The ICT Revolution and Italy's Two Lost Decades

Fabiano Schivardi

LUISS, EIEF and CEPR

Tom Schmitz

Bocconi and IGIER

European Summer Symposium in International Macroeconomics

May 26, 2017

Italy's divergence

- After decades of rapid catch-up, Italy's GDP growth has stalled in the middle of the 1990s.
- Thus, the Italian economy diverged from Northern Europe and the US.

Country	Growth rate, 1995-2015		
	Real GDP	Real GDP/hour worked	TFP
Italy	10%	6%	-4%
Eurozone	34%	24%	n.a.
Germany	30%	28%	17%
USA	61%	40%	22%

Source: OECD.

Why did Italy diverge?

- One reason may be the failure of Italian firms to adopt and efficiently use ICT.
  - The ICT revolution boosted growth in other countries since the mid-1990s (Fernald (2014), Gordon (2016)).
  - In Italy, it was limited (e.g., according to the European Commission, Italy ranks 15th/19 in the Eurozone for the integration of digital technology in firms).

- We argue this is due to Italian firms' management practices.
  - ICT and efficient management practices are complements (Brynjolfsson and Hitt (2000), Bloom et al. (2012)).
  - Empirical evidence suggests that the management practices of Italian firms are relatively inefficient.
  - This lowered ICT productivity and ICT adoption. The direct effect was further amplified by a size distribution (endogenously) skewed towards small firms and production network externalities.

Related literature

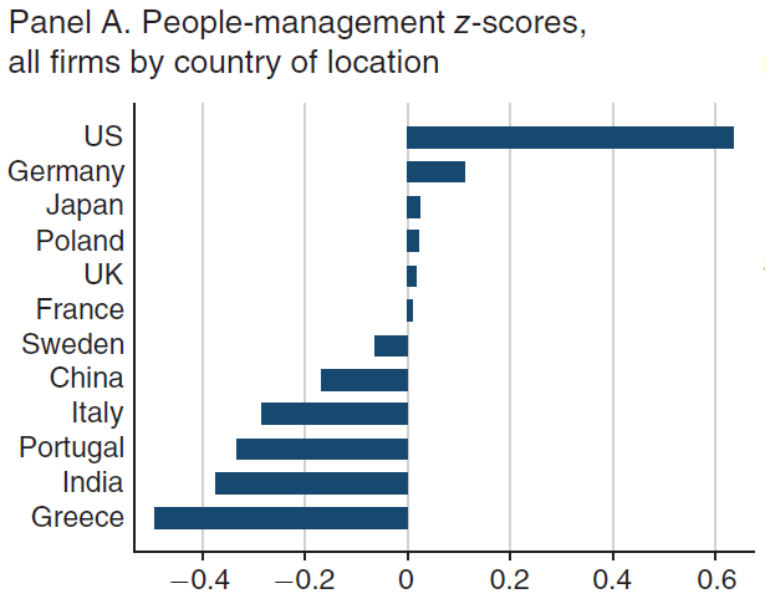
- Bloom et al. (2012) and Pellegrino and Zingales (2014) have also argued that inefficient management has lowered the producitivity with which Italian firms use ICT.
  - Our paper puts forward further channels of divergence (e.g., spillovers through production networks).
  - We provide a quantitative assessment based on a general equilibrium model, which allows to distinguish different channels and measure their importance.

- ICT and productivity: Brynjolfsson and Hitt (2000), Caroli and Van Reenen (2001), Bresnahan et al. (2002), Garicano and Heaton (2010), Brynjolfsson and Mcafee (2014), Fernald (2014), Gordon (2016).
- Italy's divergence: Daveri and Parisi (2010), Gros (2011), Hassan and Ottaviano (2013), Calligaris (2015), Calligaris et al. (2016).
- Management and aggregate productivity: Guner et al. (2015), Akcigit et al. (2016), Bloom et al. (2016).

Presentation outline

1. Micro-level evidence on management practices, ICT adoption and network effects
2. A model with heterogeneous firms, ICT and management adoption, and input-output linkages
3. The quantitative importance of the ICT Revolution
   - We find that the ICT Revolution accounts for a divergence in GDP per capita of 5.5 percentage points between Italy and Germany (25% of the total).

Italian management practices



Source: Bloom et al. (2012).

- Italian firms do systematically worse than Northern European or American ones in international comparisons of management practices.
- One explanation for this may be the share of family-managed firms.
  - 66% of Italian family firms have no managers from outside the family, against 28% in Germany, 26% in France and 35% in Spain (Bugamelli et al. (2012)).

The size distribution of firms

ICT adoption in Italy and Germany

- Italian ICT adoption rates are lower both overall and within size class, and that this does not appear to be due to low ICT supply.

	ICT specialists		**Diffic. in hiring**		**Fixed connect.**		**Max speed**	
	[1] ITA	[2] GER	[3] ITA	[4] GER	[5] ITA	[6] GER	[7] ITA	[8] GER
Size class								
10-49	11	15	33	54	95	94	2,40	2,57
50-99	35	39	22	56	97	96	2,55	2,77
100-249	58	57	24	40	97	97	2,63	2,90
250+	74	81	28	53	98	98	3,02	3,50
Total	15	23	30	52	95	95	2,43	2,64

Source: *Community survey on ICT usage and e-commerce in enterprises*. This survey covers a representative sample of firms with more than 10 employees (19'000 firms in Italy, 7'500 in Germany).

Network effects

	ERP		RFID		CRM		SCM	
	[1] ITA	[2] GER	[3] ITA	[4] GER	[5] ITA	[6] GER	[7] ITA	[8] GER
Size class								
10-49	34	33	3	3	17	25	15	20
50-99	58	60	8	4	27	36	21	33
100-249	70	68	11	8	31	40	23	38
250+	79	85	12	12	36	48	36	57
Total	38	41	4	4	19	28	16	24

Note: ERP: Enterprise Resource Planning, RFID: Radio-Frequency Identification, CRM: Customer Relationship Management, SCM: Supply Chain Management.

- Adoption gaps with Germany are larger for technologies which are particularly useful if other firms in the production network use them, too.

Effect of adoption on productivity

Network effects

- Probit regression of adoption in 2014 on the share of small/large firms in the same region and industry in 2001.

	[1]	[2]	[3]	[4]
		Panel A: ERP		
Share of firms:				
Small (1-10)	0.540**			0.695***
	(0.236)			(0.277)
Medium (50-999)		-0.0332		0.782
		(0.569)		(0.624)
Large (1000+)			-1.183	-0.963
			(1.813)	(1.865)
		Panel B: SCM		
Small (1-10)	-0.940***			-0.888***
	(0.265)			(0.323)
Medium (50-999)		1.342**		0.261
		(0.617)		(0.755)
Large (1000+)			-1.182	-1.358
			(1.235)	(1.195)
Obs.	18,824	18,824	18,824	18,824

Summary of empirical stylized facts

- Italian firms have less efficient management practices.
- This could be one of the sources of the left-skewed Italian firm size distribution.
- It can also explain that Italian ICT adoption is lower.
  - Indeed, lower adoption appears to be due to demand rather than supply factors.
- ICT adoption is especially low for technologies with a network component.

Assumptions: Final Producers

- Inelastic labour supply L, CES preferences for a continuum of final goods, and monopolistic competition.

$$C = \left(\int_0^{M_F} c_F(i)^{\frac{\varepsilon-1}{\varepsilon}} di \right)^{\frac{\varepsilon}{\varepsilon-1}}, \quad \text{with } \varepsilon > 1.$$

- Final producers pay an entry cost $f_{F,E}$ and draw a productivity $a_F(i)$. They can then produce and pay an additional fixed cost f_F, or exit.

$$y_F(i) = a_F(i)\, \xi^{\mathbb{1}_M(i)} \varphi^{\mathbb{1}_M(i)\mathbb{1}_{F,ICT}(i)} (l_F(i))^{1-\beta} (Y_S(i))^{\beta}, \quad \text{with } \beta \in (0,1)$$

$$\text{where} \quad Y_S(i) = \left(\int_0^{M_S(i)} y_S(i,j)^{\frac{\sigma-1}{\sigma}} dj \right)^{\frac{\sigma}{\sigma-1}}, \quad \text{with } \sigma > \varepsilon.$$

- Note: all fixed costs are in units of labour.

Assumptions: Final Producers

- This is a standard Melitz/Hopenhayn setup, with two additions.

1. Firms can upgrade productivity by adopting management (fixed cost $f_{F,M}$) and ICT (fixed cost $f_{F,ICT}$).
   - Note that ICT adoption requires management.
   - The parameters ξ and φ, management and ICT productivity, will be at the heart of our analysis.
2. There are firm-specific intermediate inputs.
   - ICT adoption does not only directly increase productivity, but also facilitates interaction with the suppliers which produce these inputs.

Assumptions: Suppliers

- Suppliers are modeled analogously to final producers (entry cost $f_{S,E}$, productivity draw $a_S(i,j)$ and fixed production cost f_S).
- Their output is

$$y_S(i,j) = \frac{\gamma^{\mathbb{1}_{S,ICT}(i,j)\mathbb{1}_{F,ICT}(i)}}{\tau} a_S(i,j)\, l_S(i,j).$$

- Suppliers face iceberg coordination costs τ. These can be reduced iff both suppliers and final producers adopt ICT (fixed cost $f_{S,ICT}$ for suppliers).

- Simplifying assumptions
  - Final producers are Stackelberg leaders in the investment game.
  - Suppliers make take-it-or-leave-it offers for their inputs.
  - All productivity distributions are Pareto, which is empirically realistic and delivers analytical solutions.

Solution outline

Final producers

- Final producers sort according to their productivity draw, with respect to three cut-offs $a_F^* \leq a_{F,M}^* \leq a_{F,ICT}^*$.

$a_F < a_F^*$	$a_F^* < a_F < a_{F,M}^*$	$a_{F,M}^* < a_F < a_{F,ICT}^*$	$a_F > a_{F,ICT}^*$
Exit	Prod., no mgmt, no ICT	Prod., mgmt, no ICT	Prod., mgmt, ICT

Suppliers

- Suppliers of a final producer without ICT produce if $a_S > a_S^{*\mathrm{NoICT}}$, and never adopt ICT.
- Suppliers of a final producer with ICT produce if $a_S > a_S^{*\mathrm{ICT}}$, and adopt ICT if $a_S > a_{S,ICT}^{*\mathrm{ICT}}$.
- The aggregate productivity of suppliers is increasing in the final producer's ICT adoption choice. Final producers take this into account, and it gives them an additional adoption incentive.

Details

Solution outline

- Thanks to the Pareto distribution, we can solve analytically for all cut-offs, which gives

$$a_F^* = \left(\frac{\frac{\theta}{k-\theta} \left(f_F + s_{F,M} f_{F,M} + s_{F,ICT} f_{ICT} \right)}{f_{F,E}} \right)^{\frac{1}{k}}.$$

where $s_{F,M} = \left(\frac{f_F \left(\xi^\theta - 1 \right)}{f_{F,M}} \right)^{\frac{k}{\theta}}$ and $s_{F,ICT} = \left(\frac{f_F \xi^\theta \left(\varphi^\theta \left(\frac{a_S^{*\mathrm{ICT}}}{a_S^{*\mathrm{NoICT}}} \right)^{\beta\theta} - 1 \right)}{f_{F,ICT}} \right)^{\frac{k}{\theta}}$.

- Wages are given by

$$w = L^{\frac{1}{\varepsilon-1}} a_F^* \left(\frac{\Lambda \left(a_S^{*\mathrm{NoICT}} \right)^{\beta\theta}}{f_F} \right)^{\frac{1}{\theta}}.$$

- θ and Λ are combinations of model parameters. Details

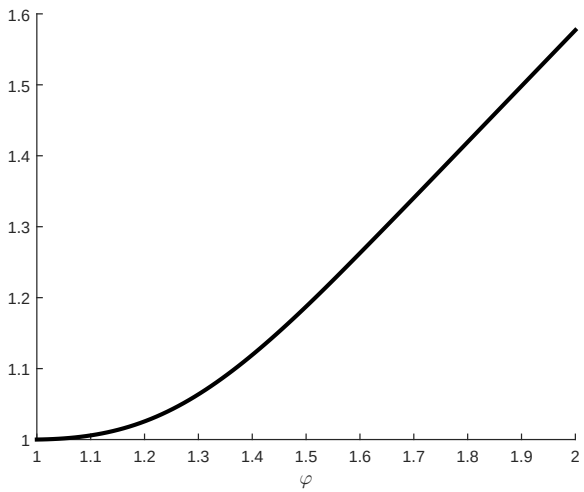
Analysis

- We calibrate the model to Italy and Germany, both before the ICT revolution (when $\varphi = \gamma = 1$) and after the ICT revolution (when $\varphi > 1$ and $\gamma > 1$).
- We assume that Italy is characterized by

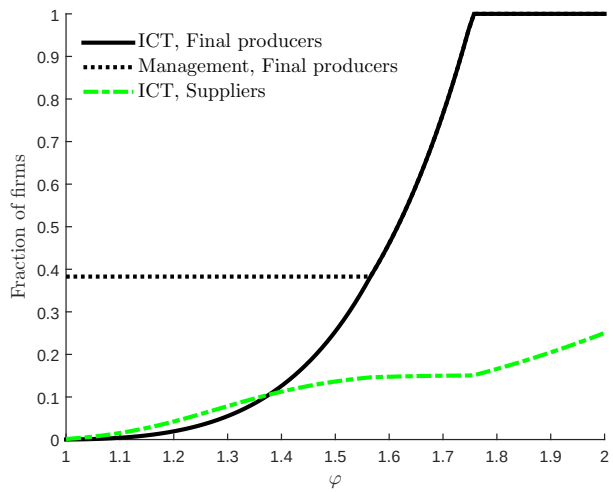
1. Low management productivity ξ.
   - Italian firms have less efficient management practices.
   - This has a negative impact on their productivity (Bloom et al. (2016)).
2. Low ICT productivities φ and γ.
   - Italian firms increase their productivity less after adopting ICT technologies (Bloom et al. (2012), Pellegrino and Zingales (2014)).
   - Importantly, this is true even after controlling for the direct effect of management on productivity (and therefore cannot be captured by the management productivity parameter ξ).

Comparative statics with respect to φ

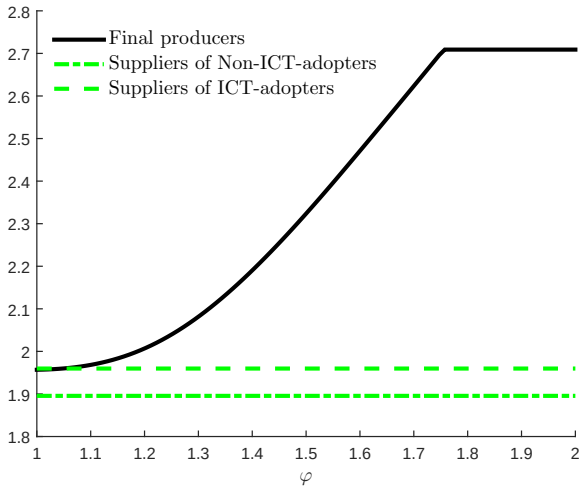
Wage



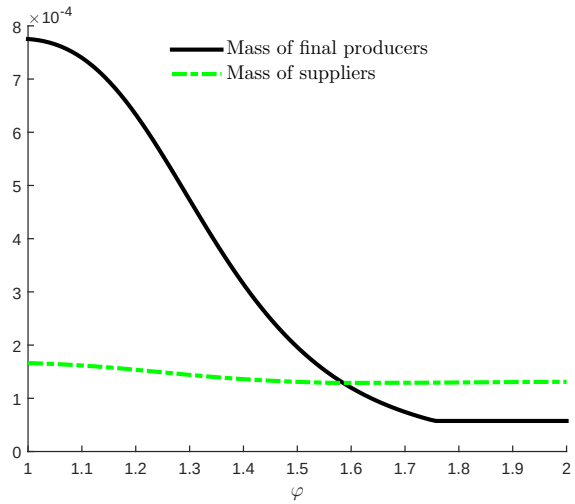
Percentage of firms with management and ICT



Exit productivity cut-offs



Masses of final producers and suppliers

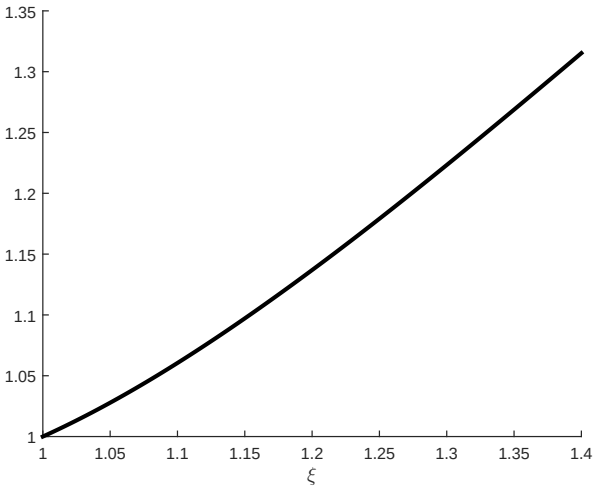


Comparative statics with respect to φ

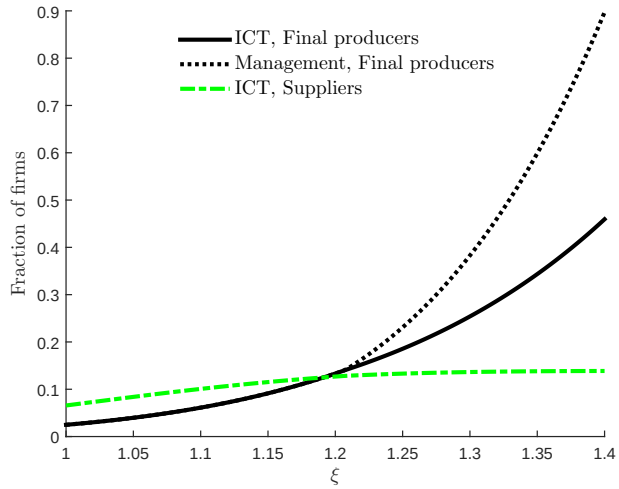
- Increases in γ have a very similar effect.
- This indicates a first divergence channel: lower ICT productivity in Italy (ultimately due to inefficient management).
  - This directly lowers the increase in aggregate productivity associated with the ICT revolution.
  - As the returns to ICT are lower, it also explains low adoption rates.
  - These are enhanced by network externalities: low adoption by final producers spills over to their suppliers.
- However, this is not the only channel for divergence.

Comparative statics with respect to ξ

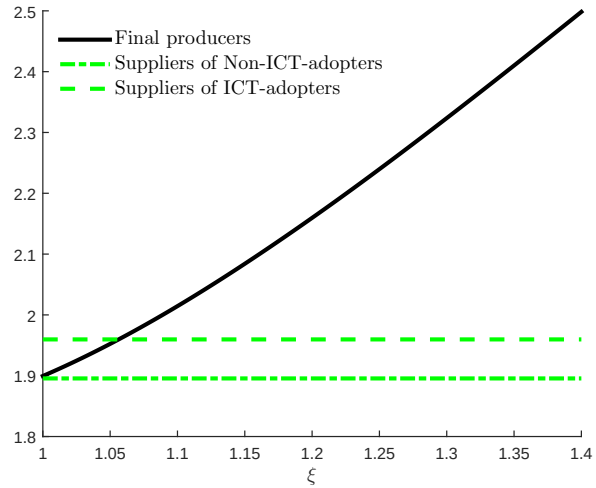
Wage



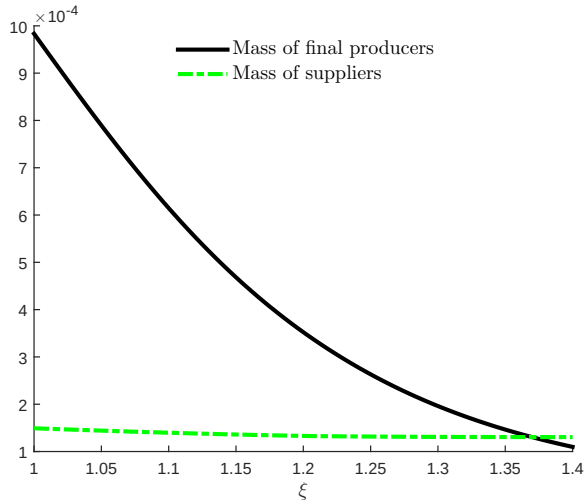
Percentage of firms with management and ICT



Exit productivity cut-offs



Masses of final producers and suppliers



Comparative statics with respect to ξ

- Low management productivity can reproduce a large number of stylized facts about the Italian economy even before the ICT revolution.
  - With respect to Germany, the average Italian firm is smaller, less productive and less likely to adopt management.
  - As a result, Italy's income per capita is lower.

- The ICT revolution amplifies these differences: even when ICT productivities are the same in Italy and in Germany, the wage ratio w^D/w^I increases.
  - Low management productivity depresses ICT adoption, both directly (by increasing the cost-to-benefit ratio of ICT) and indirectly (by skewing the size distribution towards smaller firms, which are less likely to adopt ICT).
  - As ICT becomes very productive, all firms need to adopt management. This increases the aggregate importance of a technology which is less efficient in Italy.

Calibrated parameters (1/2)

Parameter	Description	Value	Source/Target
ξ^I	Italian mgmt productivity	1.158	Bloom et al. (2016)
ξ^D	German mgmt productivity	1.200	Bloom et al. (2016)
φ^I	Italian ICT prod. for final producers	1.102	Bloom et al. (2012)
φ^D	German ICT prod. for final producers	1.160	Bloom et al. (2012)
γ^I	Italian ICT red. in coordination costs	$\frac{1}{0.898}$	Simplification
γ^D	German ICT red. in coordination costs	$\frac{1}{0.84}$	Simplification
β	Intermediate input share	0.5	Jones (2011)
ε	Elasticity of substitution for final goods	3	Jones (2011)
σ	Elasticity of substitution for inputs	5	-
τ	Coordination costs	2	Normalization
k	Shape of the Pareto productivity distr.	5.33	Chaney (2008)

Calibrated parameters (2/2)

Parameter	Description	Value	Source/Target
$f_{F,E}$	Entry cost (fin. prod.)	0.9	Exit rate of 60% (Germany)
f_F	Fixed production cost (fin. prod.)	1	Normalization
$f_{F,M}$	Mgmt. adoption cost (fin. prod.)	0.886	50% mgmt. adoption (Germany)
$f_{F,ICT}$	ICT adoption cost (fin. prod.)	1.9	39% ICT adoption (Germany)
$f_{S,E}$	Entry cost (suppliers)	0.99	Exit rate of 60% (Germany)
f_S	Fixed production cost (suppliers)	1	Normalization
$f_{S,ICT}$	ICT adoption cost (suppliers)	1.8	32% of ICT adoption (Germany)
L	Labour endowment	1	Normalization

Quantitative predictions

	[1] Before ICT	[2] After ICT	[3] $\varphi^D = \varphi^I$	[4] $\xi^D = \xi^I$	[5] No spillovers	[6] $\varphi \to +\infty$
Rel. wage	**1.026**	**1.081**	1.029	1.052	1.081	1.122
Divergence		**5.49 pp**	0.4 pp	5.2 pp	5.48 pp	9.6 pp
% of act. div.		**25.0%**	**1.6%**	**23.7%**	24.9%	43.7%
$s^D_{F,M}$	50%	50%	50%	50%	50%	100%
$s^I_{F,M}$	29%	29%	31%	50%	29%	100%
$s^D_{F,ICT}$	0%	39%	39%	39%	17%	100%
$s^I_{F,ICT}$	0%	10%	31%	12%	5%	100%
G. supplier ICT	0%	32%	32%	32%	46%	46%
I. supplier ICT	0%	7%	29%	8%	20%	20%
Rel. firm size	1.13	1.50	1.15	1.32	1.26	1.03

Quantitative predictions

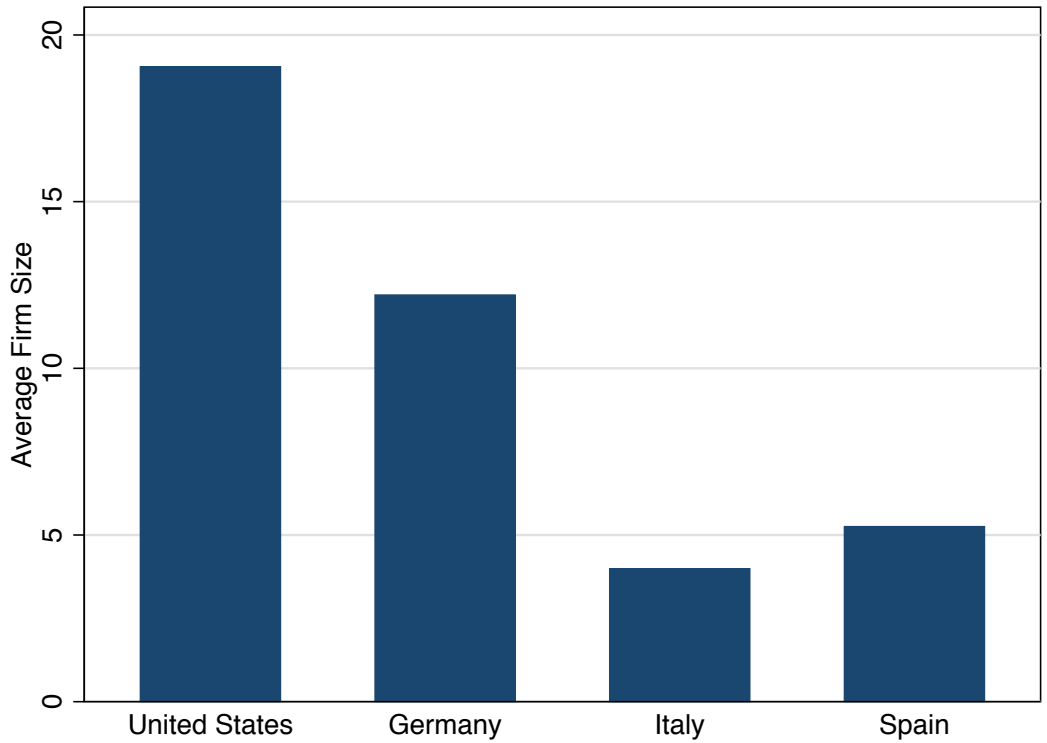
	[1] Before ICT	[2] After ICT	[3] $\varphi^D = \varphi^I$	[4] $\xi^D = \xi^I$	[5] No spillovers	[6] $\varphi \to +\infty$
Rel. wage	1.026	1.081	1.029	1.052	1.081	1.122
Divergence		5.49 pp	0.4 pp	5.2 pp	5.48 pp	9.6 pp
% of act. div.		25.0%	1.6%	23.7%	24.9%	43.7%
$s^D_{F,M}$	50%	50%	50%	50%	50%	100%
$s^I_{F,M}$	29%	29%	31%	50%	29%	100%
$s^D_{F,ICT}$	0%	**39%**	39%	39%	**17%**	100%
$s^I_{F,ICT}$	0%	**10%**	31%	12%	**5%**	100%
G. supplier ICT	0%	**32%**	32%	32%	**46%**	46%
I. supplier ICT	0%	**7%**	29%	8%	**20%**	20%
Rel. firm size	1.13	1.50	1.15	1.32	1.26	1.03

Conclusions

- Inefficient management in Italy has depressed both ICT adoption and ICT productivity.
  - This can account for a divergence of 5.5 percentage points in relative GDP/capita, a sizeable share of the actual divergence.

- The model suggests that in order to catch up, management practices of Italian firms need to be improved.
  - However, this is difficult and can probably only be realized in the long run.
  - In the short run, ICT subsidies may help somewhat, because of network externalities.

Italian firms are small



Source: Eurostat (Structural Business Statistics).

Back

Productivity, size and ICT adoption

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Size dummies								
50-99 emp	0.142***	0.025	0.021	-0.019	0.074**	0.091***	0.095***	-0.042
100-249 emp	0.229***	0.014	0.015	0.006	0.134***	0.153***	0.171***	-0.076**
250+ emp	0.272***	-0.062*	-0.085**	-0.030	0.154***	0.123***	0.198***	-0.218***
ICT specialists		0.513***						0.082**
Training			0.486***					0.147***
ERP				0.499***				0.269***
CRM					0.259***			-0.011
SCM						0.369***		0.157***
RFDI							0.098*	-0.024
Cons.	11.277***	11.291***	11.381***	11.240***	11.293***	11.248***	11.377***	10.916***
	(0.085)	(0.084)	(0.089)	(0.085)	(0.090)	(0.085)	(0.090)	(0.114)
R-sq	0.1057	0.1469	0.1420	0.1487	0.1190	0.1317	0.1071	0.2578
No. Obs	7583	7493	6900	7040	6966	7534	6889	6303

Back

Detailed model solution

- We solve the model in two stages.
  - First, solve for prices and quantities taking entry and technology adoption as given.
  - Then, turn to technology adoption choices and impose free entry.

Prices, quantities and inputs

- Final producers' input choices are given by

$$y_S(i,j) = \left(\frac{p_S(i,j)}{P_S(i)}\right)^{-\sigma} Y_S(i)$$

$$\text{and} \quad \frac{wl_F(i)}{1-\beta} = \frac{P_S(i)\, Y_S(i)}{\beta} = \mathrm{MC}_F(i)\, y_F(i).$$

- They charge a markup $\frac{\varepsilon}{\varepsilon-1}$ over their marginal cost.

Back

Detailed model solution

- Suppliers choose a markup $\frac{\sigma}{\sigma-1}$ over marginal cost.
- This yields variable profits

$$\pi_F^{\text{Var}}(i) = \chi\left(\widetilde{a}_F(i)\right)^{\varepsilon-1}\left(\widetilde{A}_S(i)\right)^{\beta(\varepsilon-1)} B,$$

$$\text{where } \chi \equiv \frac{1}{\varepsilon-1}\left(\frac{\varepsilon}{\varepsilon-1}\right)^{-\varepsilon}\left(\beta^{\beta}(1-\beta)^{1-\beta}\right)^{\varepsilon-1}\left(\frac{\sigma}{\sigma-1}\right)^{\beta(1-\varepsilon)},$$

$$\widetilde{A}_S(i) = \left(\int_0^{M_S(i)}\left(\widetilde{a}_S(i,j)\right)^{\sigma-1} dj\right)^{\frac{1}{\sigma-1}} \text{ and } B \equiv w^{1-\varepsilon} C.$$

$$\pi_S^{\text{Var}}(i,j) = \frac{\beta(\varepsilon-1)}{\sigma}\left(\frac{\widetilde{a}_S(i,j)}{\widetilde{A}_S(i)}\right)^{\sigma-1}\pi_F^{\text{Var}}(i).$$

Back

Detailed model solution

Technology adoption

- Suppliers of a non-adopting final producer do not adopt ICT.
- They decide upon remaining on the market based on their productivity draw, which gives the cutoff

$$a_S^*\left(i_{\text{NoICT}}\right) = \tau \widetilde{A}_S\left(i_{\text{NoICT}}\right)\left(\frac{\sigma f_S}{\frac{\beta(\varepsilon-1)}{w}\pi_F^{\text{Var}}\left(i_{\text{NoICT}}\right)}\right)^{\frac{1}{\sigma-1}}.$$

- Imposing free entry, this gives

$$a_S^*\left(i_{\text{NoICT}}\right) = \left(\frac{\sigma-1}{k-(\sigma-1)}\frac{f_S}{f_{S,E}}\right)^{\frac{1}{k}} \equiv a_S^{*\text{NoICT}}.$$

$$\widetilde{A}_S\left(i_{\text{NoICT}}\right) = \left(\frac{\beta(\varepsilon-1)\chi\left(a_S^{*\text{NoICT}}\right)^{\sigma-1}\left(\widetilde{a}_F\left(i_{\text{NoICT}}\right)\right)^{\varepsilon-1}\frac{B}{w}}{\sigma\tau^{\sigma-1}f_S}\right)^{\frac{1}{\sigma-1-\beta(\varepsilon-1)}}$$

Back

Detailed model solution

- Suppliers of a adopting final producer adopt ICT if they are productive enough.
- Under a parameter condition ensuring that not all suppliers adopt, this gives eventually
- Imposing free entry, this gives

$$a_S^*\left(i_{\mathrm{ICT}}\right) = \left(\frac{\frac{\sigma-1}{k-(\sigma-1)}\left(f_S + s_{S,ICT} f_{S,ICT}\right)}{f_{S,E}}\right)^{\frac{1}{k}} \equiv a_S^{*\mathrm{ICT}}.$$

$$\widetilde{A}_S\left(i_{\mathrm{ICT}}\right) = \left(\frac{\beta\left(\varepsilon-1\right)\chi\left(a_S^{*\mathrm{ICT}}\right)^{\sigma-1}\left(\widetilde{a}_F\left(i_{\mathrm{ICT}}\right)\right)^{\varepsilon-1}\frac{B}{w}}{\sigma\tau^{\sigma-1}f_S}\right)^{\frac{1}{\sigma-1-\beta(\varepsilon-1)}}$$

Back

Detailed model solution

- Final producers make profits

$$\pi_F(i) = \begin{cases} \Lambda \left(a_F(i) \left(a_S^{*\mathrm{NoICT}} \right)^{\beta} \right)^{\theta} \left(\frac{B}{w} \right)^{\frac{\beta\theta}{\sigma-1}} B - f_F w & \text{w/o mgmt and ICT} \\ \Lambda \left(\xi a_F(i) \left(a_S^{*\mathrm{NoICT}} \right)^{\beta} \right)^{\theta} \left(\frac{B}{w} \right)^{\frac{\beta\theta}{\sigma-1}} B - \left(f_F + f_{F,M} \right) w & \text{with mgmt, w/o ICT} \\ \Lambda \left(\xi\varphi a_F(i) \left(a_S^{*\mathrm{ICT}} \right)^{\beta} \right)^{\theta} \left(\frac{B}{w} \right)^{\frac{\beta\theta}{\sigma-1}} B - \left(f_F + f_{F,M} + f_{F,ICT} \right) w & \text{with mgmt and ICT} \end{cases},$$

where $\theta \equiv \frac{(\varepsilon-1)(\sigma-1)}{\sigma-1-\beta(\varepsilon-1)}$ and $\Lambda \equiv \chi^{\frac{\theta}{\varepsilon-1}} \left(\frac{\beta(\varepsilon-1)}{\sigma\tau^{\sigma-1} f_S} \right)^{\frac{\beta\theta}{\sigma-1}}$.

- This defines (under some parameter conditions) the three cut-offs.
- Imposing free entry, we get to the equation in the main slides.
- Imposing labour market clearing, we get

$$M_{F,E} = \frac{\theta L}{\varepsilon k f_{F,E}}.$$

Back