ICT, Innovation, and Productivity in Chilean Firms

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Outline

- Question
- Methodology
- Data
- Main results

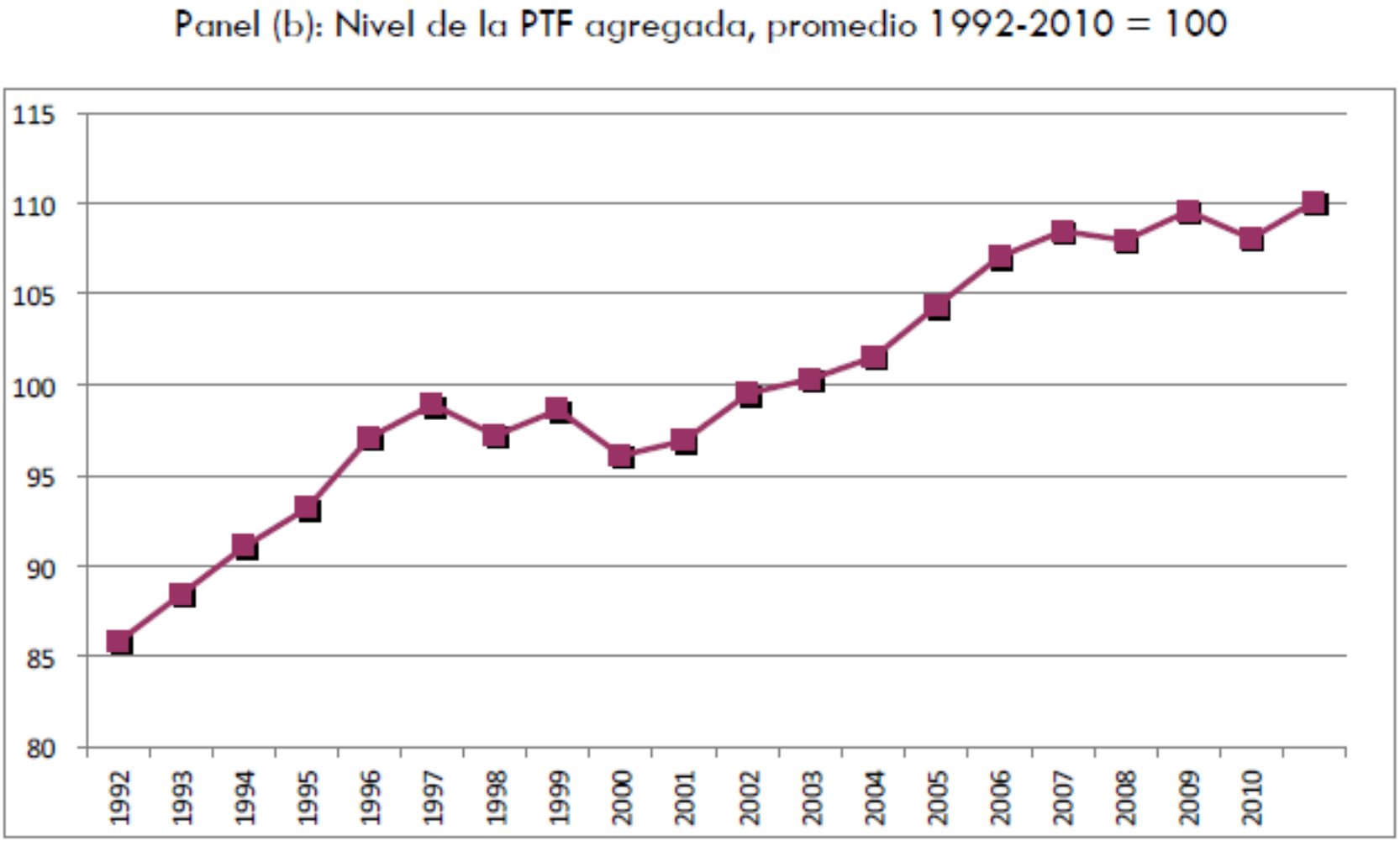
Question

- How ICT investment affects productivity?
  - Why?
  - Mechanisms?
- Services industry

Question

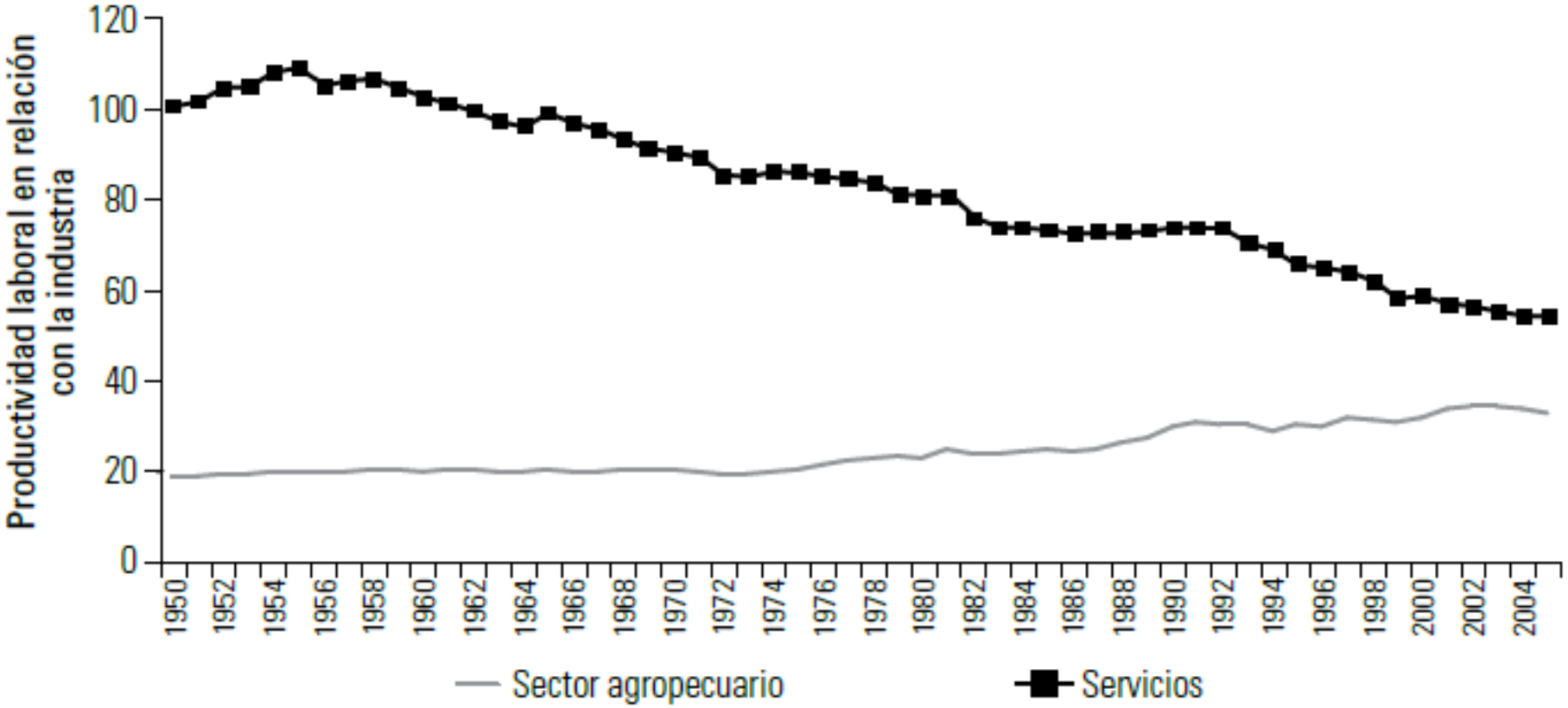
- Is this important?
- Productivity (PTF) – technological change – is key for economic growth
- Very important for Chile
  - Slow productivity growth in the last decades
- Very important for services industries in LATAM (IADB, 2010)
  - Large productivity gap and growing employment share of services

Question


Panel (b): Nivel de la PTF agregada, promedio 1992-2010 = 100
115
110
105
100
95
90
85
80
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

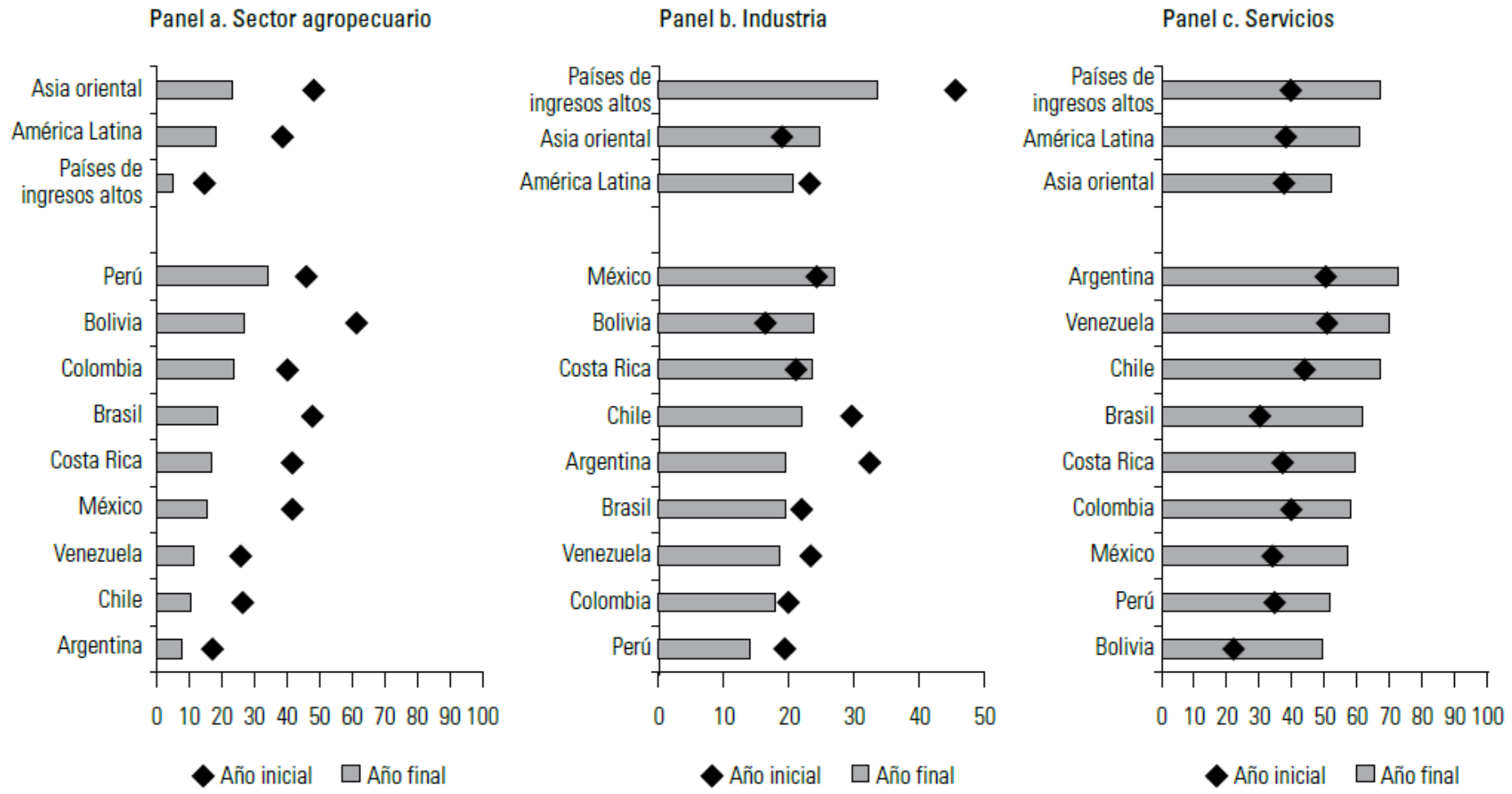
Question

Gráfico 3.7 Evolución de la productividad laboral en relación con el sector de la industria, América Latina, 1950–2005 (productividad industrial, 1950 = 100)



Question

Gráfico 3.9 Proporción del empleo por sector económico, 1970–2005



Previous Literature

- Solow paradox (1987)
- Firm-level studies: positive impact of ICT on productivity (Black and Lynch, 2001; Bresnahan, et al. 2002; Greenan, et al., 2001; Bugamelli and Pagano, 2004; Castiglione, 2009)
- Hall et al. (2014): ICT, innovation and productivity

Previous Literature

- Complementary effects
- Black and Lynch (2001) and Bresnahan, et al. (2002): interaction between ICT, human capital, and organisational innovation.
- Hall, et al. (2014). Complementarities between R&D and ICT

Previous Literature

- Solow´s paradox revival

- Acemoglu et al. (2014): no strong relationship between ICT investment and productivity growth in the US industries

Previous Literature

- Evidence is scarce for Latin American countries
- Commander et al. (2011): Brazil and India
- Aboal and Tacsir (2015): Uruguay
- Gallego and Gutiérrez (2015): Colombia

Methodology

- CDM model: Crépon, et al. (1998).

- 3 set of equations

1. Determinants of R&D and ICT

2. Determinants of Innovation: R&D and ICT investments

   - Technological (product or process) and non-technological (organizational & marketing)

3. Determinants of Productivity: Innovation

Methodology

Methodology

Methodology

Other specifications

ICT	⇨	Productivity	Commander, Harrison and Filho (2011)
ICT*Non-Tech Innovation	⇨	Productivity	Hempell (2005); Hempell, van Leeuwen and van der Wiel (2006)

Data

- Two waves of Longitudinal Enterprise Survey (2007 – 2009)
- Representative by size, industry (1-digit), and region
- Panel: more than 2,600 firms in both surveys
- Detailed information on firms characteristics
  - R&D investment
  - ICT investment
  - Innovation

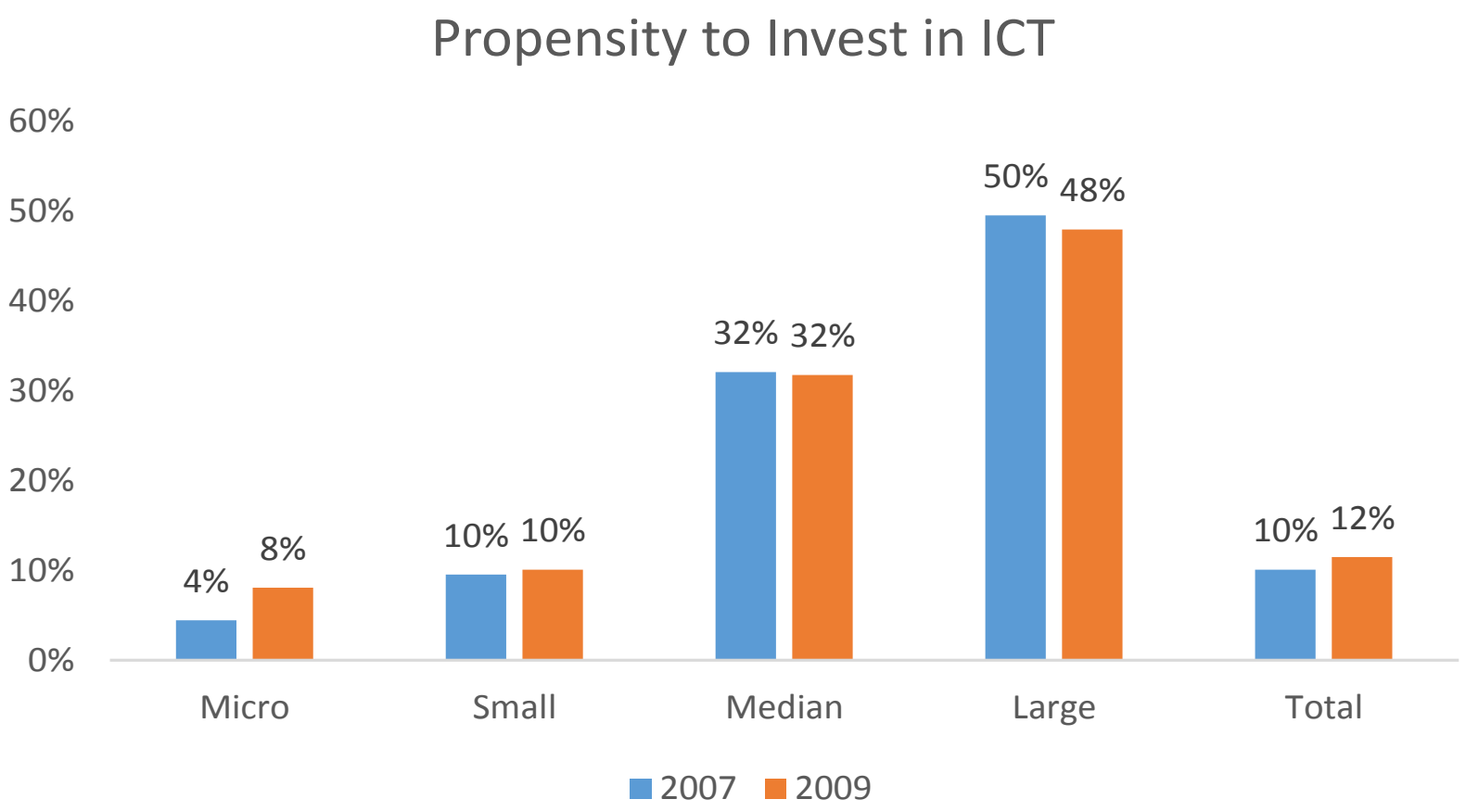
Data

- Sections (2009)

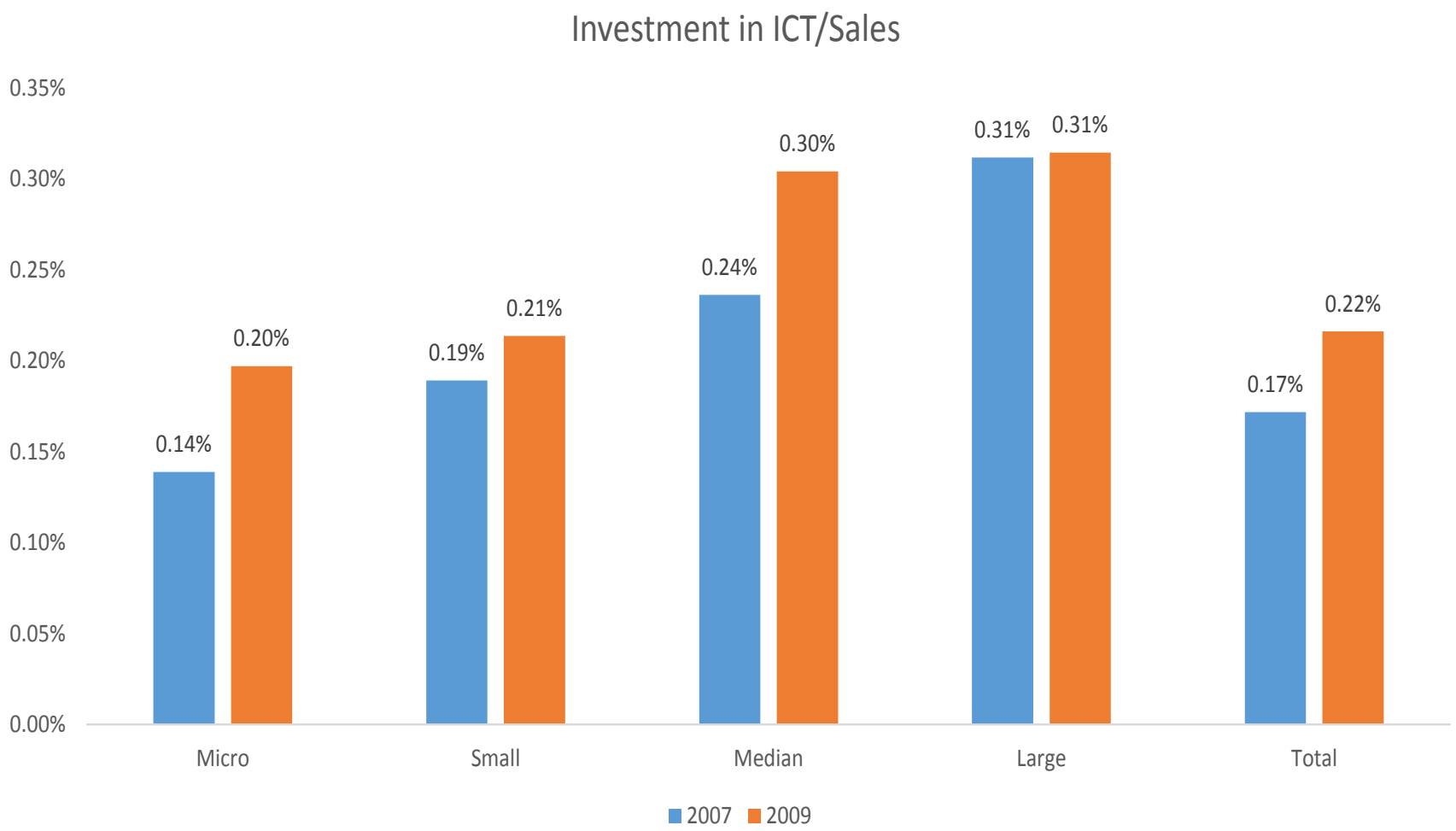
- Accounting and financing
- Commercialization
- Manager (Innovation)
- Human resources
- Information technologies

- Lagged effects: investment and innovation in 2007 affects productivity in 2009

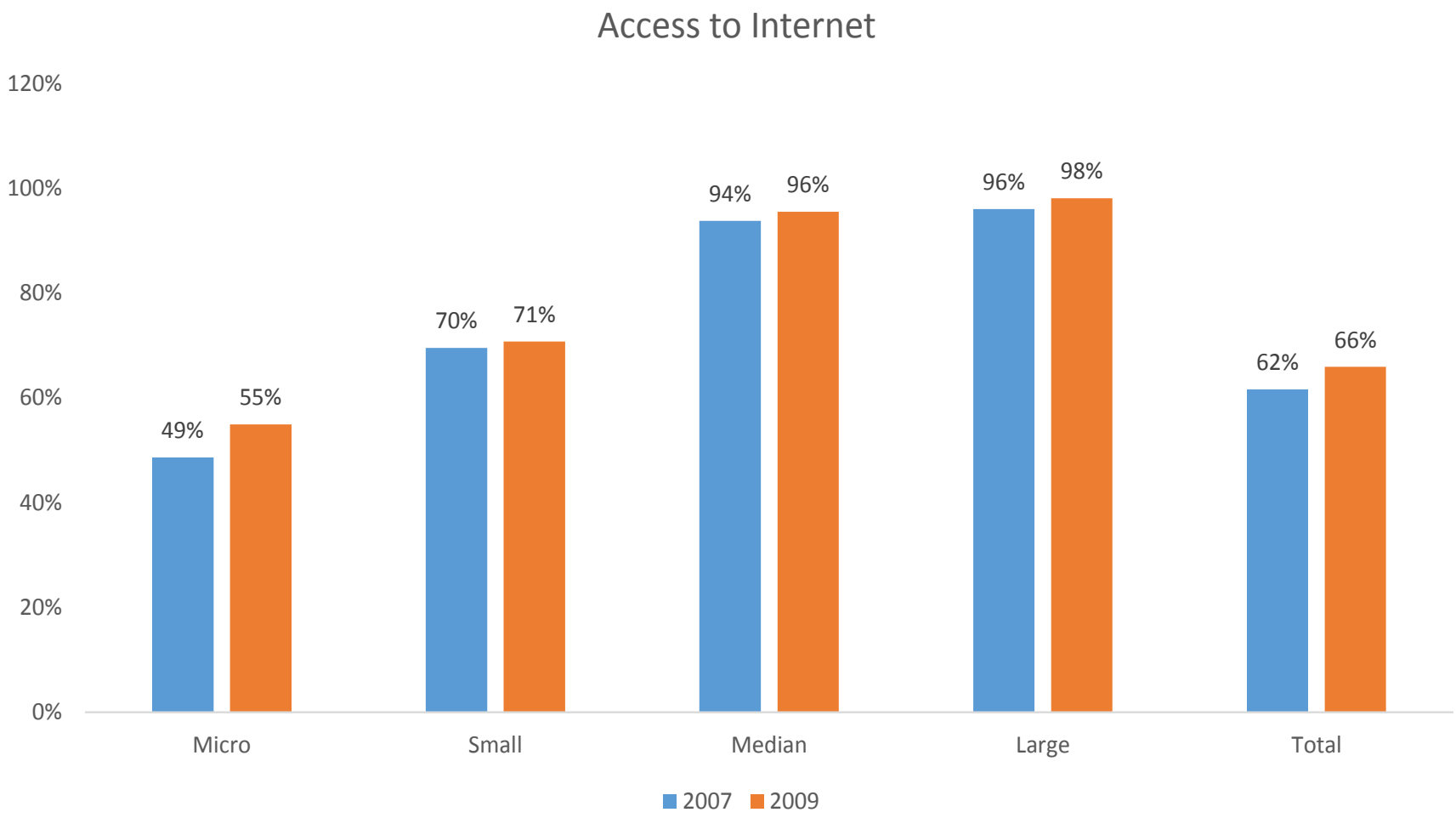
Data


Propensity to Invest in ICT
60%
50%
40%
30%
20%
10%
0%
4%
8%
10%
10%
32%
32%
50%
48%
10%
12%
Micro
Small
Median
Large
Total
2007
2009

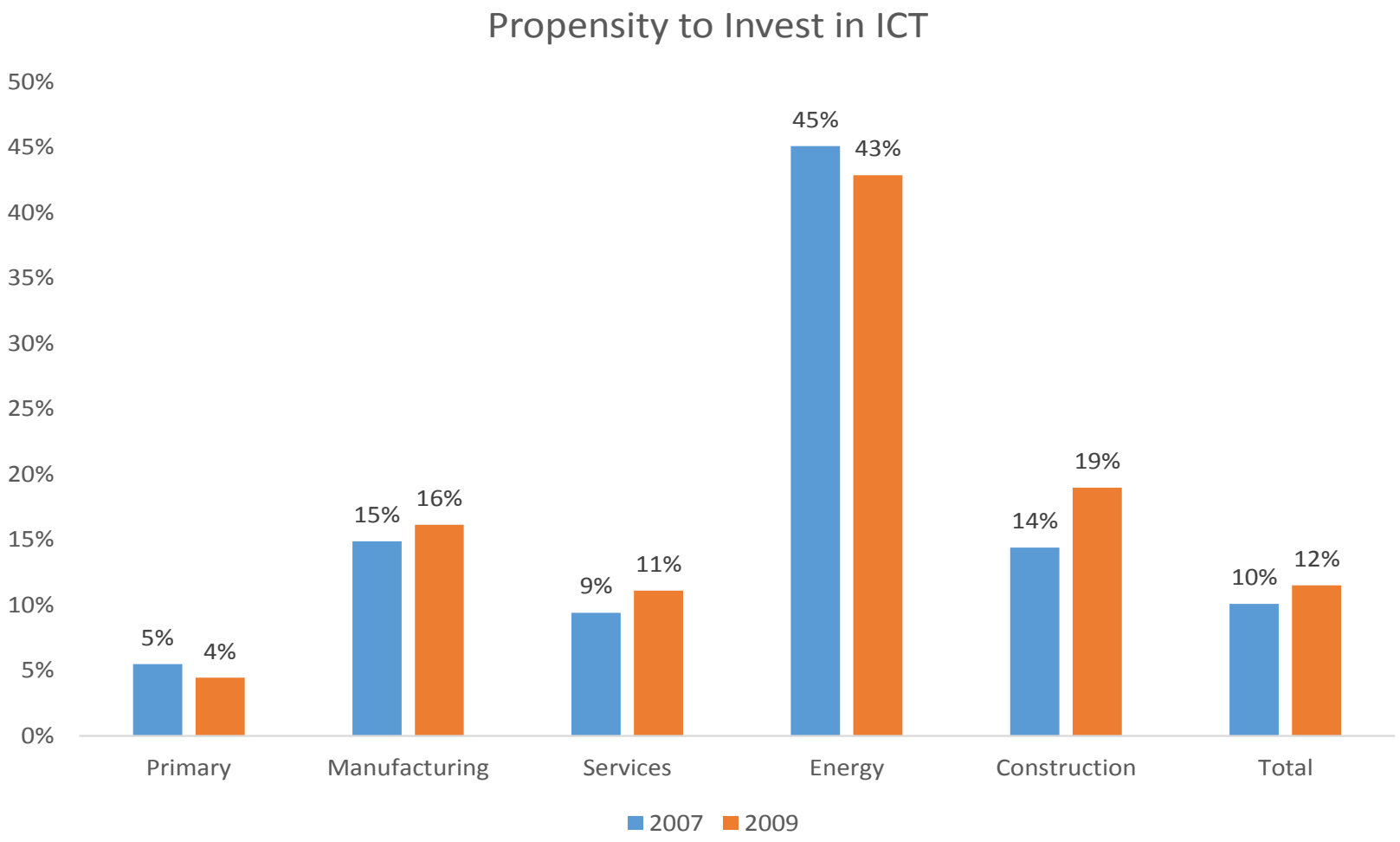
Data


Investment in ICT/Sales
0.35%
0.30%
0.25%
0.20%
0.15%
0.10%
0.05%
0.00%
0.14%
0.20%
0.19%
0.21%
0.24%
0.30%
0.31%
0.31%
0.17%
0.22%
Micro
Small
Median
Large
Total
2007
2009

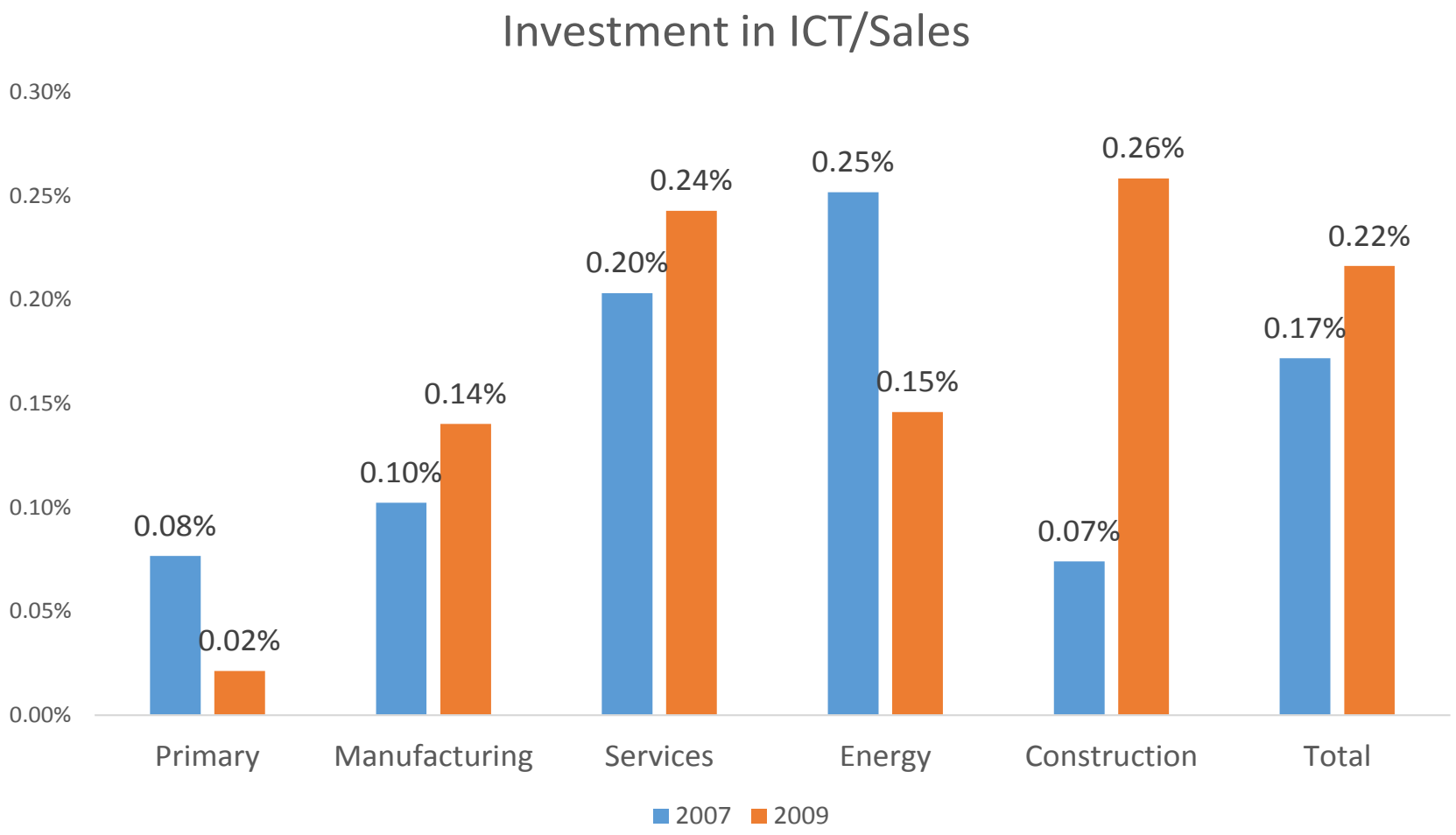
Data


Access to Internet
120%
100%
80%
60%
40%
20%
0%
49%
55%
70%
71%
94%
96%
96%
98%
62%
66%
Micro
Small
Median
Large
Total
2007
2009

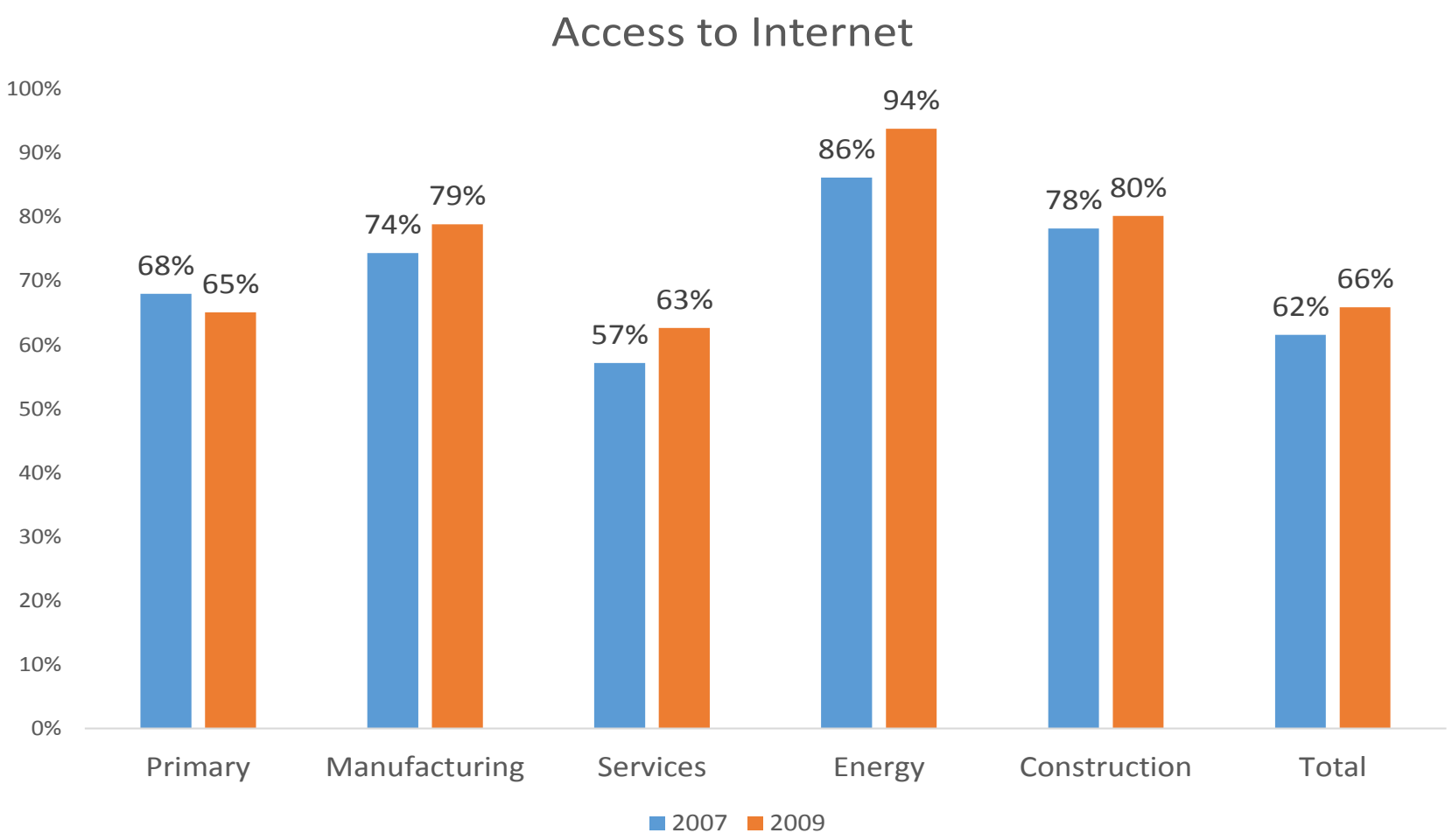
Data


Propensity to Invest in ICT
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
5%
4%
15%
16%
9%
11%
45%
43%
14%
19%
10%
12%
Primary
Manufacturing
Services
Energy
Construction
Total
2007
2009

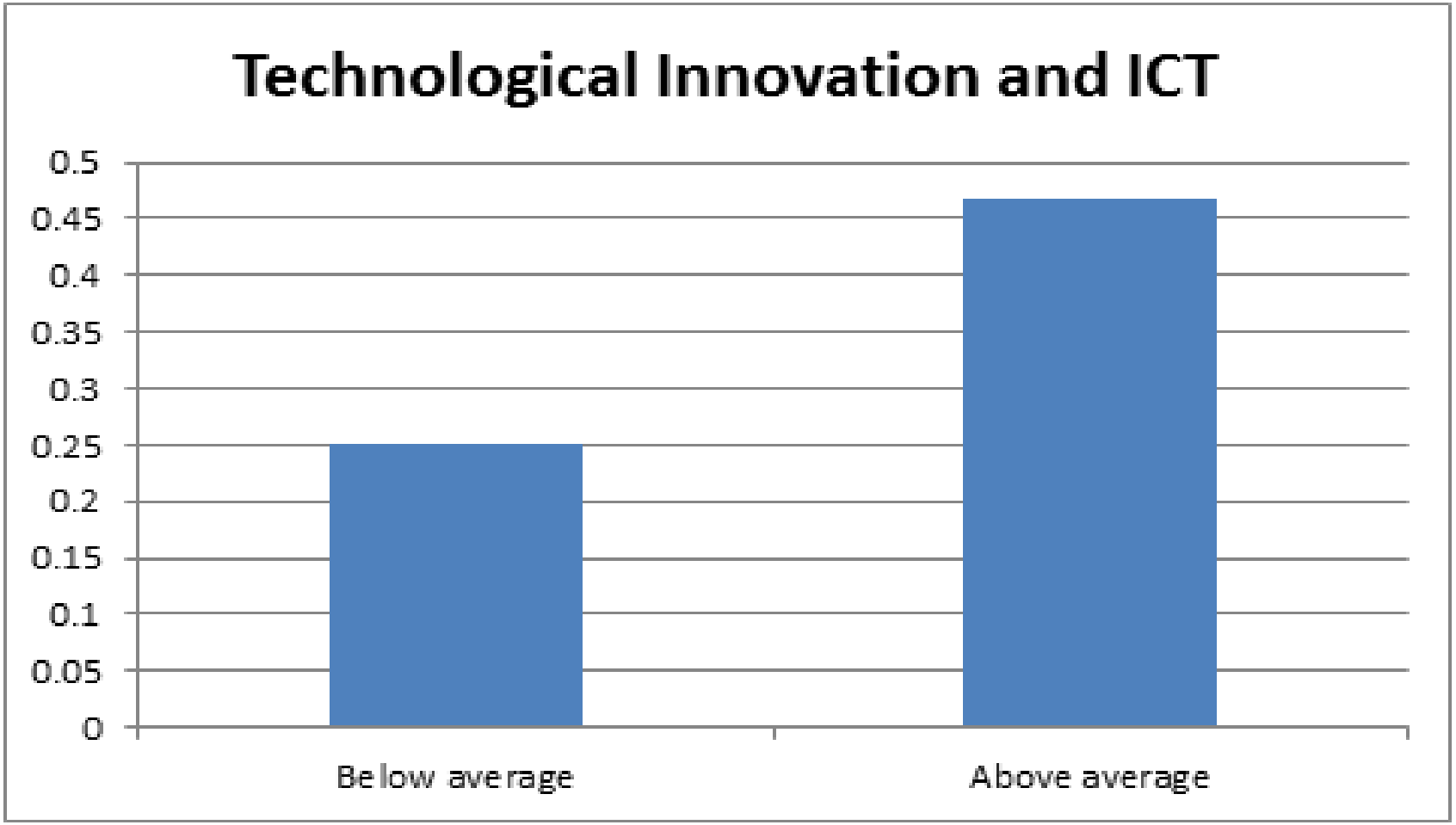
Data


Investment in ICT/Sales
0.30%
0.25%
0.20%
0.15%
0.10%
0.05%
0.00%
0.08%
0.02%
0.10%
0.14%
0.20%
0.24%
0.25%
0.15%
0.07%
0.26%
0.17%
0.22%
Primary
Manufacturing
Services
Energy
Construction
Total
2007
2009

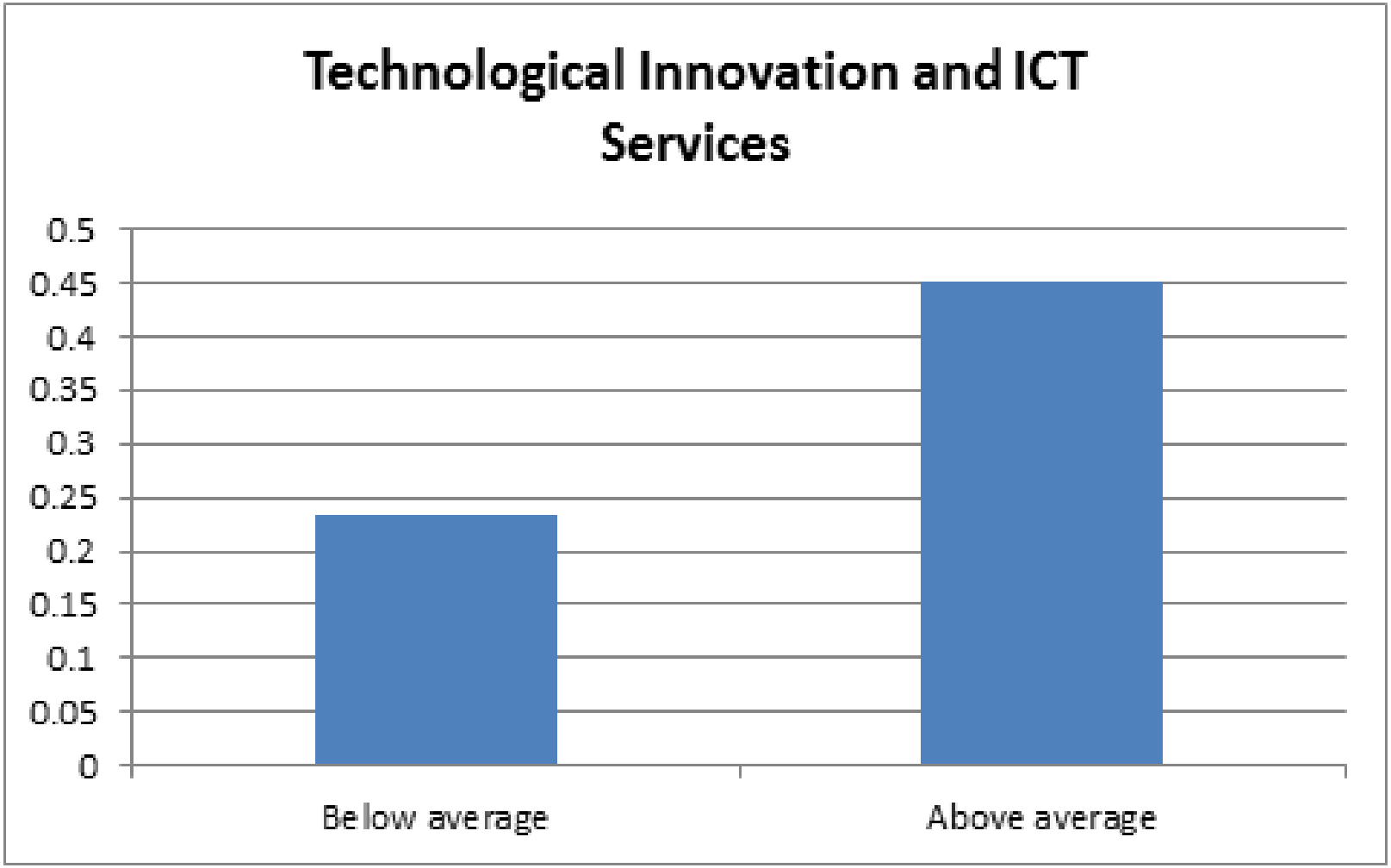
Data


Access to Internet
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
68%
65%
74%
79%
57%
63%
86%
94%
78%
80%
62%
66%
Primary
Manufacturing
Services
Energy
Construction
Total
2007
2009

Data


Technological Innovation and ICT
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Below average
Above average

Data


Technological Innovation and ICT Services
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Below average
Above average

Results: Investment in R&D and ICT

VARIABLES	Intensity R&D-All Sectors	Selection (MFX) R&D-All Sectors	Intensity ICT-All Sectors	Selection (MFX) ICT-All Sectors
Exporter	1.954**	0.0191*	0.387**	0.0563*
	(0.859)	(0.00984)	(0.162)	(0.0326)
Foreign	1.312	-0.00238	0.403**	0.119***
	(0.840)	(0.00513)	(0.185)	(0.0408)
Public support	0.428		0.153	
	(0.555)		(0.146)	
Human capital			1.969***	
			(0.331)	
Size		**0.00584*** **		**0.0875*** **
		(0.00106)		**(0.00591)**
On-line				0.186***
				(0.0261)
ICT sector-region				**1.105*** **
				(0.125)
Constant	-1.219		0.259	
	(2.959)		(1.302)	
Observations	2,427	2,427	2,393	2,393

Results: Innovation

VARIABLES	(1) Technological Innovation	(2) Any Innovation	(3) Non Technological Innovation
R&D	**0.181****	**0.206*****	**0.129****
	(0.0730)	**(0.0750)**	**(0.0596)**
ICT	**0.0945*****	**0.0896*****	**0.0627*****
	(0.0269)	**(0.0274)**	**-0.0233**
Exporter	-0.302***	-0.318***	-0.176**
	(0.103)	(0.116)	(0.0767)
Foreign	-0.256***	-0.317***	-0.217***
	(0.0763)	(0.0772)	(0.0378)
Size	0.0794***	0.0815***	0.0702***
	(0.00675)	(0.00691)	(0.00564)
Innovation sector & region	**1.401*****	**1.332*****	**0.406*****
	(0.118)	**(0.119)**	**(0.0836)**
Observations	2,265	2,265	2,265

Results: Productivity

VARIABLES	(1) All Sectors	(2) All Sectors	(3) All Sectors	(4) All Sectors	(5) All Sectors
Tech Innovation	**0.695*** **		**-0.120**		**-0.111**
	(0.222)		**(0.221)**		**(0.222)**
Any Innovation		**0.838*** **		**-0.0168**	
		(0.231)		**(0.230)**	
ICT			**0.653*** **	**0.644*** **	**0.737*** **
			(0.0786)	**(0.0790)**	**(0.0814)**
ICT * No Tech Innovation					-0.298***
					(0.0825)
No Tech Innovation					1.167***
					(0.307)
Capital per worker	0.277***	0.276***	0.237***	0.237***	0.236***
	(0.0186)	(0.0185)	(0.0175)	(0.0174)	(0.0173)
Size	-0.0929***	-0.107***	-0.0454*	-0.0532**	-0.0451*
	(0.0259)	(0.0281)	(0.0245)	(0.0267)	(0.0246)
Constant	14.03***	13.99***	14.29***	14.27***	13.97***
	(0.315)	(0.317)	(0.309)	(0.310)	(0.294)
Observations	2,017	2,017	2,017	2,017	2,017
R-squared	0.307	0.308	0.340	0.340	0.347

Results: Investment in R&D and ICT in Services

VARIABLES	Intensity R&D-Services	Selection (MFX) R&D-Services	Intensity ICT-Services	Selection (MFX) ICT-Services
Exporter	2.279**	0.0127	0.159	0.122***
	(0.908)	(0.00944)	(0.200)	(0.0454)
Foreign	0.395	-0.00221	0.308	0.0688
	(1.092)	(0.00541)	(0.224)	(0.0478)
Public support	2.234***		0.277	
	(0.736)		(0.196)	
Human capital			2.017***	
			(0.320)	
Size		0.00448***		0.0879***
		(0.00106)		(0.00763)
On-line				0.230***
				(0.0274)
ICT sector-region				0.793***
				(0.118)
Constant	-0.197		2.765**	
	(2.823)		(1.104)	
Observations	1,502	1,502	1,480	1,480

Results: Innovation in Services

VARIABLES	Technological Innovation	Any Innovation	Non Technological Innovation
R&D	0.00265	0.00919	0.00776
	(0.0185)	(0.0191)	(0.0151)
ICT	0.0735**	0.0604**	0.0449*
	(0.0288)	(0.0292)	(0.0248)
Exporter	0.0878	0.134**	0.0770
	(0.0669)	(0.0673)	(0.0592)
Foreign	-0.0369	-0.0693	-0.132***
	(0.0544)	(0.0555)	(0.0325)
Size	0.0782***	0.0777***	0.0681***
	(0.00840)	(0.00859)	(0.00694)
Innovation sector & region	1.039***	1.034***	0.317***
	(0.135)	(0.136)	(0.107)
Observations	1,393	1,393	1,393

Results: Productivity in Services

	(1)	(2)	(3)	(4)	(5)
VARIABLES	Services	Services	Services	Services	Services
Tech Innovation	2.043***		0.672		0.701
	(0.416)		(0.461)		(0.465)
Any Innovation		1.836***		0.636	
		(0.398)		(0.428)	
ICT			0.556***	0.565***	0.635***
			(0.0915)	(0.0888)	(0.0961)
ICT*No Tech Innovation					-0.284**
					(0.140)
No Tech Innovation					1.226**
					(0.603)
Capital per worker	0.256***	0.257***	0.236***	0.236***	0.236***
	(0.0225)	(0.0225)	(0.0212)	(0.0212)	(0.0211)
Size	-0.229***	-0.214***	-0.133***	-0.131***	-0.131***
	(0.0411)	(0.0406)	(0.0428)	(0.0417)	(0.0428)
Constant	14.79***	14.76***	13.75***	13.70***	13.36***
	(0.361)	(0.362)	(0.410)	(0.412)	(0.406)
Observations	1,245	1,245	1,245	1,245	1,245
R-squared	0.184	0.181	0.212	0.212	0.216

Conclusions

- Evidence favoring the idea that ICT affects innovation positively
  - Any type of innovation
  - R&D is not relevant for services
- Indirect positive effects on productivity

Conclusions

- No evidence of direct or complimentary effects
- Determinants of R&D and ICT are different
  - Common factors: size and exporting
  - Differences: foreign ownership is important for ICT
  - Public financial support seems to be important for services