Understanding productivity dynamics: a task taxonomy approach

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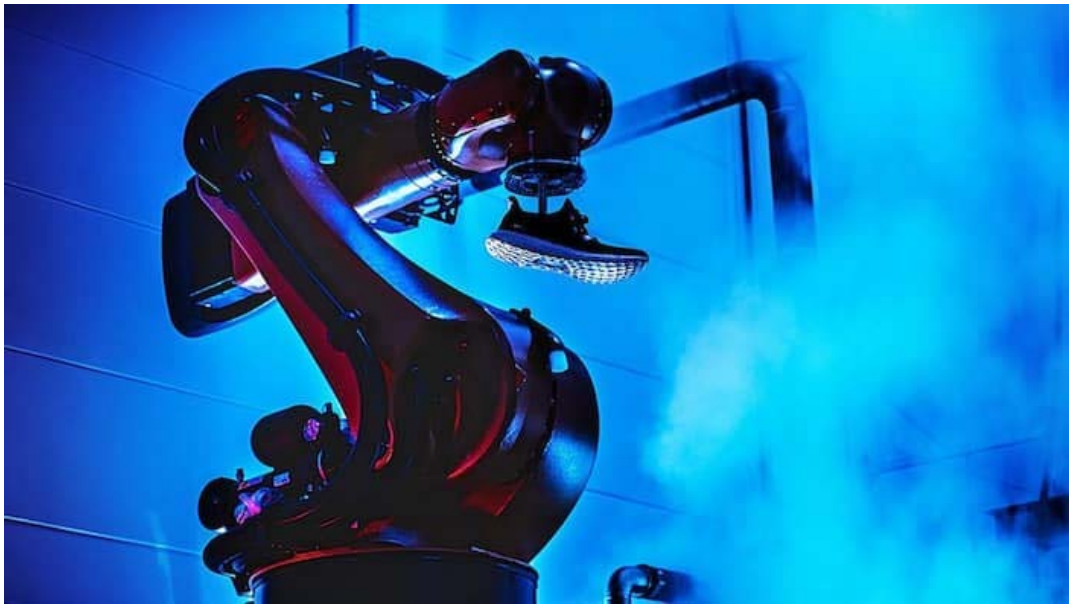
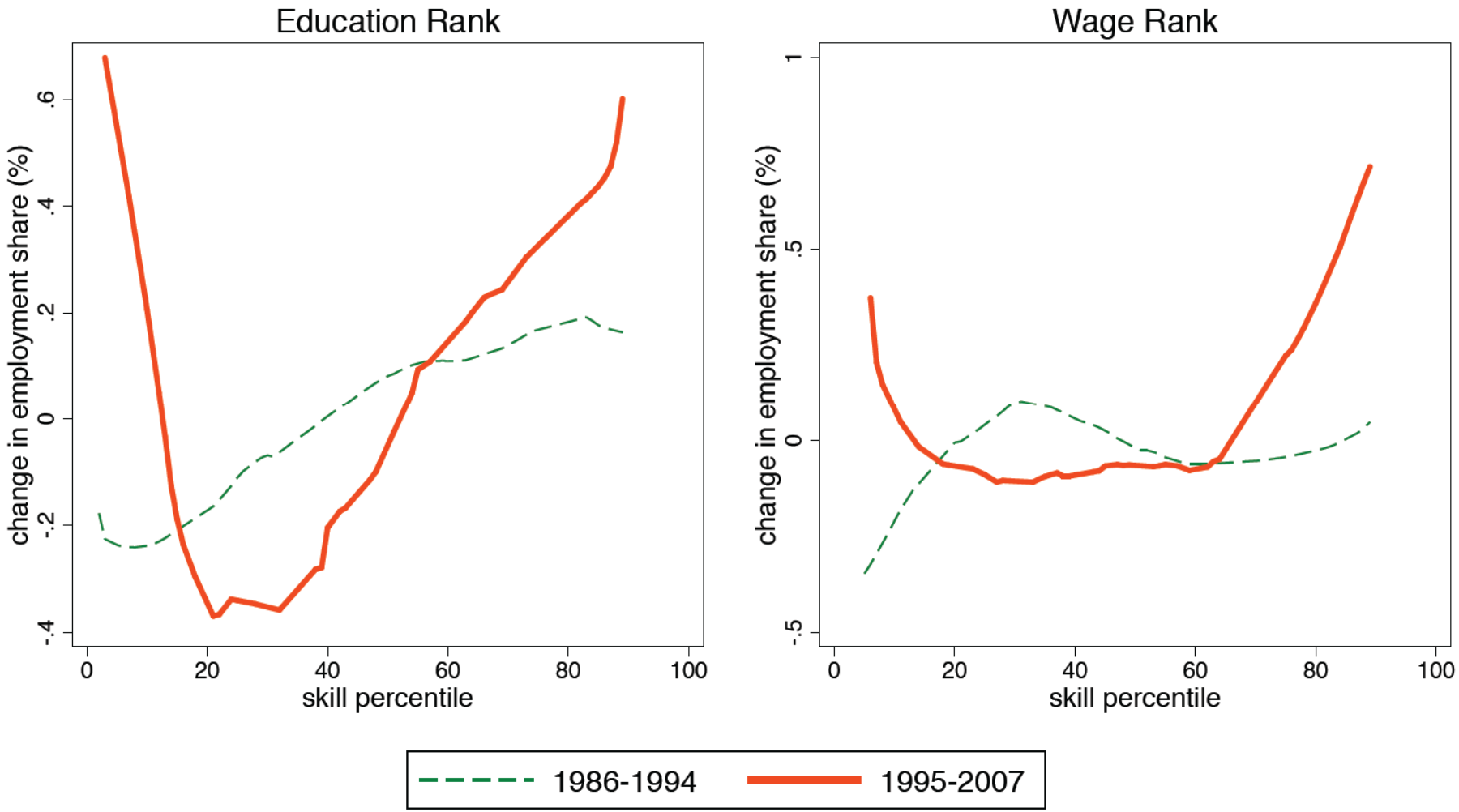
Motivation



Job Polarization



Motivation

Technology – computers, robots, AI, ICT

- Workplace: displacing middle skilled workers – polarization
- How does technology affects firms? Are firms becoming skill focused or polarised?
- How do these shifts within and across firms contribute to productivity growth?

To get the answers, we propose a firm taxonomy based on tasks

Road map

Firm taxonomy based on tasks

Estimate productivity (TFP)

Productivity Dynamics

Discussion and policy implications

Data

Quadros de Pessoal (QP), firm census with matched employer-employee data,1986–2012

Sistema de Contas Integradas das Empresas (SCIE), contains information on firms' balance sheets and income statements, 2004-2009

After merging the two datasets we obtain 815 424 firms for 2004-2009

Task approach

Abstract	Routine	Manual
Solve problems, manage Complex communications	Follow instructions Repetitive tasks	Require flexibility Adaptability
E.g., Managers, engineers, physicians, economists	E.g., Office clerks, repetitive assemblers	E.g., Housekeepers, plumbers, hairdressers
Cannot yet be automated	**Can programmed into a machine**	**Cannot yet be automated**

Routinization

- Routine workers are being substituted by computer capital
- Abstract workers are enhanced by computer capital

Firm taxonomy based on tasks

Occupations (ISCO codes)

↓

O*NET task intensity scales

↓

Abstract **Routine** **Manual**

↓

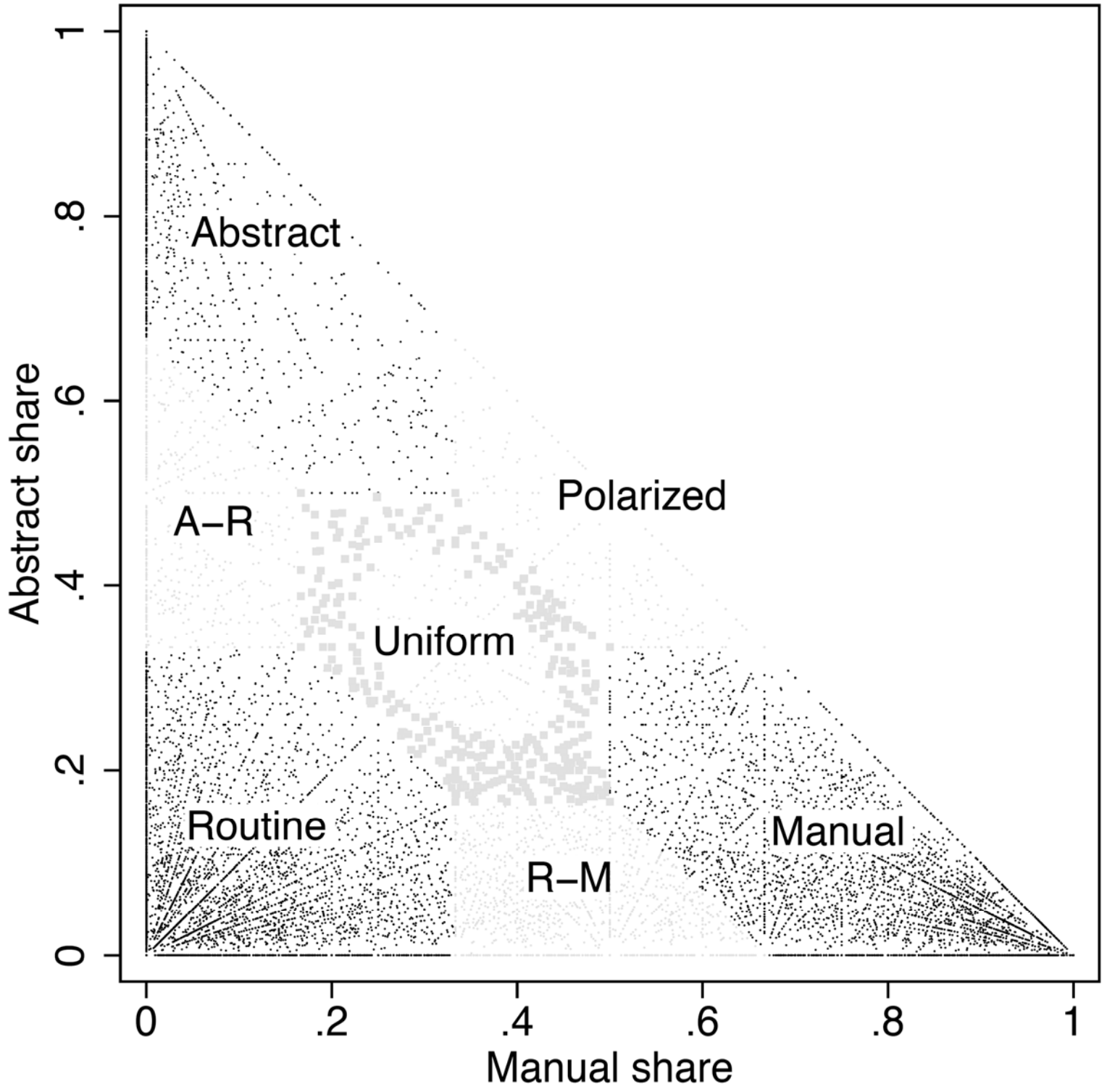
For each firm: compute the employment shares by task

↓

Abstract A_S **Routine** R_S **Manual** M_S

Taxonomy categories and boundaries

Firm Task Category	**Share of employees**		
	Abstract (A_s)	**Manual** (M_s)	**Routine** (R_s)
Abstract (A)	$\geq 1/2$	$<1/3$	$<1/3$
Manual (M)	$<1/3$	$\geq 1/2$	$<1/3$
Routine (R)	$<1/3$	$<1/3$	$\geq 1/2$
Polarized	$\geq 1/3$	$\geq 1/3$	$\leq 1/6$
Abstract-Routine	$\geq 1/3$	$\leq 1/6$	$\geq 1/3$
Routine-Manual	$\leq 1/6$	$\geq 1/3$	$\geq 1/3$
Uniform	$A_s - R_s \leq 1/6, A_s - M_s \leq 1/6, R_s - M_s \leq 1/6$		
Other	Not classified in the remaining categories		



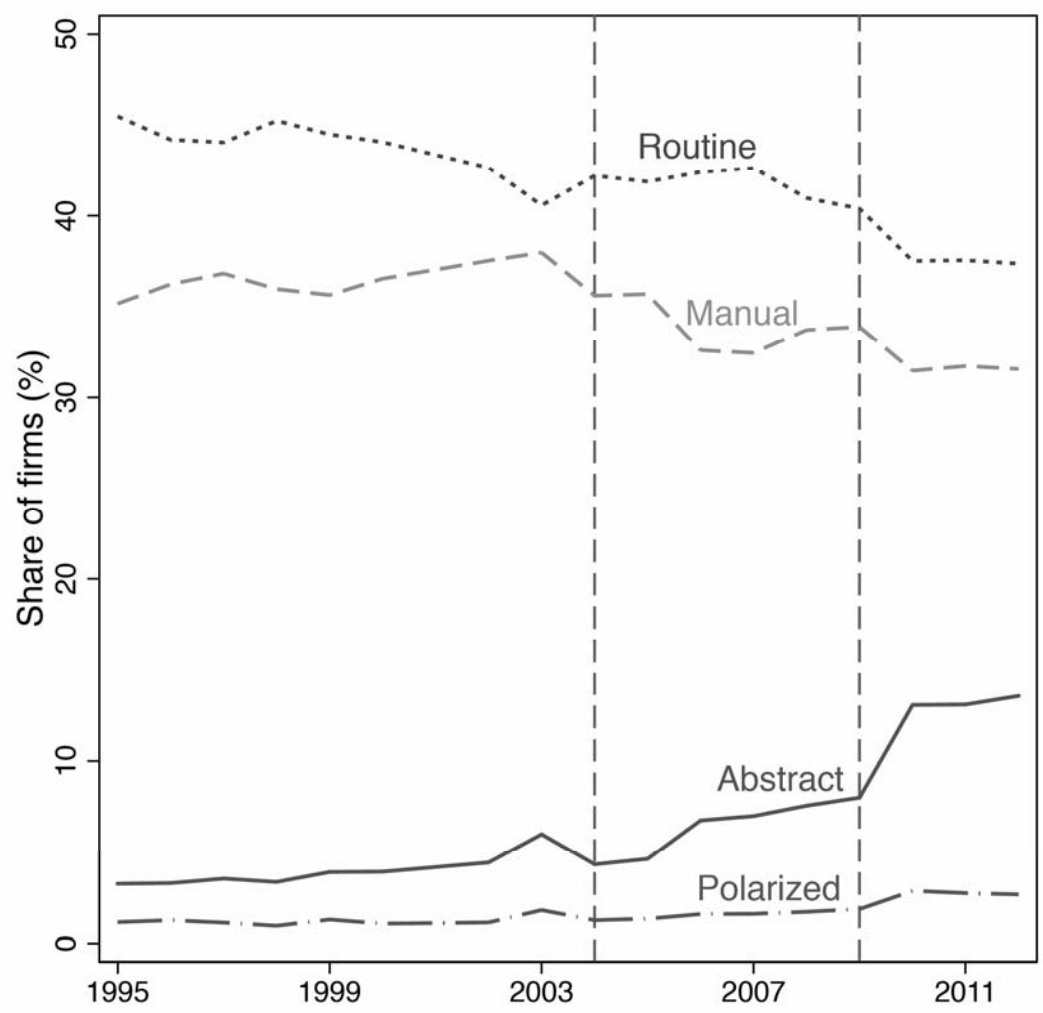
Taxonomy applied to 2009 Portuguese firms

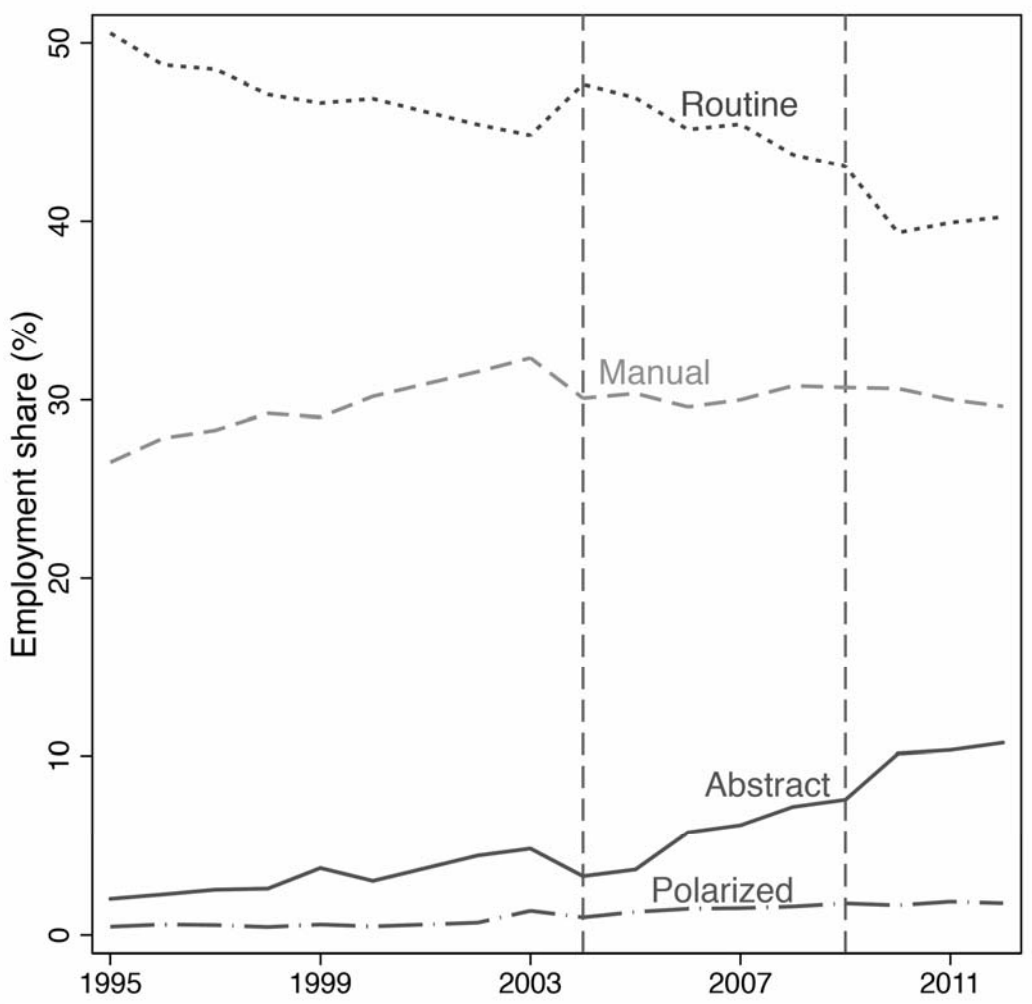
Notes: Unlabeled grey squares around the Uniform category correspond to category **Other**

A-R stands for Abstract-Routine

R-M for Routine-Manual.

Share of firms and employment by firm category





Link1

Summary statistics by firm category for 2009

	2009			
	All	Abstract	Routine	Manual
College	10.14	43.5	9.7	4.0
	(0.24)	(0.39)	(0.22)	(0.14)
Capital per employee	58.49	77.82	61.08	50.86
	(317.5)	(211.1)	(347.3)	(181.2)
VA per employee	20.82	32.50	22.61	15.94
	(60.5)	(76.2)	(61.2)	(20.1)
R&D expend. p.emp.	40.73	144.42	38.51	15.36
	(1155.61)	(1982.00)	(1187.75)	(467.46)

Notes: College refers to the share of college graduates in the firms' workforce. VA and capital are in thousands of 2009 euros. R&D expenditures per employee are in 2009 euros

Estimate productivity

Assume a Cobb-Douglas production function (in logs):

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \epsilon_{it}$$

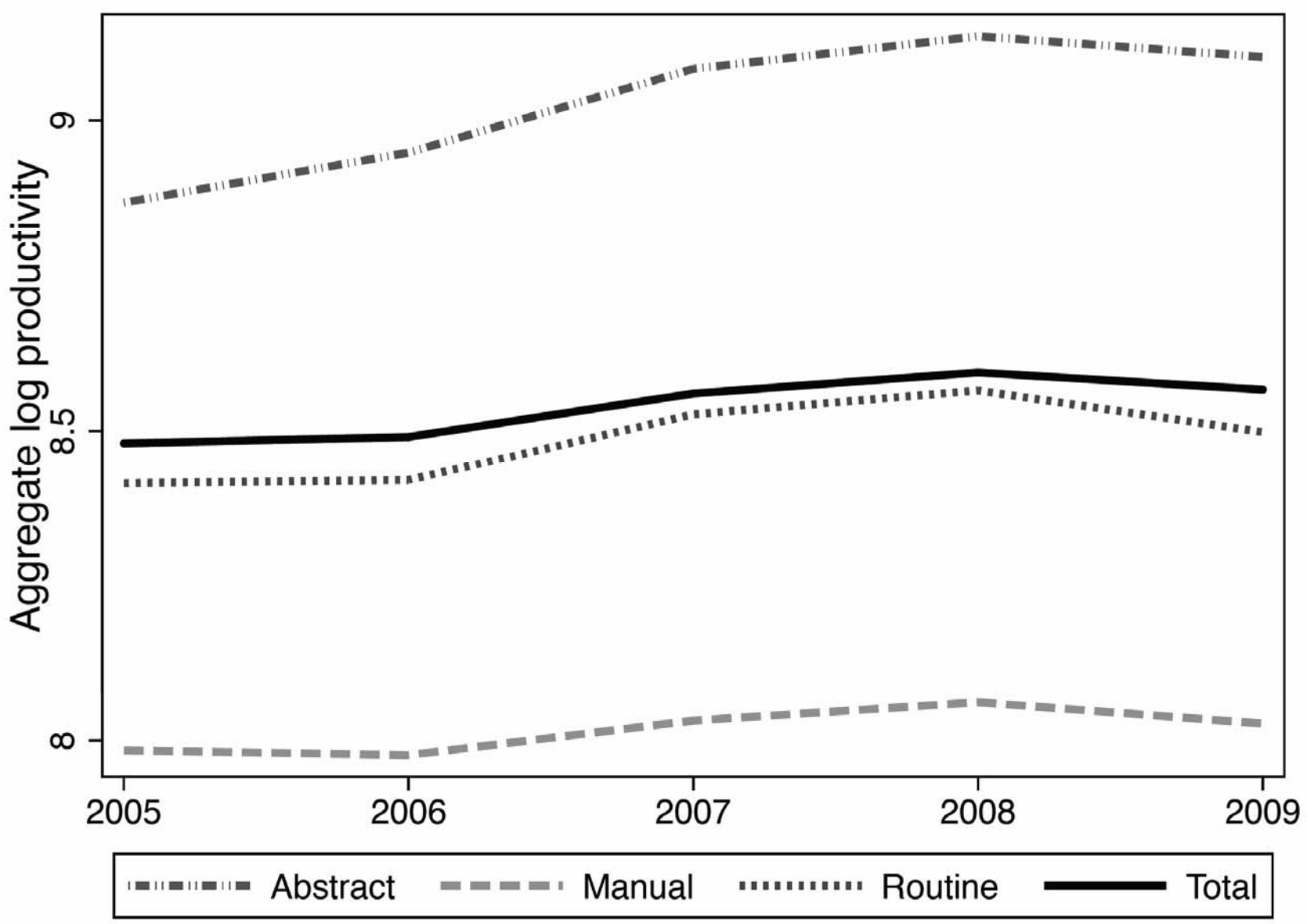
Total Factor Productivity (TFP): the residual

Estimating through OLS or FE lead to biased and inconsistent estimated because of simultaneity and selection

We approach the estimation problem using the ACF methodology (Ackerberg, Caves and Frazer, 2015)

For comparability, we also apply the methodologies of Olley and Pakes (1996) and Levinsohn and Petrin (2003)

Total factor productivity by firm category



Productivity dynamics

We extend Olley and Pakes (1996) and Melitz and Polanec (2015) decomposition methods to account for transitions between firm taxonomy categories:

$$\Delta\Phi = \Delta\bar{\phi}_S + \Delta cov_S + s_{E2}(\Phi_{E2} - \Phi_{S2}) + s_{X1}(\Phi_{S1} - \Phi_{X1}) + s_{E_{tr}2}(\Phi_{E_{tr}2} - \Phi_{S2}) + s_{X_{tr}1}(\Phi_{S1} - \Phi_{X_{tr}1})$$

Productivity growth decomposition
(without transitions between categories of the taxonomy)

	Total	Survivors		Entrants	Exitors
	Change	Avg prod	Reallocation		
2006	0.006	-0.035***	0.042***	-0.002**	0.001**
2007	0.011***	-0.044***	0.059**	-0.002**	-0.001**
2008	0.001***	-0.082***	0.07***	-0.002**	0.016**
2009	-0.001***	-0.113***	0.08***	0.002**	0.03

Notes:

- Decomposition performed using TFP results for all firms
- Average productivity (Avg prod) component refers to the change in the unweighted average productivity
- Reallocation component represents the market share reallocations
- Test the significance of the changes from the base year (2005) using the methodology proposed by Hyytinen, Ilmakunnas and Maliranta (2016)
- * 10% significant, ** 5% significant and *** 1% significant

Productivity growth decomposition by firm category

	Total	Survivors				Transitions	
	Change	Avg prod	Reallocation	Entrants	Exitors	Entrants	Exitors
Abstract							
2006	0.036***	-0.04***	0.009**	-0.005	0.003***	0.03	0.039**
2007	0.183***	-0.033***	0.013***	-0.007	0.019***	0.139	0.052***
2008	0.244***	-0.047***	0.112**	-0.013	0.034***	0.103	0.055***
2009	0.221***	-0.056***	0.161***	0.013	0.053***	-0.025	0.075***
Routine							
2006	0.005	-0.036***	0.053***	-0.003***	-0.002***	-0.01***	0.003**
2007	0.025***	-0.05***	0.097***	-0.006***	-0.008***	-0.01***	0.003***
2008	0.003***	-0.101***	0.101**	-0.005**	0.008***	-0.003***	0.004***
2009	-0.006***	-0.129***	0.112***	-0.014***	0.031***	-0.007***	0.001***
Manual							
2006	-0.013	-0.032***	0.038***	-0.005***	-0.006***	-0.009	0.001
2007	0.014***	-0.035***	0.065***	-0.004***	-0.013***	-0.001	0.002
2008	0.018***	-0.07***	0.098***	-0.008***	-0.004***	0.001	0.001
2009	-0.015***	-0.098***	0.09***	-0.011***	0.006***	-0.004	0.001*

Discussion and policy implications

Descriptive evidence point to polarization across firms, not within firms

The main driver of productivity growth has been the market share expansion of the most productive firms, followed by the exiting of the least productive

We have established a link between productivity growth and the organization of activities inside firms

Firms focusing in Abstract tasks are driving productivity growth

Discussion and policy implications

It is not surprising that Portugal is associated with low productivity, as its levels of physical and human capital are still well below the European average, comparable to similarly lagging European regions

Innovation policies directed at these regions require the development of innovation and knowledge capabilities to promote the growth and creation of competitive firms, and in turn productivity growth

Discussion and policy implications

Policy-makers need to consider innovation policies together with education and training policies

The high prevalence of long-term unemployment and the existence of large segments of the labor market where short duration and low-wage jobs prevail will probably persist or be aggravated with the deepening of the routinization process

The reverse is also true: the lack of the supply of skills will hamper the innovation capabilities of firms and regions

These structural imbalances reinforce the need do design policies that can form a coherent regional policy system to promote productivity growth and cohesion

Thank you

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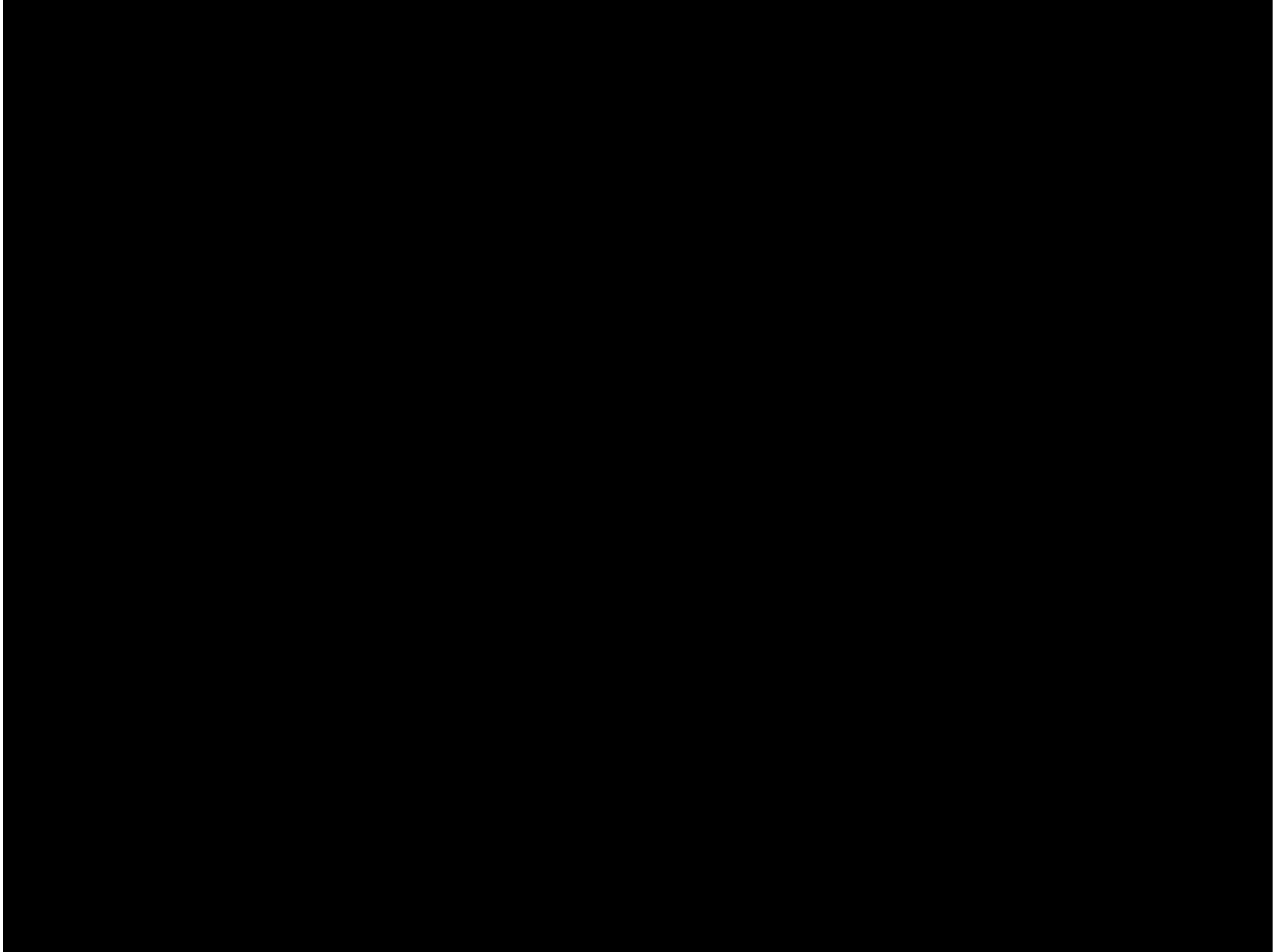


Table 2: Firms across industries and size (2004-2009)

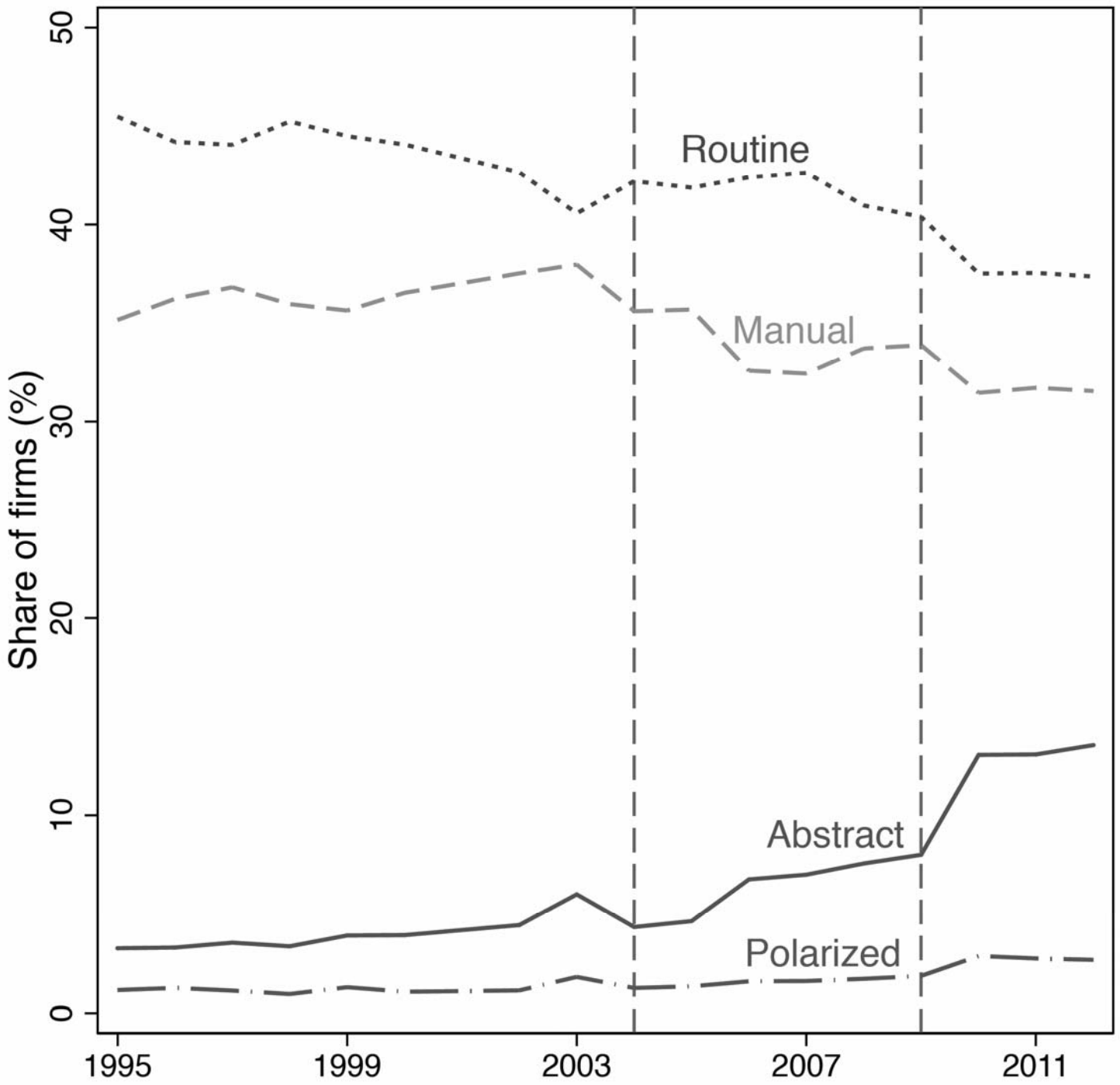
	2004	2005	2006	2007	2008	2009	Total
Manufacturing							
High-Tech	0.4	0.4	0.4	0.2	0.2	0.1	0.3
Medium-High-Tech	2.5	2.4	2.2	1.8	1.7	1.7	2.0
Medium-Low-Tech	10.1	9.8	8.4	6.6	6.2	6.1	7.8
Low-Tech	12.6	12.4	11.0	12.9	12.1	11.7	12.1
Services							
Knowl.-Intens.	11.9	12.3	21.8	17.3	18.3	19.0	17.1
Less Knowl.-Int.	62.4	62.6	56.2	61.2	61.5	61.3	60.8
Firm size							
[1,10[	75.1	75.5	76.6	76.1	76.7	77.1	76.2
[10,50[	21.0	20.8	19.6	20.2	19.6	19.4	20.0
[50,100[	2.3	2.2	2.1	2.1	2.1	2.0	2.1
[100,250[	1.1	1.1	1.1	1.1	1.1	1.1	1.1
>=250	0.5	0.5	0.5	0.5	0.5	0.5	0.5
No. observations	118,223	122,481	142,933	141,240	146,858	143,689	815,424

Table 3: Observed and theoretical uniform share of firms by firm category

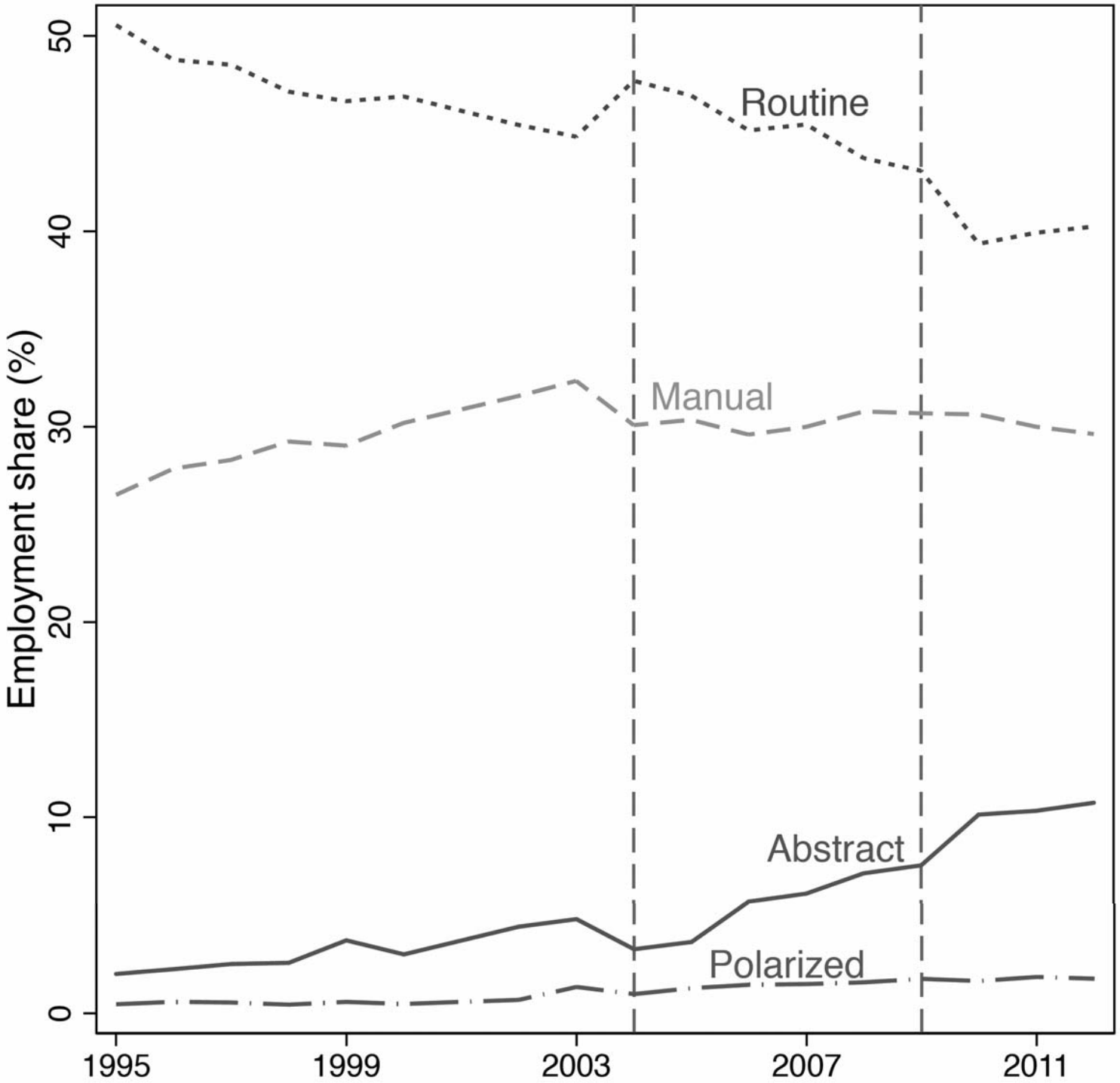
	Share of firms (%)					
Firm category	**1995-2012**	**1995**	**2004**	**2009**	**2012**	**Uniform distribution**
Abstract	6.44	3.25	4.32	7.99	13.54	19.44
Manual	34.74	35.17	35.61	33.89	31.55	19.44
Routine	41.98	45.48	42.20	40.39	37.37	19.44
Polarized	1.61	1.15	1.25	1.86	2.67	8.33
Abstract-Routine	3.99	3.13	2.81	4.05	6.29	8.33
Routine-Manual	10.08	10.74	12.81	10.66	6.97	8.33
Uniform	0.48	0.42	0.38	0.48	0.67	5.56
Other	0.69	0.66	0.62	0.69	0.95	11.11

Note: The theoretical uniform distribution arises from assuming firms equally distributed across the space defined by the three tasks. The years 2004-2009 correspond to the two datasets merged.

	2004				2009			
	All	Abstract	Routine	Manual	All	Abstract	Routine	Manual
Firm size								
[1,10[	75.66	80.4	72.3	79.0	77.46	79.5	76.0	78.7
[10,50[	20.52	16.4	22.7	18.4	18.99	17.2	19.8	18.4
[50,100[	2.22	1.9	2.8	1.5	2.03	1.9	2.3	1.7
[100,250[	1.12	0.9	1.5	0.7	1.04	0.9	1.3	0.8
>=250	0.49	0.3	0.6	0.4	0.48	0.6	0.5	0.4
Mean (no. employees)	13.72	10.5	15.7	11.7	13.61	13.0	14.7	12.5
	(97.86)	(45.81)	(117)	(74.84)	(124.58)	(92.89)	(150.62)	(92.76)
Mean firm age	15.92	10.96	15.98	16.45	14.89	12.19	15.28	15.06
	(13.09)	(10.26)	(13.52)	(12.83)	(13.18)	(9.8)	(13.6)	(13.28)
Manufacturing								
High-Tech	0.4	2.9	0.3	0.2	0.1	0.3	0.2	0.1
Medium-High-Tech	2.4	2.0	1.4	3.6	1.6	2.0	1.1	2.1
Medium-Low-Tech	10.7	1.3	10.7	11.9	6.1	1.4	2.9	11.0
Low-Tech	12.7	3.4	19.6	5.7	12.2	1.1	20.6	4.9
Services								
Knowl.-Intens.	10.7	60.3	8.5	7.4	17.3	69.8	15.4	7.1
Less Knowl.-Int.	63.1	30.1	59.6	71.2	62.7	25.5	59.9	74.9
College	5.29	28.2	5.2	3.0	10.14	43.5	9.7	4.0
	(0.17)	(0.36)	(0.16)	(0.12)	(0.24)	(0.39)	(0.22)	(0.14)
Capital per employee	44.77	59.83	48.22	38.85	58.49	77.82	61.08	50.86
	(292.4)	(211.1)	(390.4)	(105.4)	(317.5)	(211.1)	(347.3)	(181.2)
VA per employee	19.09	31.22	21.05	15.28	20.82	32.50	22.61	15.94
	(51.00)	(76.2)	(64.3)	(18.8)	(60.5)	(76.2)	(61.2)	(20.1)
R&D expend. p.emp.*	40.82	114.81	41.97	20.02	40.73	144.42	38.51	15.36
	(1012.41)	(1951.90)	(1045.94)	(587.94)	(1155.61)	(1982.00)	(1187.75)	(467.46)
No. Observations	118,223	5,108	49,894	42,099	143,689	11,478	58,037	48,690



Share of firms by firm category



Share of employment by firm category

Back1

Table A4.1: Allocation between occupations and tasks

Abstract

21	Physical, mathematical and eng. science prof.
24	Other professionals
23	Teaching professionals
31	Physical and eng. science associate prof.
33	Teaching associate professionals
12+13	Small enterprises & corporate managers
22	Life science and health professionals
32	Life science and health associate prof.

Routine

34	Other associate professionals
41	Office clerks
42	Customer services clerks
52	Models, salespersons and demonstrators
73	Precision, handicraft, print. and rel. trades work.
74	Other craft and related trades workers
81	Stationary-plant and related operators
82	Machine operators and assemblers

Manual

51	Personal and protective services workers
91	Sales and services elementary occupations
71	Extraction and building trades workers
72	Metal, machinery and related trades workers
83	Drivers and mobile-plant operators
93	Laborers in mining, const., manuf. and transp.

Table A4.3: Production function descriptive statistics by year

	2004	2005	2006	2007	2008	2009	2004-2009
log VA	11.26	11.38	11.38	11.41	11.40	11.34	11.24
	(1.46)	(1.42)	(1.42)	(1.43)	(1.45)	(1.45)	(1.48)
log capital	11.76	11.94	11.96	11.96	11.98	11.94	11.78
	(1.71)	(1.66)	(1.66)	(1.65)	(1.66)	(1.68)	(1.72)
log labor	1.72	1.79	1.78	1.75	1.75	1.71	1.67
	(1.04)	(1.05)	(1.05)	(1.07)	(1.07)	(1.06)	(1.06)
log intermediate	11.56	11.69	11.74	11.17	11.12	10.97	11.10
	(2.1)	(2.05)	(1.99)	(2.5)	(2.52)	(2.48)	(2.43)
log investment	8.39	8.79	8.88	8.94	8.85	8.62	8.78
	(2.52)	(2.78)	(2.43)	(2.4)	(2.42)	(2.45)	(2.48)
Observations	118,223	122,481	142,933	141,240	146,858	143,689	815,424

Notes: Working data for 2004-2009 used for ACF estimation. Intermediate inputs are the sum of materials and energy. All values, except labor, are in 2009 euros (GDP deflator). Labor refers to the number of employees. Standard deviation between parenthesis.

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