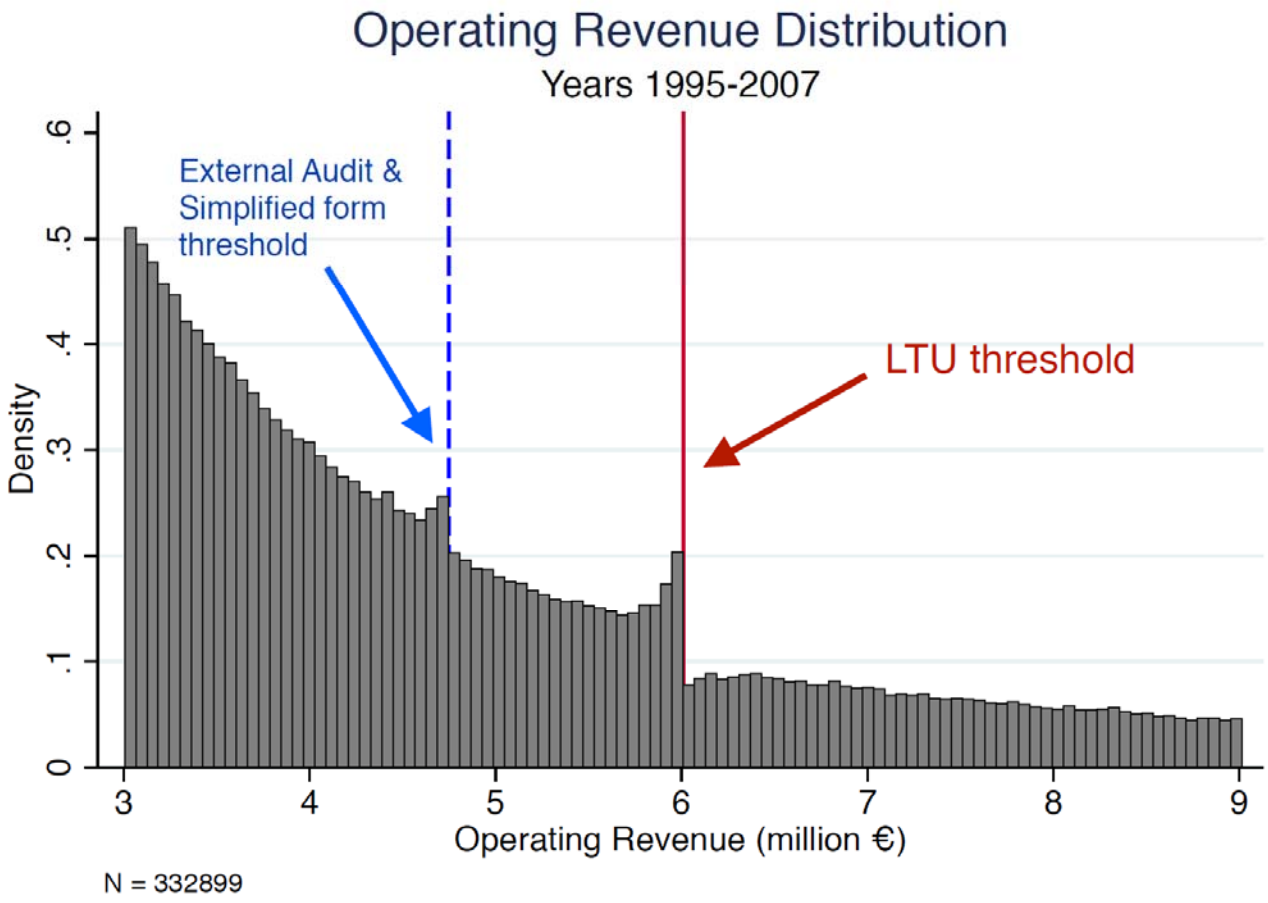


Source: Garicano, et al. 2015

Size related regulation: Spain 50 employees (Almunia, Jimeno, Lopez Rodriguez, in progress)



Tax inspection distortion (Almunia, Lopez Rodriguez)



IT and size: Firms with 1-9 workers (Eurostat, 2014)

Have a PC?

69% Spanish firms, 86% Portuguese, 90% German;

Share sold online?

1% Spain; 6% Portugal; 15% in Germany;

IT training for employees?

3% Spain, 10% en Portugal

Two arguments

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II. Management practices matter for Italy

Why do Americans do IT better (Bloom et al. (2012))?
MANAGEMENT!

- management practices are complementary to IT capital and
- US firms employ such practices

Pellegrino and Zingales (2014)

- Management practices are key
- Using firm level data: a system of managerial selection based on cronysm reduces firm's ability to adapt ICT

Bugamelli and Pagano (2004)

- In Italy,"the marginal product excess over the user cost is due to those firms that did not complement their ICT investment with an increase in the human capital of their labor force and with a reorganization of the workplace."

(1). Productivity benefits of IT depend on ORG: older precedents

Bresnahan, Brynjolfsson, and Hittt (2002):

- Productivity of IT is higher if firms decentralized
- Also higher high-skill labor

Black and Lynch (2001):

- US plant productivity higher when non managers use computers
  - And are more educated

Bartel, Ichniowski, and Shaw (2007)

- Valves: IT changes product mix (towards customized, short runs)
- Required change in skills, org, hr

Garicano and Heaton (JLabEcon, 2010)

Impact of IT in a public sector environment: police

Did the ICT revolution in policing have anything to do with huge drops in crime? (big increase in productivity in the public sector)

What was the role of managerial changes in facilitating/encouraging the change?

Data: Law Enforcement Management and Administrative Statistics (LEMAS)

Triennial survey of law enforcement agencies in the United States, years 1987-2003.

Period of large IT expansion: In 1987, fewer than 20% any computer, not designed as a longitudinal survey, but broad coverage

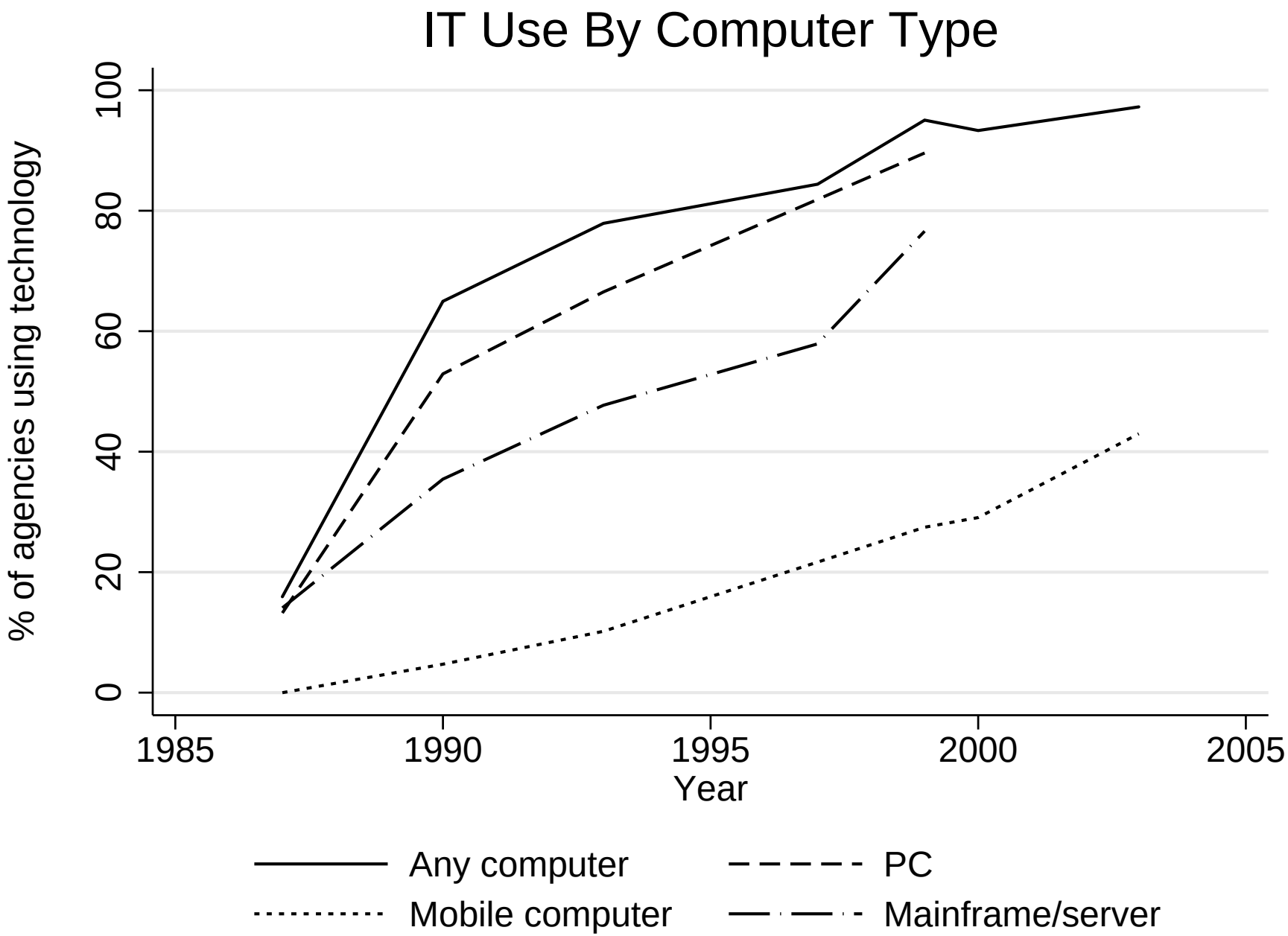
Questions:

variety of police operations, equipment usage, agency structure and functions, administrative policies compensation

Variety of IT use

Merged with arrest and offense data from the FBI's Uniform Crime Reports (UCR)

And census place level demographic data (where possible)


IT Use By Computer Type
% of agencies using technology
0
20
40
60
80
100
1985
1990
1995
2000
2005
Year
Any computer
PC
Mobile computer
Mainframe/server

IT and Policing: Basic Specifications

- OLS regressions
- separately report specifications including year, agency, and agency and year fixed effects.
- In all regressions we attempt to control for other relevant factors that may affect our outcomes of interest

- interpret our coefficients as measures of the effect of IT on the outcomes of interest.
  - interpretation appropriate if differential acquisition of information technology is driven by factors exogenous to the agency (e.g. variations in the cost of technology over time and place)

Effectiveness

- Clearance rates: arrests/offenses
- Deterrence: offense/ population

Does IT appear to improve productivity? NO!

Table 2: Relationship Between IT Use and Productivity

Productivity Outcome	(I)	(II)	(III)	(IV)
Crime Clearance Rate				
All crime	.00147	-.00037	-.00141	.0235
	(.00588)	(.00603)	(.00595)	(.0130)
Violent crime	.0131	.0109	.0126	-.00555
	(.0104)	(.0105)	(.0103)	(.0225)
Property crime	.00339	.00289	.00210	.00841
	(.00508)	(.00519)	(.00514)	(.0111)
Offense Rate				
All crime	.00374**	.00326**	.00264**	.00886**
	(.00077)	(.00075)	(.00073)	(.00208)
Violent crime	.00019	.00015	.00005	.00157*
	(.00014)	(.00014)	(.00014)	(.00072)
Property crime	.00355**	.00312**	.00260**	.00729**
	(.00070)	(.00069)	(.00065)	(.00183)
Include year and agency fixed effects?	Yes	Yes	Yes	Yes
Include additional controls?	No	Yes	Yes	Yes
Include state trends?	No	No	Yes	No
Instrument to account for measurement error?	No	No	No	Yes

Note: This table reports regressions of measures of police productivity on a computerization index. Each table entry represents a coefficient estimate from a separate regression where "Productivity Outcome" is the left-hand side variable and controls are included as specified in the bottom rows of the table. All specifications include a full set of year and police agency fixed effects. Column II-IV regressions include the percent Black, percent Hispanic, and per capita income of the area covered by the agency as additional controls. The arrest regressions also include agency size deciles interacted with log number of agency employees as additional controls. The offense regressions include indicators for deciles of resident population interacted with log population, and log agency employees as additional controls. Column III includes state-

Effectiveness of IT?

A puzzle:

- IT adoption grew
- But no detectable change in clearance
- and INCREASE in crime rates with IT!

Solutions to puzzle?

(1) IT increases recorded crime

or

(2) IT by itself just doesn't cut it

complementarities with organizational innovation

(1) IT increases recorded crime?

YES!

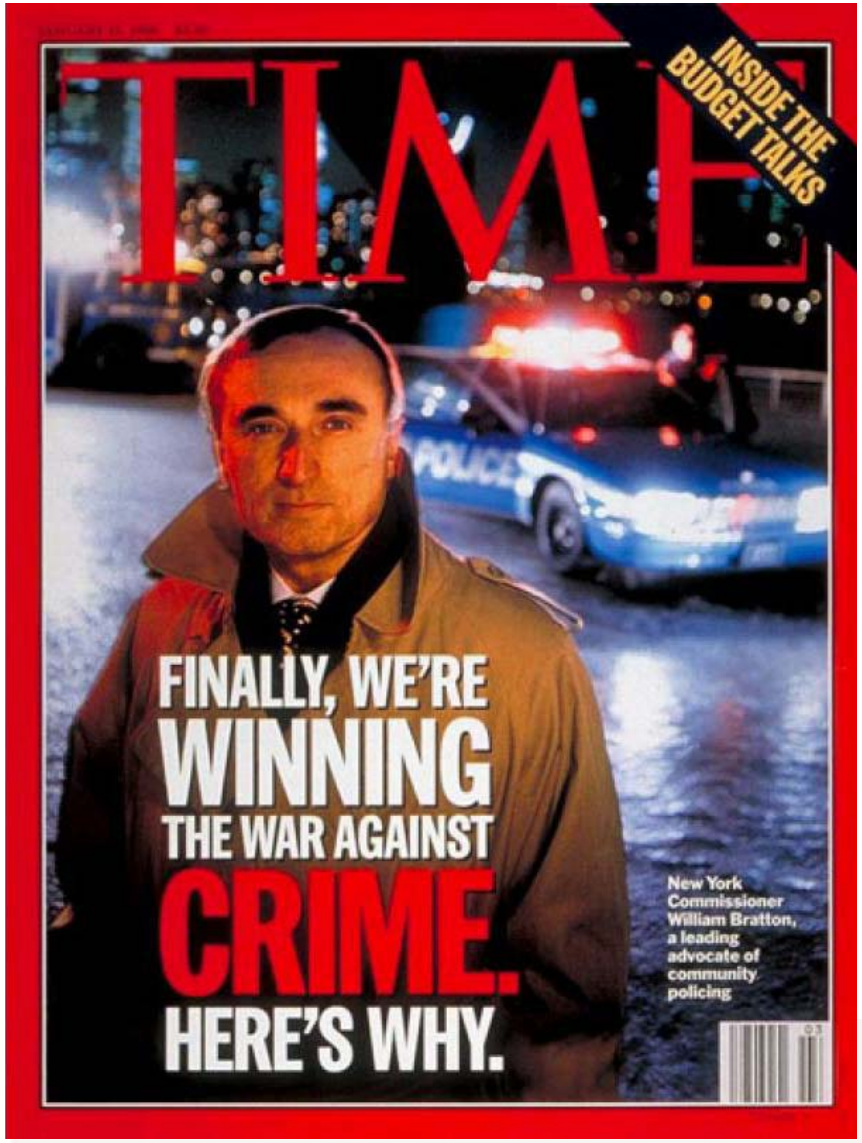
Use variable “computer used for record keeping?”

Analysis shows indeed this “increases” petty crime

think of a bike stolen

But puzzle remains for severe crimes

(2) Complementarities: Compstat



Introduced by the New York Police Department in 1994 by Commissioner William Bratton.

- the real time mapping of crime by time and place
- (notorious) early morning meetings

Weisburd:

(1) statement of the measurable goals of the department;
(2) internal accountability, particulary through Compstat meetings
(3) geographic organization of command-- district commanders have authority and resources to accomplish their goals over their areas;
(4) empowerment of middle managers;
(5) data driven problem identification and assessment;
(6) innovative problem solving tactics.

Geocoding plus meeting plus stats

Police Department
City of New York

Michael R. Bloomberg
Mayor

Raymond W. Kelly
Police Commissioner

Volume 20 Number 47

CompStat

Citywide

Report Covering the Week 11/18/2013 Through 11/24/2013

Crime Complaints

	Week to Date			28 Day			Year to Date*			2 Year	12Year	20Year
	2013	2012	% Chg	2013	2012	% Chg	2013	2012	% Chg	% Chg	% Chg (2001)	% Chg (1993)
Murder	8	6	33.3	27	17	58.8	303	379	-20.1	-35.8	-48.5	-82.7
Rape	17	24	-29.2	95	94	1.1	1,291	1,300	-0.7	0.9	-26.6	-58.3
Robbery	170	158	5.6	1,613	1,583	2.3	17,124	18,007	-4.9	-2.3	-31.4	-37.8
Fel. Assault	345	367	-6.0	1,471	1,338	9.9	18,158	17,726	2.4	7.7	-14.2	-51.9
Burglary	347	402	-13.7	1,323	1,585	-16.5	15,477	17,133	-9.7	-7.0	-46.8	-82.9
Gr. Larceny	918	811	13.2	3,565	2,986	19.4	40,402	37,891	6.6	17.0	-2.1	-47.8

LSE

Compstat: our data

(1) use of information technology for crime data collection and analysis (5 above)

(2) a problem-solving paradigm (6 above)

(3) use of feedback for priority-setting and evaluation (relating to 1, 2, and 5 above) and

(4) a geographic-based deployment structure (3 above).

(5) high skilled department

When Org adapts, productivity improves

Table 9: Complementarities Between IT and Management Practices in Solving and Deterring Crime

	Clearance Rate			Offending Rate		
	All Crime	Violent	Property	All Crime	Violent	Property
Explanatory Indicator	I	II	III	IV	V	VI
Compstat	.0197*	.0277*	.0141	-.00486*	-.00036	-.00451*
	(.00819)	(.0130)	(.00789)	(.00210)	(.00029)	(.00190)
Computer use	.00214	.0128	.00412	.00388	.00024	.00364*
	(.00950)	(.0159)	(.00940)	(.00206)	(.00031)	(.00185)
High-skilled workers	.00758	.00414	.0116	.00673**	.00053*	.00620**
	(.00638)	(.0112)	(.00628)	(.00168)	(.00021)	(.00153)
Problem-solving emphasis	-.00393	-.0187	-.00174	.00830**	.00068**	.00762**
	(.00578)	(.0100)	(.00568)	(.00166)	(.00021)	(.00151)
Geographic awareness	.00752	.00969	.00656	.00142	.00010	.00132
	(.00637)	(.0104)	(.00635)	(.00146)	(.00020)	(.00132)
Evaluation	.00086	.00179	.00263	.00370*	.00020	.00350*
	(.00571)	(.0100)	(.00562)	(.00152)	(.00020)	(.00137)
Overall effect	.0339**	.0374	.0372**	.0192**	.00140**	.0178**
	(.0127)	(.0224)	(.0125)	(.00314)	(.00043)	(.00285)
N	1768	1765	1768	1768	1768	1768
R^2	0.224	0.291	0.214	0.330	0.509	0.295

Note: This table reports agency-level regressions of the 1997-2003 average clearance rate (arrest/offenses, columns I-III) and offending rate (offenses/population, columns IV-VI) on indicators for a Compstat system as well as individual modern police management practices. Each column entry reports coefficient estimates from a separate regression. Agencies with a Compstat system simultaneously implemented elements of all five of the listed management practices in more than half of the sample years between 1997-2003. All regressions control for the average percent Black, percent Hispanic, per capita income, and poverty rate of the area

Does management matter to technology adoption?

Yes: IT works when together with management

- substantial decreases in crime and
- more crimes cleared

Goes in similar direction of findings in e.g. education (it is not about the laptop), and other fields

II. So, precisely, what organizational changes?

Should we expect IT to be always complementary to decentralization?

ICT has two different effects:

a) Reduces information costs (the IT part)

b) Reduces communication costs (the CT part)

Do information and communication technology have different impact on tasks and organization?

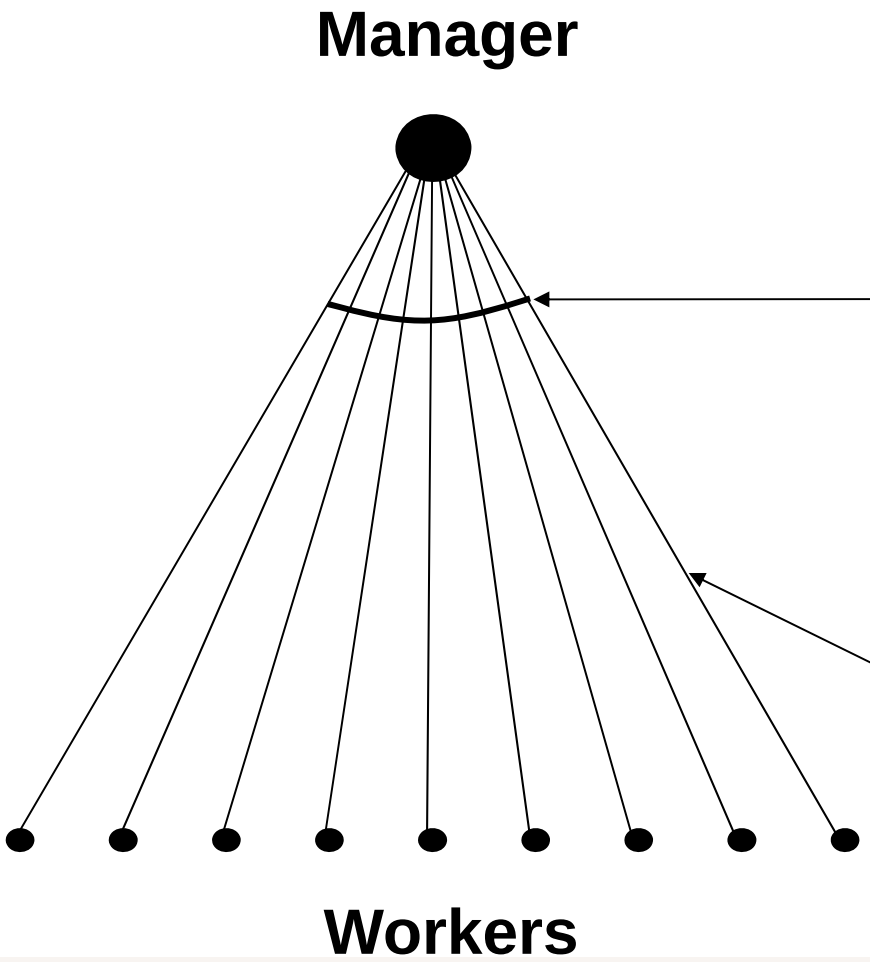
Bloom, Garicano, Sadun, Van Reenen (Management Science, forthcoming)

Theory: A theory (from Garicano, JPE 2000) to distinguish the impact of information technology and communication technology on firm organization

- Information technology increases decentralization & spans
- Communication technology reduces decentralization

Empirics: Combine two new international firm-level datasets on organizations and ICT hardware and software to test the theory

- Results for IT and CT match the theory
- Magnitude: change in autonomy associated with IT growth over time similar to that for growth in US education levels over time

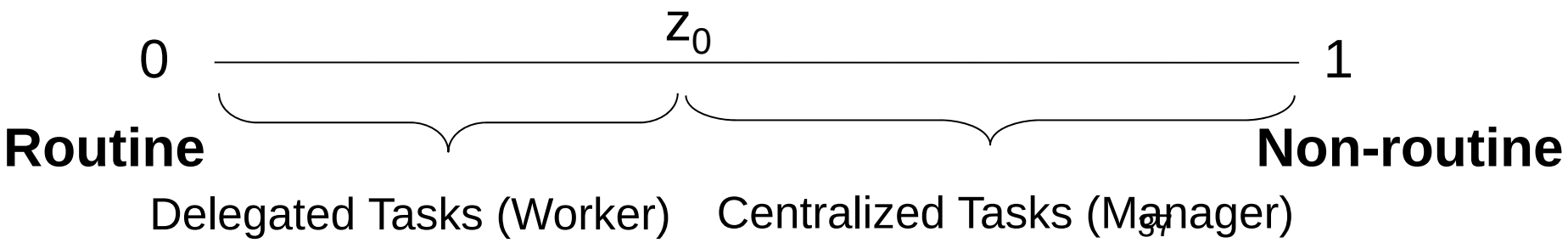


Span of control: number of workers reporting to manager

Worker autonomy: **low** if managers take most decisions; **high** if workers take most decisions

HOW DO FIRMS DETERMINE THEIR HIERARCIES?

- Firms face tasks in the interval [0,1] distributed according to density function f(*z*)



- In order to solve problems, the firm needs to train each worker at a training cost *a* (information "acquisition")

- Asking the manager entails a communication cost h ("helping" cost), subject to the managers total time constraint

- So the optimal organization will balance of training and helping costs, with z_0 decreasing in "a" and increasing in "h"

WHAT ABOUT THE IMPACT OF ICT ON HIERACHIES?

The model has clear predictions for information technologies (**IT**) and communication technologies (**CT**) on firm organization

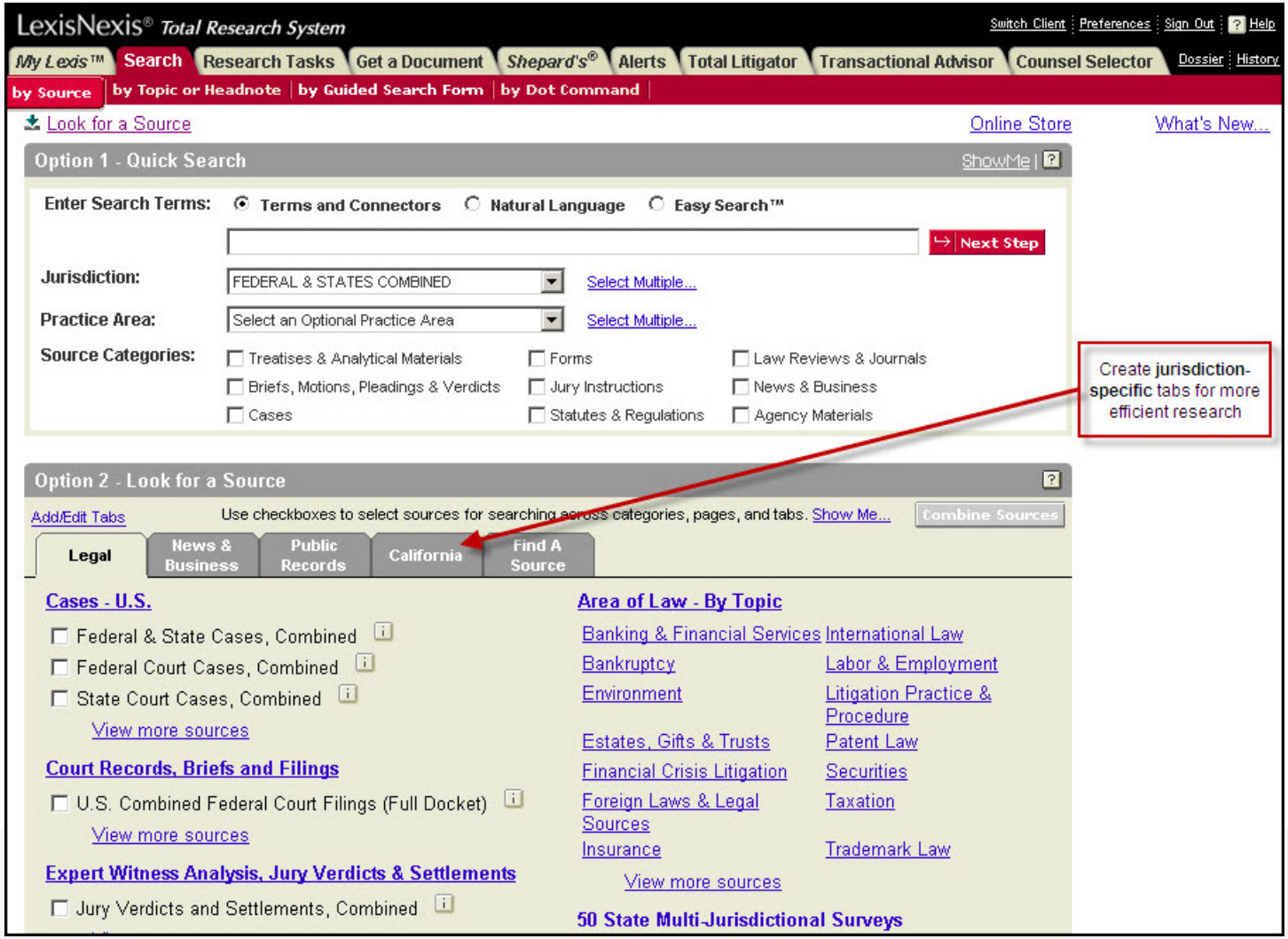
IT will reduce information acquisition costs (*a*), leading to an:

- Increase in z_0 (decentralization) as workers can tackle more tasks
- Increase in *s* (the span of control) as workers ask less questions so that managers can direct more people

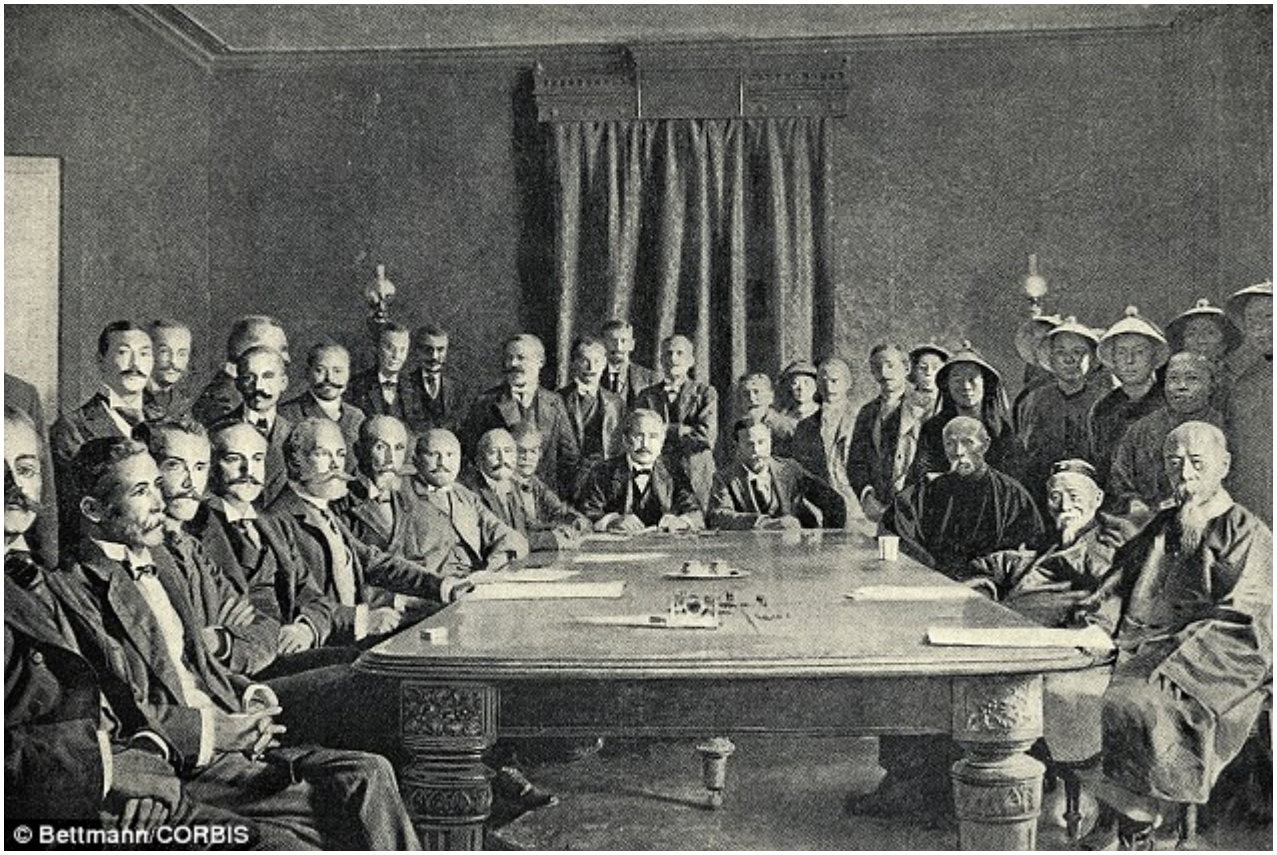
CT will reduce communication costs (*h*), leading to:

- A reduction in z_0 (centralization) as cheaper to ask for help
- An ambiguous impact on the span of control, as more questions are asked but each takes less time to ask

Information Technology: empowers



Communication technology: centralize



ICT DATA IS FROM HARTE HANKS INTERNATIONAL

- Harte Hanks runs an annual ICT survey across Europe and the US, on all establishments in firms with >=100 employees

- Collecting data using same methodology since 1996 (use 2001-2006) and sold commercially so “market tested”

- As a result increasingly widely used in IT studies (Bresnahan, Brynjolfsson and Hitt, 2002; Beaudry, Doms and Lewis, 2006; Forman, Goldfarb & Greenstein, 2007 etc)

MEASURING COMMUNICATION TECHNOLOGY (FOR WORKERS AND MANAGERS)

- NETWORK defined as the presence of leased lines which are the standard way for businesses to connect offices and production sites to transmit data and voice.

- Alternative measure is LAN/WAN presence

MEASURING INFORMATION TECHNOLOGY (FOR WORKERS)

- CADCAM software assists engineers and machinists in manufacturing or prototyping product components. Important in all phases of production (roughing, finishing, contour milling) and allows workers and plants to design and produce products without centralized engineering input.

MEASURING INFORMATION TECHNOLOGY (FOR MANAGERS)

- Enterprise Resource Planning (ERP) provides real-time production, stock, quality, sales, HR etc.

- ERP potentially also helps communication, so we ran another survey to evaluate this and found ERP primarily increased information, although some additional communication role

TABLE 3: PLANT MANAGER AUTONOMY

ERP (Enterprise Resource Planning)	**0.104***		**0.116****
Information technology	**(0.054)**		**(0.054)**
NETWORK		**-0.098***	**-0.110****
Communication technology		**(0.053)**	**(0.053)**
% Employees College Educated	**0.100****	**0.098****	**0.099****
	(0.032)	**(0.032)**	**(0.032)**
ln(PC/Employee)	**-0.041**	**-0.021**	**-0.031**
	(0.031)	**(0.031)**	**(0.031)**
ln(Firm Employment)	**0.063**	**0.067***	**0.065**
	(0.040)	**(0.040)**	**(0.040)**
Plant Employment	**0.147****	**0.150****	**0.147****
	(0.045)	**(0.045)**	**(0.045)**
Foreign Multinational	**0.181****	**0.200****	**0.193****
	(0.080)	**(0.080)**	**(0.080)**

Notes: OLS, industry & country dummies, 948 firms, noise controls, CEO on-site dummy. Dependent variable plant manager autonomy z-score

TABLE 4: WORKER AUTONOMY

CADCAM	**0.540****		**0.535****
Information technology	**(0.275)**		**(0.274)**
NETWORK		**-0.229**	**-0.226**
Communication technology		**(0.178)**	**(0.180)**
Percentage College	**0.523****	**0.529****	**0.529****
	(0.116)	**(0.116)**	**(0.116)**
ln(PC/Employee)	**-0.004**	**0.025**	**0.010**
	(0.108)	**(0.108)**	**(0.109)**

Notes: Probit, dependent variable worker more control over production decisions that managers. Same controls as plant manager autonomy (industry & country dummies, 687 firms, noise Controls, CEO onsite dummy, firm & plant size, domestic MNE).

TABLE 5: PLANT MANAGER SPAN OF CONTROL

CADCAM	**0.153****		**0.155****
Information technology	**(0.076)**		**(0.076)**
NETWORK		**0.051**	**0.053**
Communication technology		**(0.043)**	**(0.043)**
Percentage College	**0.056****	**0.058****	**0.056****
	(0.023)	**(0.023)**	**(0.023)**
ln(PC/Employee)	**0.013**	**0.012**	**0.011**
	(0.024)	**(0.024)**	**(0.024)**

Notes: OLS, dependent variable is ln(SPAN). Same controls as for autonomy (industry & country dummies, 859 firms, noise controls, CEO onsite, plant size, MNE).

OTHERS ROBUSTNESS (TABLES 8, 9 & 11)

Confirm the full set of 9 parameter sign predictions hold

Check results on CEO span

Confirm robustness to:

- Regional Dummies (local culture/institutions)
- Product market competition
- Other firm controls: capital intensity, productivity, age, wages, global size, public listing, management etc.
- Different ICT measures (e.g. LAN/WAN)
- Different organizations measures (PCF)
- Dropping firm size, multinationals and skills controls

Conclusion

- ICT slow adoption may be partly due to distorted FSD, too many small firms
- And to inadequate management practices
  - Information technology adoption impact on productivity when organizations change to adapt to it

    Absent such change may not even find any impact
  - Organizational Change is non trivial

    Information technology decentralizes-empowers

    Communication technology centralizes
  - "Bad" management practices may go a long way towards explaining European productivity slowdown