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Automation and Firm Performance

Lene Kromann

Sesam seminar nr. 102 hos Vattenfall A/S

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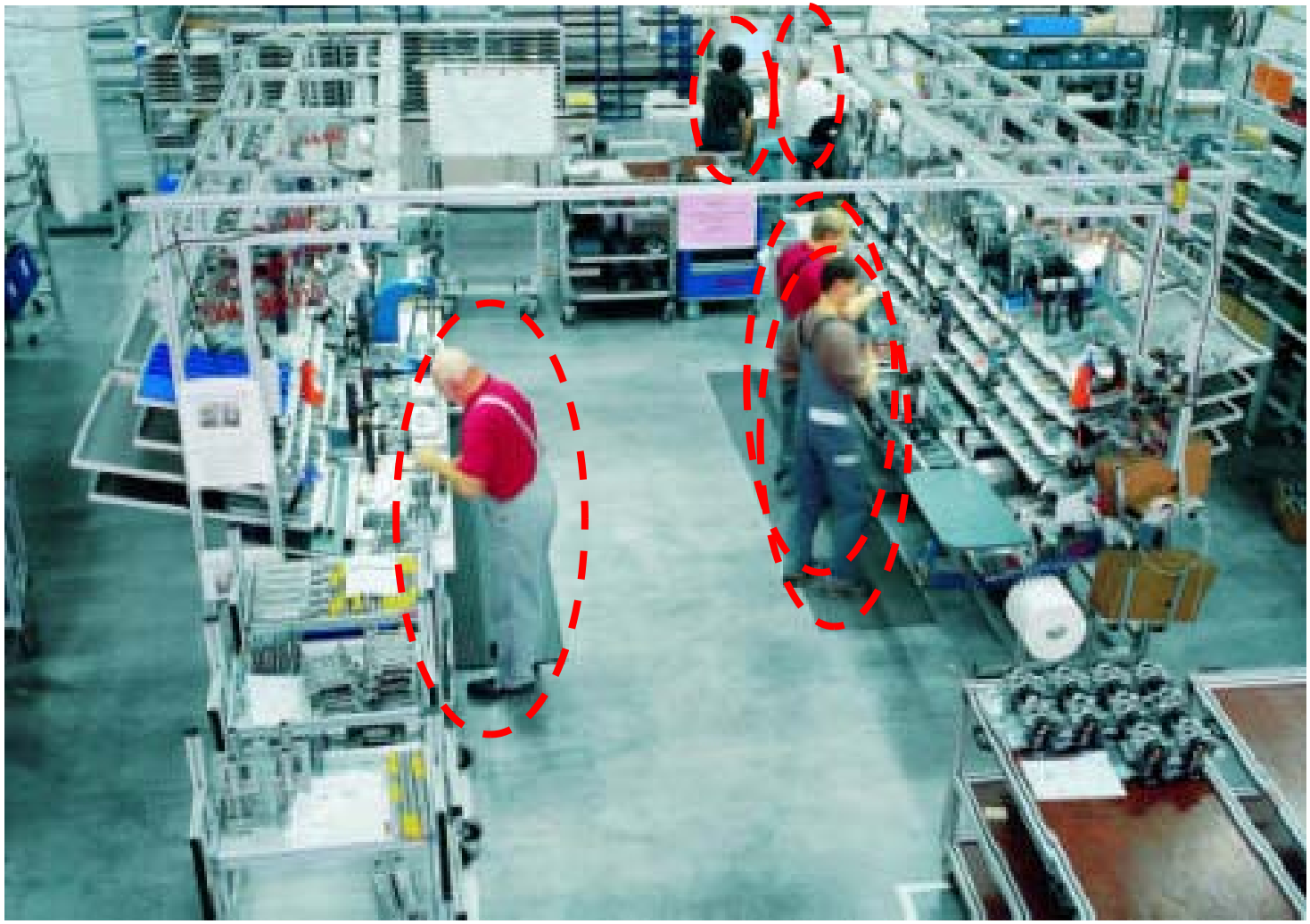

Where are we going…

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Is this the future?

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Reasons for international outsourcing

	Main reason	Secondary reason	Not important	Not relevant
Lower salaries	0.58	0.19	0.09	0.14
Lower production cost other than salaries	0.39	0.34	0.11	0.17
Access to new markets	0.13	0.16	0.43	0.28
Focus on their core activity	0.23	0.31	0.21	0.25
Decided by the parent firm	0.23	0.09	0.32	0.36
…				

Other reasons: higher quality or introduciton of new products; lack of workers in DK; To do as our competitors; access to specialized knowledge or technology, tax reductions; less regulations; Other motives

Source: Danish questionnaire on outsourcing

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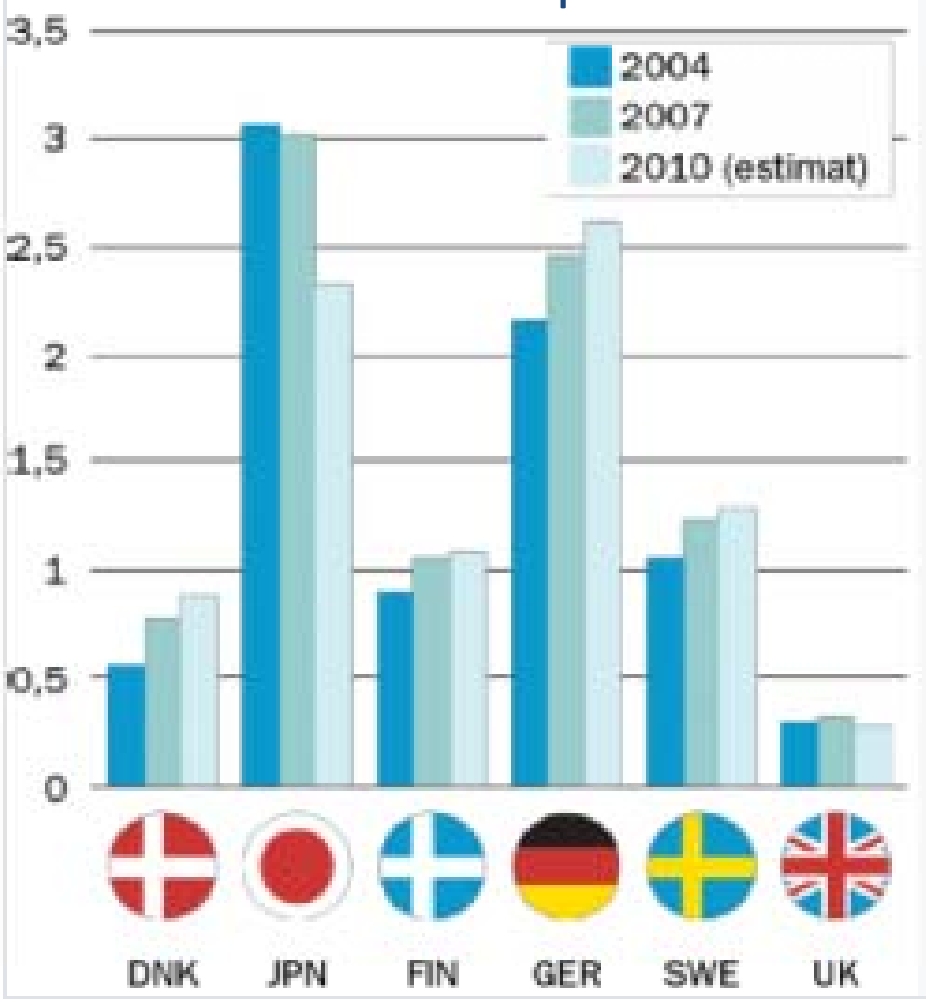
Industrial robots

Number of industrial robots per million working hours



Source: Kromann, Skaksen og Sørensen (2012)

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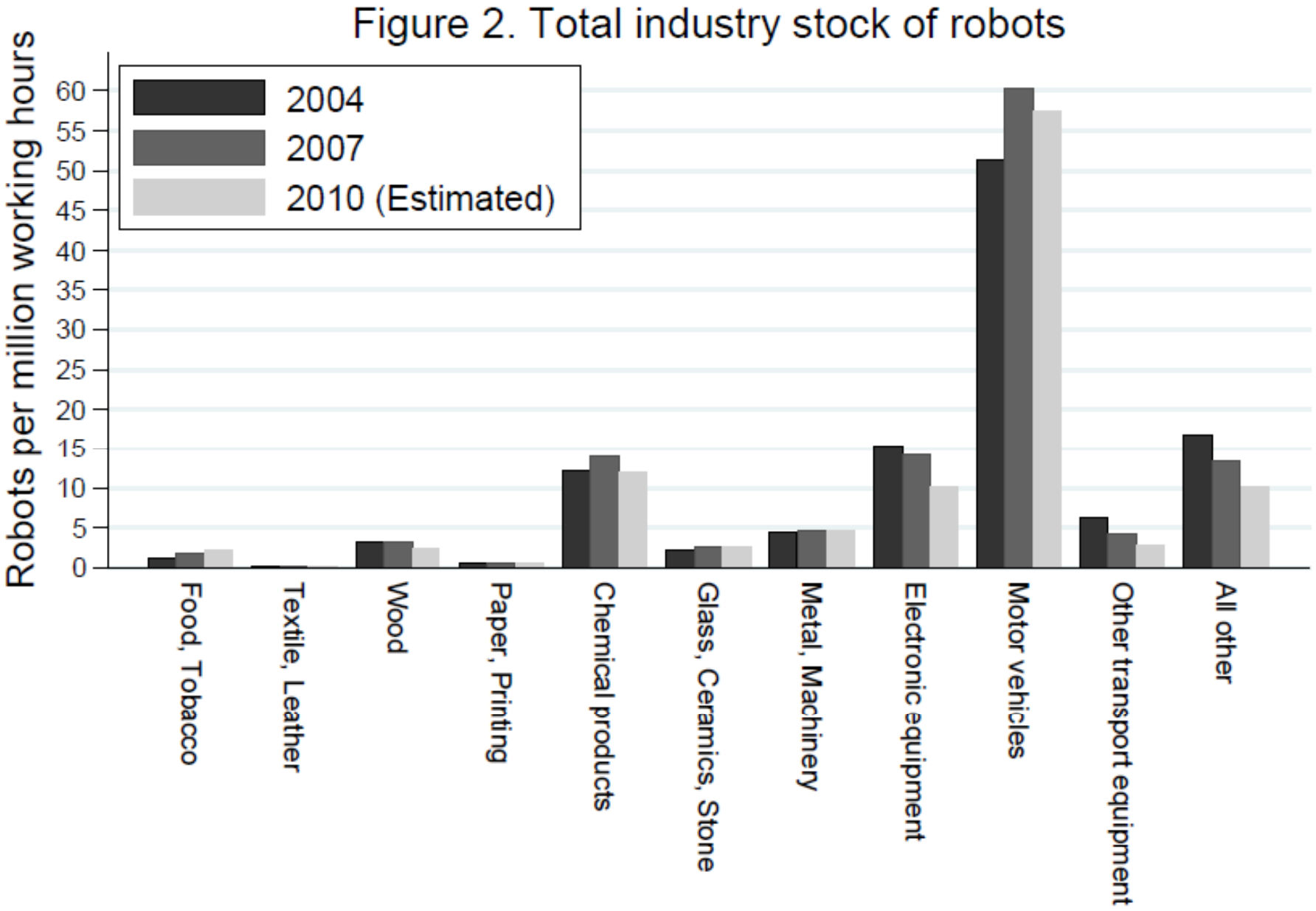

Source: Kromann, Skaksen og Sørensen (2012)

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Outline of the talk

Automation and Firm Performance:

- The Questionnaire
  - *Literature*
  - *Development of the AIM questionnaire*
  - *Contents of the questionnaire (85 questions)*
- Automation
  - *The mechanization of the production process*
  - *The digitalization of the production process*
- Other management practices
  - *Waste minimization, (TQM, SCM)*
  - *Total productive maintenance*
  - *Performance monitoring, decentralization, people management*
- Register data
- Individual effects and Synergetic effects on firm performance
  - *Mechanization, digitalization*
- *Interactive Benchmarking (hvis tiden tillader)*

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The Questionnaire

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Development of the questionnaire

- CBS made the first version of the AIM questionnaire (jan 2011)
- Workshop internally in the AIM group (feb 2011)
  - Economists, engineers, consultants, and suppliers of technology
- Workshop with 10 companies at Grundfos (april 2011)
  - Which ”areas” in the firm is relevant for the competitiveness
  - How to ask the questions
  - Which survey method to use
- Visited 15 manufacturing firms (summer 2011)
  - Introduced to the firm and their production
  - Filled in the questionnaire (time and filled it in ourself)
  - Discussed pros and cons of the questionnaire
- 30 companies filled in the questionnaire (dec 2011-feb 2012)
  - Reformulated questions
  - Added help text to many of the questions
- Final version of the questionnaire: March 2012
- Goal: 600 responses (response rate of 50% or more)
- Now: 475 responses (response rate of 40%)

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AIM Questionnaire

1. **Implementation of automation** (7 spg) *
2. **General characteristics of the firm's production** (3 spg)
3. **-> Mechanization of processes** (7 spg) *
4. **-> Increased use of IT** (4 spg) *
5. **Overall characteristics of the firm's production systems** (4 spg) *
6. **-> Tools for making the best use of technology** (5 spg)
7. **-> Improving waste management: Is there a focus on ...** (8 spg)
8. **-> Use of performance management** (11 spg)
9. **Employee competence** (12 spg)
10. **The firm's results and goals** (15 spg)
11. **The market** (1 spg)
12. **Integrated development** (5 spg)
13. **-> Allocation of technical workers** (3 spg)

TOTAL: 85 Questions

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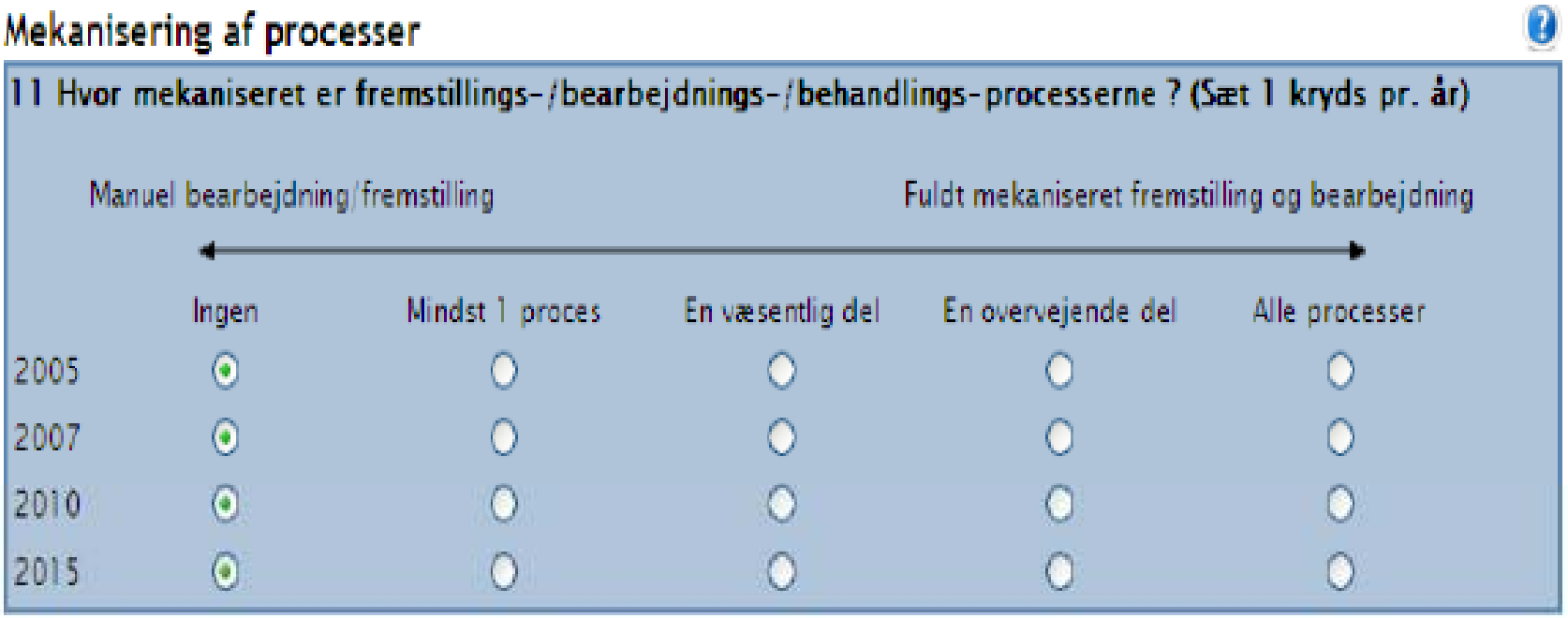
Online questionnaire



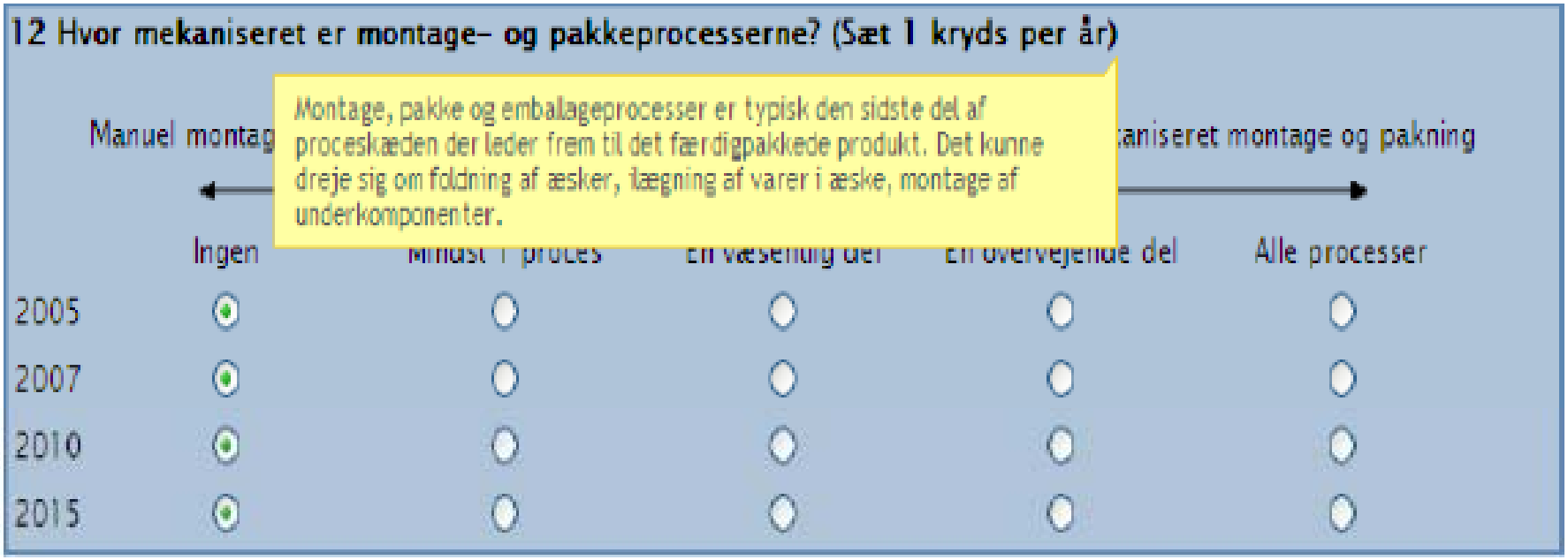
Mekanisering af processer

11 Hvor mekaniseret er fremstillings-/bearbejdnings-/behandlings-processerne ? (Sæt 1 kryds pr. år)

Manuel bearbejdning/fremstilling → Fuldt mekaniseret fremstilling og bearbejdning

	Ingen	Mindst 1 proces	En væsentlig del	En overvejende del	Alle processer
2005	◉	○	○	○	○
2007	◉	○	○	○	○
2010	◉	○	○	○	○
2015	◉	○	○	○	○

Online questionnaire



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Automation

Definition and descriptive figures

Typical measures: Expenditures on R&D, patents, ICT capital or the answers to survey questions on innovation activities, types of technologies used.

Our measure: What are the consequences of the technologies used on the individual stages in the production process.

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Mechanization of the production process

Mechanization: The proportion of the processes carried out mechanically rather than manually. In other words, reducing manual input in the manufacture of the product and its way through the production process.

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Mechanization of processes

11) How mechanized are the manufacturing, processing and handling processes?
12) How mechanized are the assembly and packaging processes?
13) How mechanized are the firm's inventory processes?
14) How mechanized is the material handling/feeding of components and raw materials between/to the manufacturing, processing, assembly, packaging and inventory processes?
15) How mechanized are the changeover processes in your manufacturing, processing, assembly and packaging?
16) How mechanized is the inspection of work pieces in the manufacturing, processing, assembly and packaging processes?

Manual → Fully-mechanized

	None	At least 1 process	A significant portion	A predominant portion	All processes
2005					
2007					
2010					
2015					

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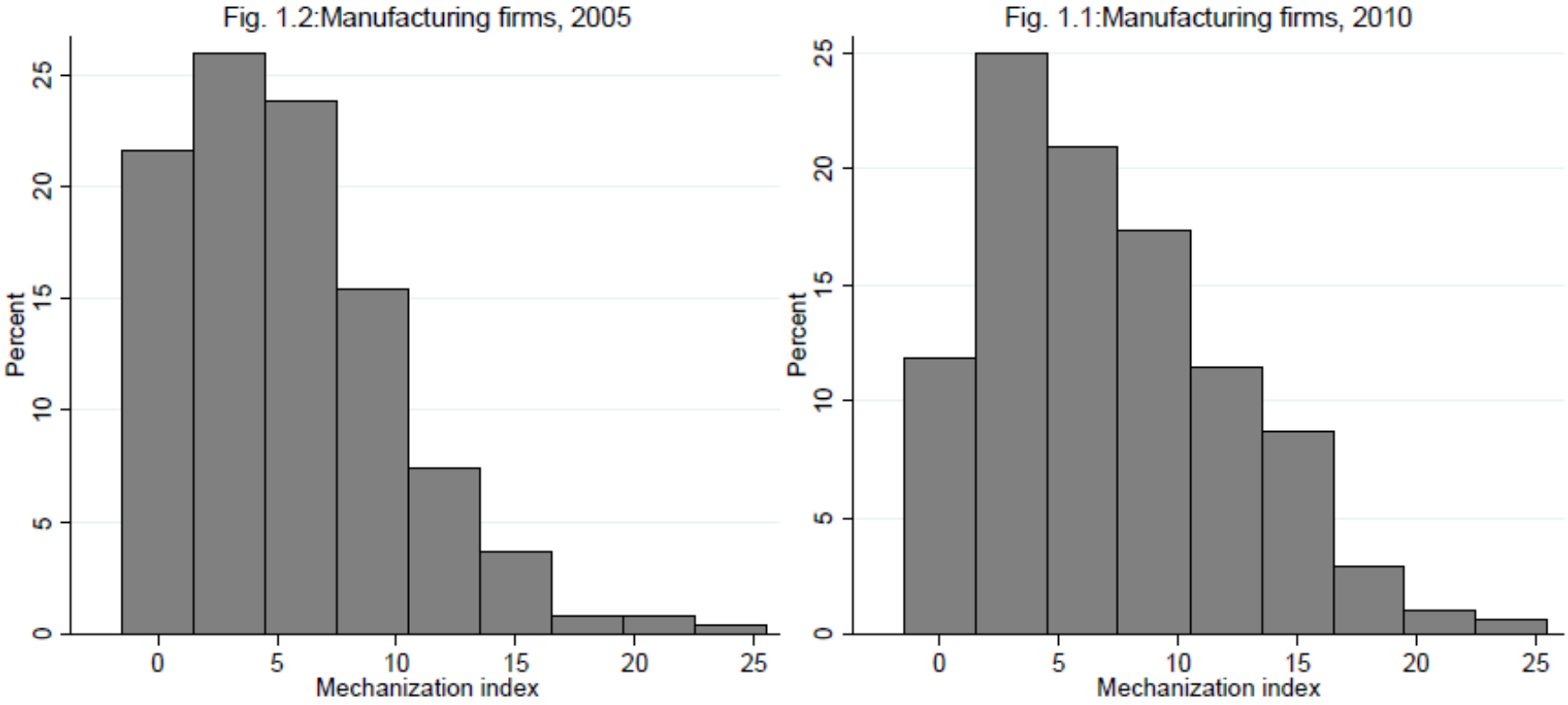
Mechanization of processes

Figure 1:Mechanization index and score



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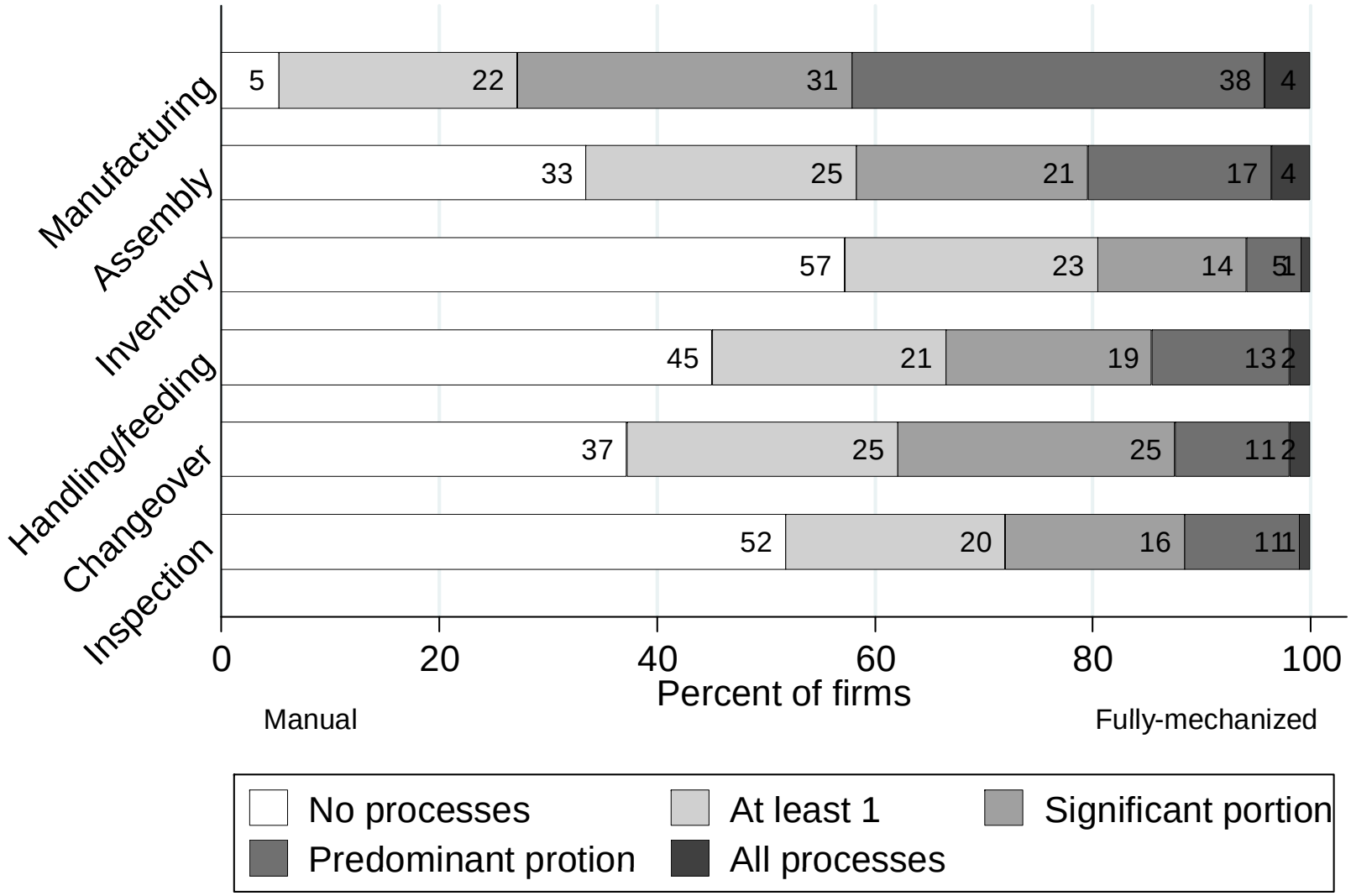
Mechanization



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Inspection and manufacturing process

Fig. 1.5:Inspection of work pieces

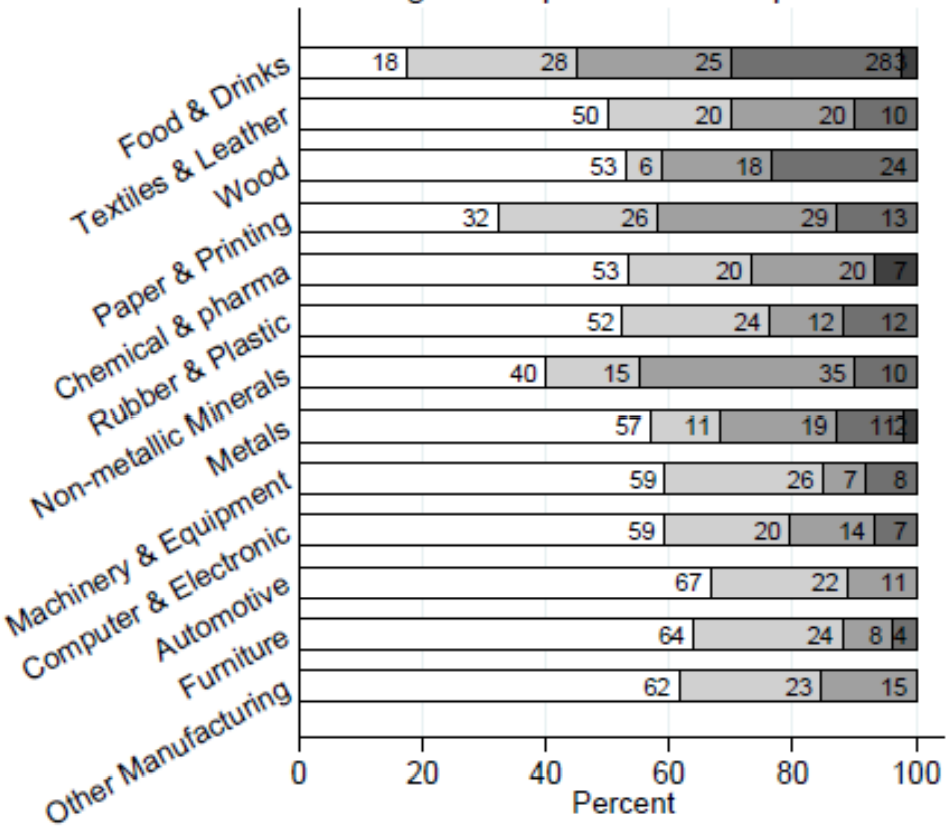
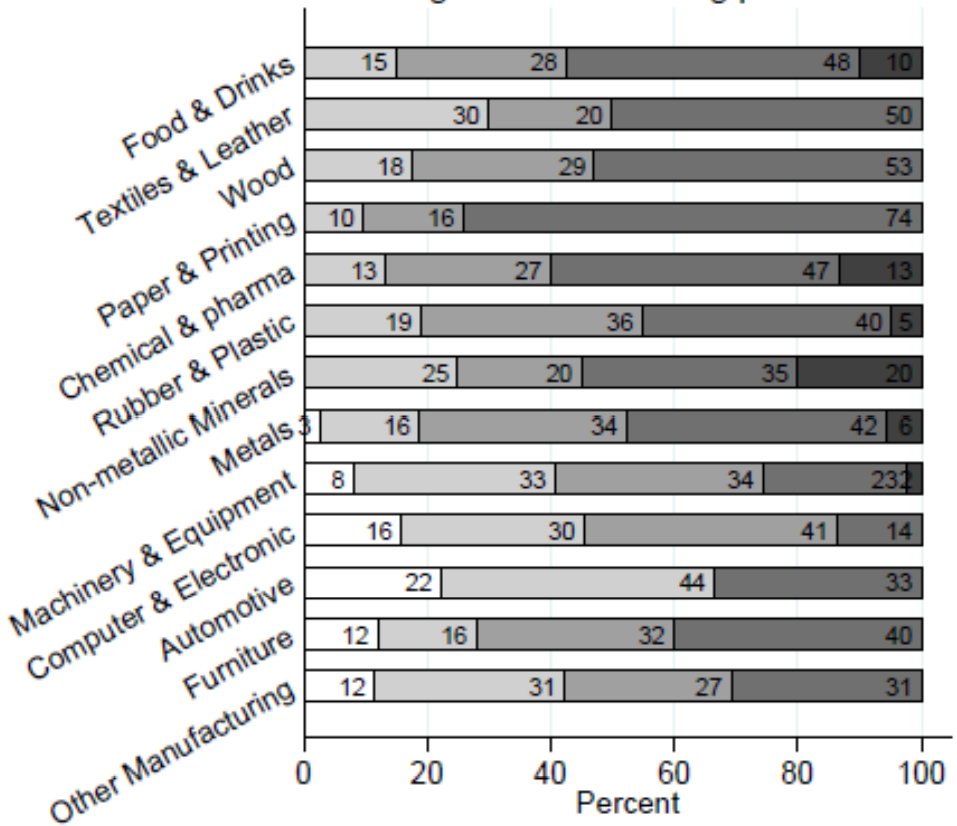


Fig. 1.6:Manufacturing process



Source: AIM survey and register data on 472 Danish manufacturing firms

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Digitalization of the production proces

Digitalization: The proportion of processes using IT systems to optimize the use of equipment rather than an employee selects the next job, consider process settings, and monitor the quality of products. In other words, digitalization measures the reduction of manual intervention in execution, inspection, tracking, and phasing-in of new products.

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Digitalization

18) How automatized is the execution (scheduling and start-up) of jobs run on the mechanized equipment?
19) How automatized is the process control (continuous correction of machine settings) of the mechanized processes?
20) To what extent is tracking used (continuous registration of process data for the individual product)?
21) How automatized is the phasing-in of new products on the mechanized equipment?

Operator-driven ⟷ Fully-automatized execution

	No automation	At least 1 aspect on at least 1 station/line	A significant portion	A predominant portion	All aspects of execution for all processes
2005					
2007					
2010					
2015					

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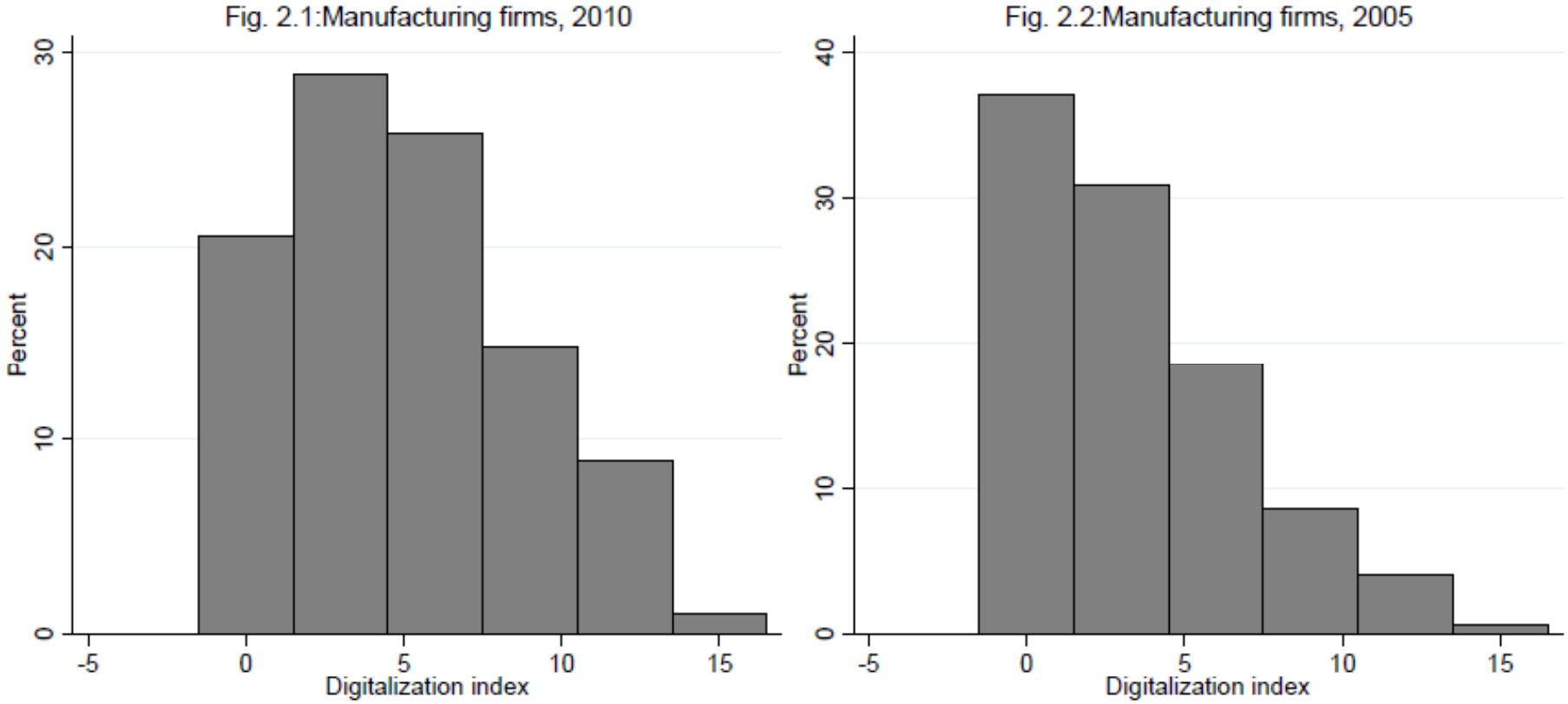
Digitalization

Figure 2:Digitalization and mechanization index and score



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Digitalization

Fig. 2.3:Execution

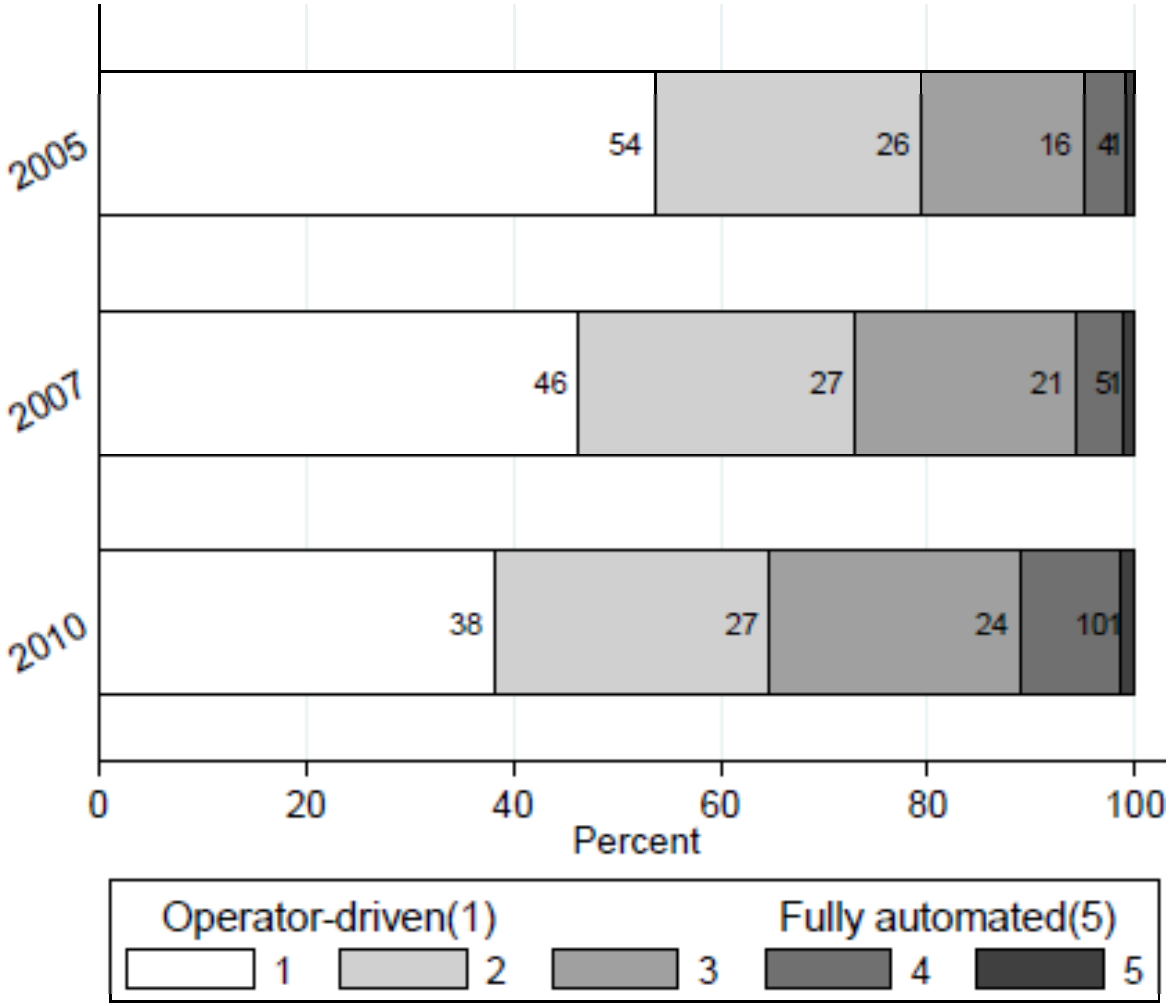

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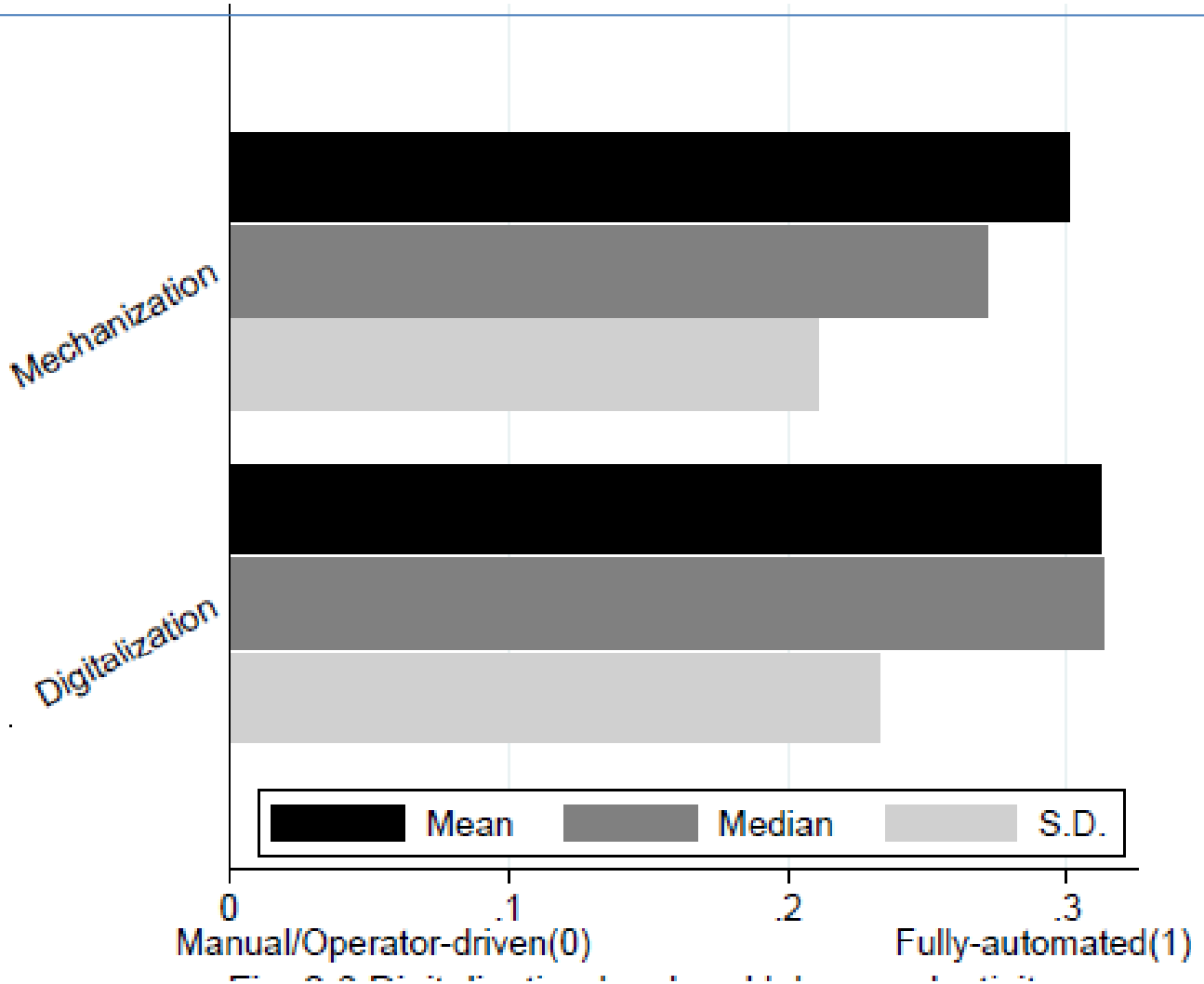
Fig. 2.4: Average mechanization/digitalization rate



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Labor productivity

Fig. 2.5:Mecahnization level and labor productivity

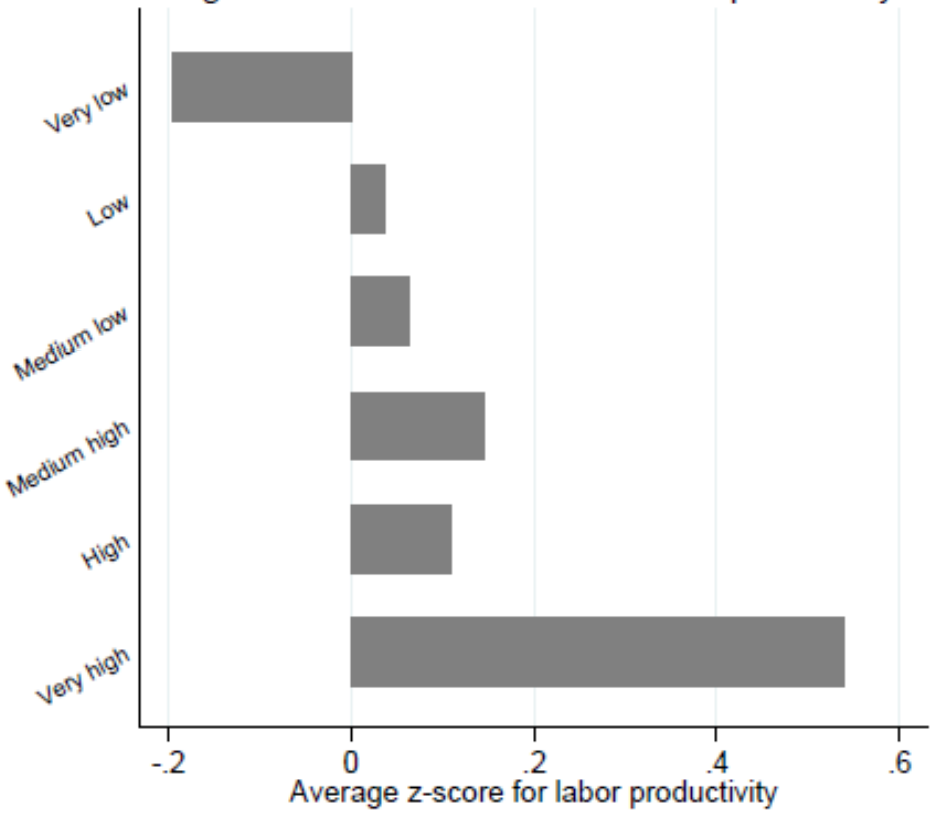
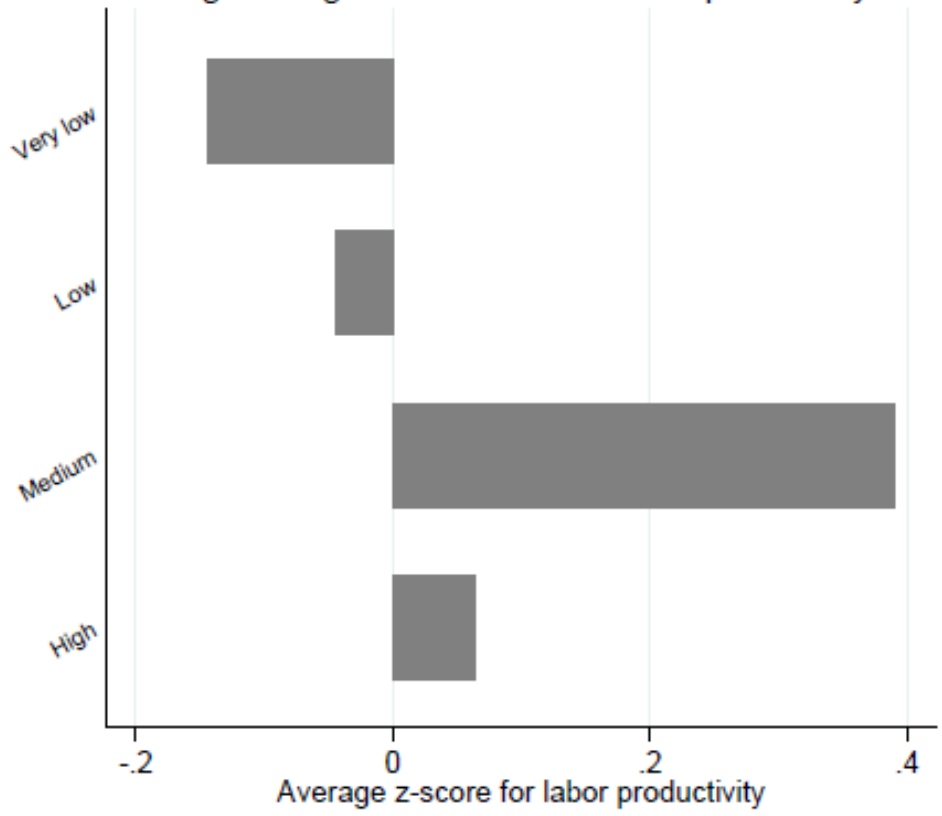


Fig. 2.6:Digitalization level and labor productivity



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Other management practices

Definition and descriptive figures

- **Minimize all kind of waste (JIT);**
- Are decisions about daily operations the responsibility of the workers (DEC);
- Let a high level of product and process quality be the responsibility of the workers (TQM);
- Does the firm cooperate and exchange knowledge with suppliers(SCM);
- **Internal productive maintenance (TPM);**
- People management;
- Performance management/monitoring (KPI);

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Improving waste management

31) Minimizing **defects** in production (including material waste and disposal of raw materials or work-in-progress)?
32) Minimizing the **overproduction** of goods in the production process?
33) Minimizing the **inventory of unfinished goods**?
34) Eliminating **processes that do not add value** for the customers or employees (for example, removing problems instead of using inspection or reprocessing)?
35) Rationalizing **worker movement**?
36) Reducing **transport and goods** handling?
37) Minimizing **waiting time** for other processes?
38) Using **employees' talents and knowledge** sharing optimally?

No focus ⟷ Strong focus

	1	2	3	4	5
2005					
2007					
2010					

Fig. 3.5:Manufacturing firms, 2005

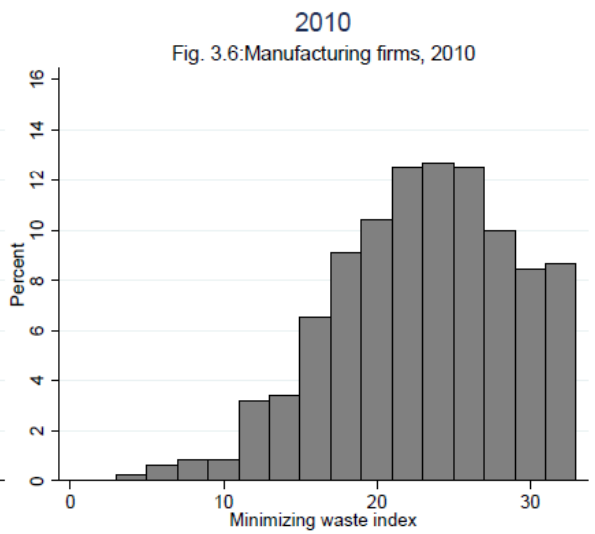


Fig. 3.6:Manufacturing firms, 2010

Management practices (combined index)

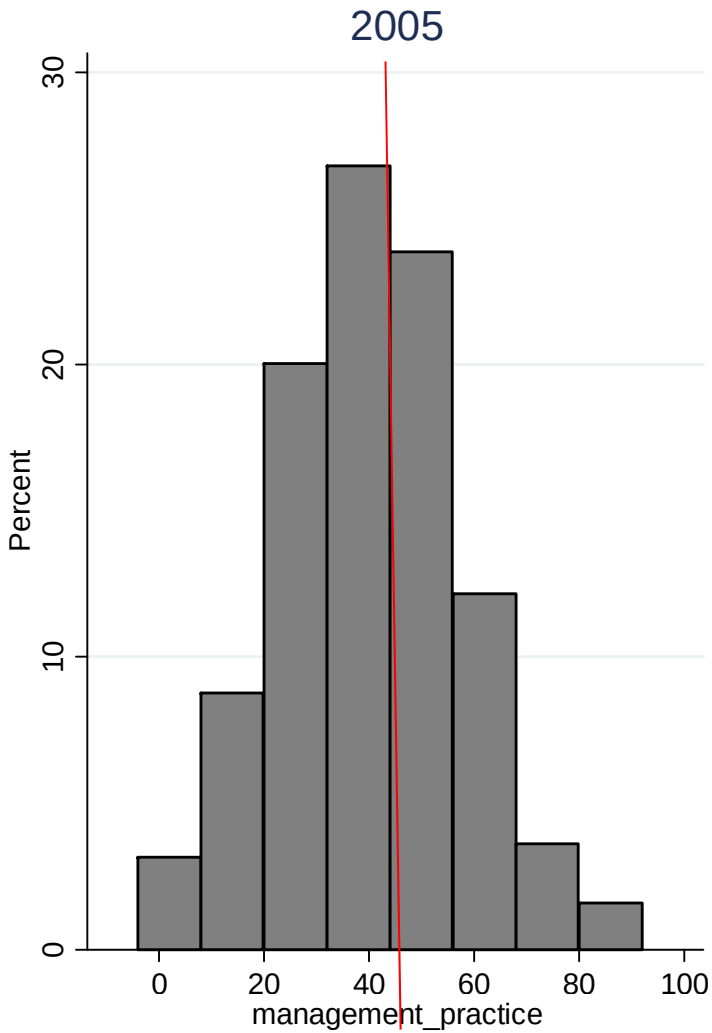
- **Improving waste**
- **Decentralization**
- **Performance monitoring**

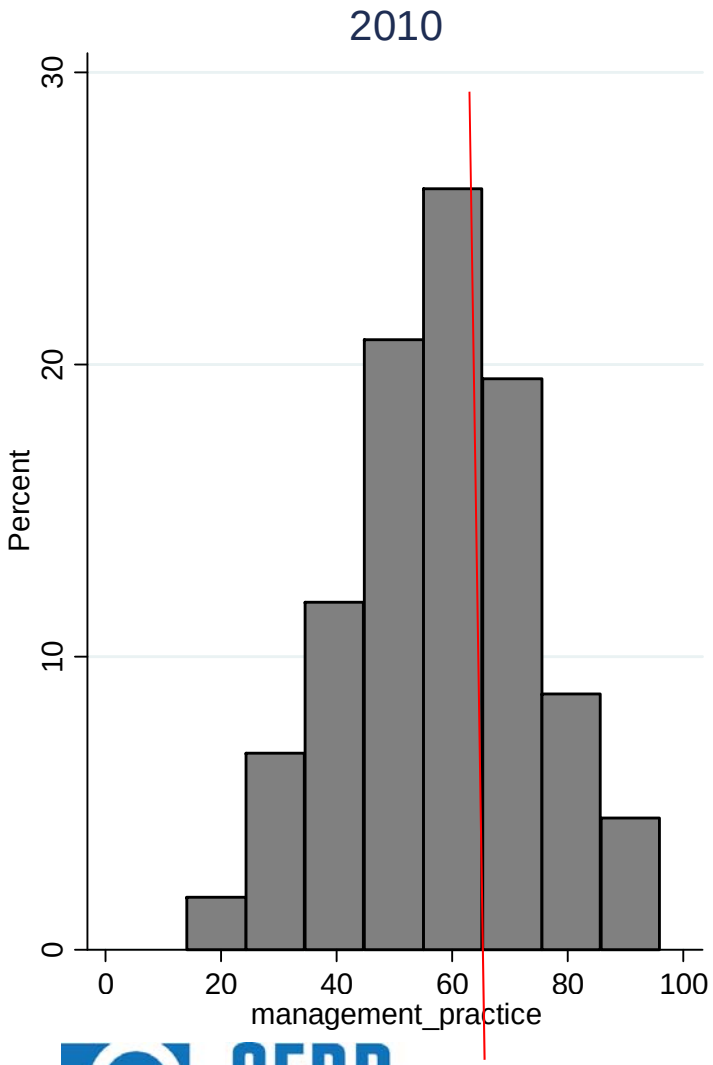
39)How many key performance indicators are used for managing daily production?
40)How often are the key performance indicators that are used to monitor daily production measured or computed?
41) Are key performance indicators and general business goals aligned?
42) Communication of key performance indicators concerning daily operations
43) Follow-up on key performance indicators concerning daily operations.

- **People management**

44)Does the workplace have a systematic approach for identifying efficient production workers who achieves results?
45)Does the workplace have a systematic approach for identifying inefficient and ineffective production workers who do not achieve results?
47) What proportion of production employee wages are performance-based?
53) To what extent are learning from problem-solving collected and used?

Management practices





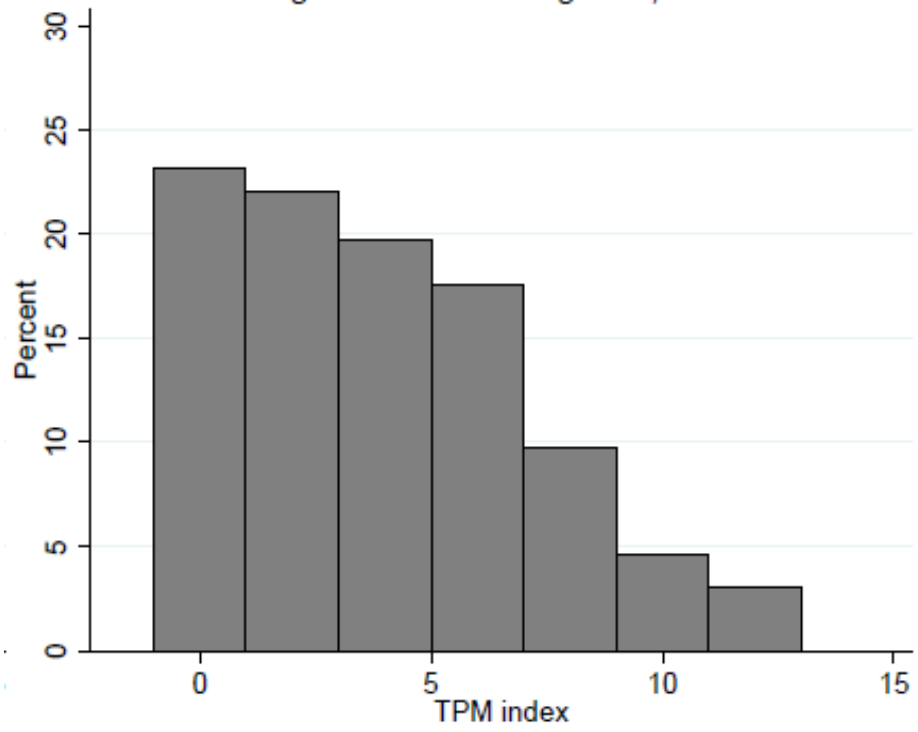
Total productive maintenance

1.To what extent does the firm use TPM (building up internal maintenance competence, using preventive maintenance)

Index quesitons:

1. How many workers are allocated to the maintenance of existing machinery?
2. How many workers are allocated to the introduction of new production processes, machinery and systems
3. How many workers are allocated to improving existing machinery?

Fig. 6.4:Manufacturing firms, 2010



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Total productive maintenance

Fig. 6.5:Use of TPM and mechanization

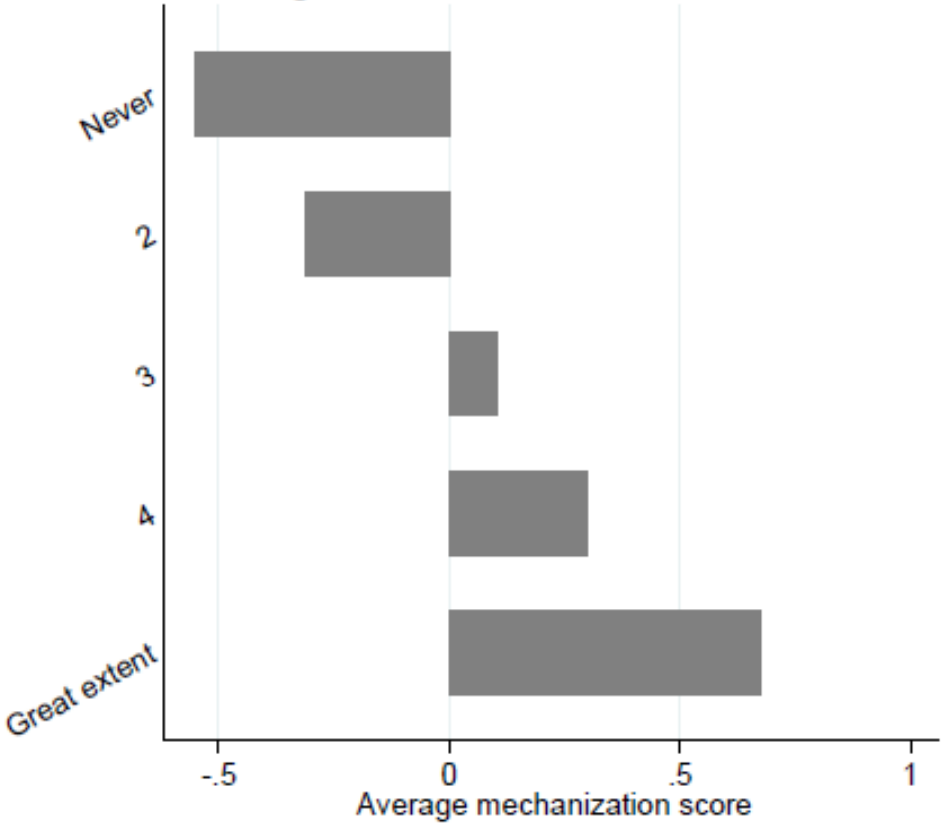
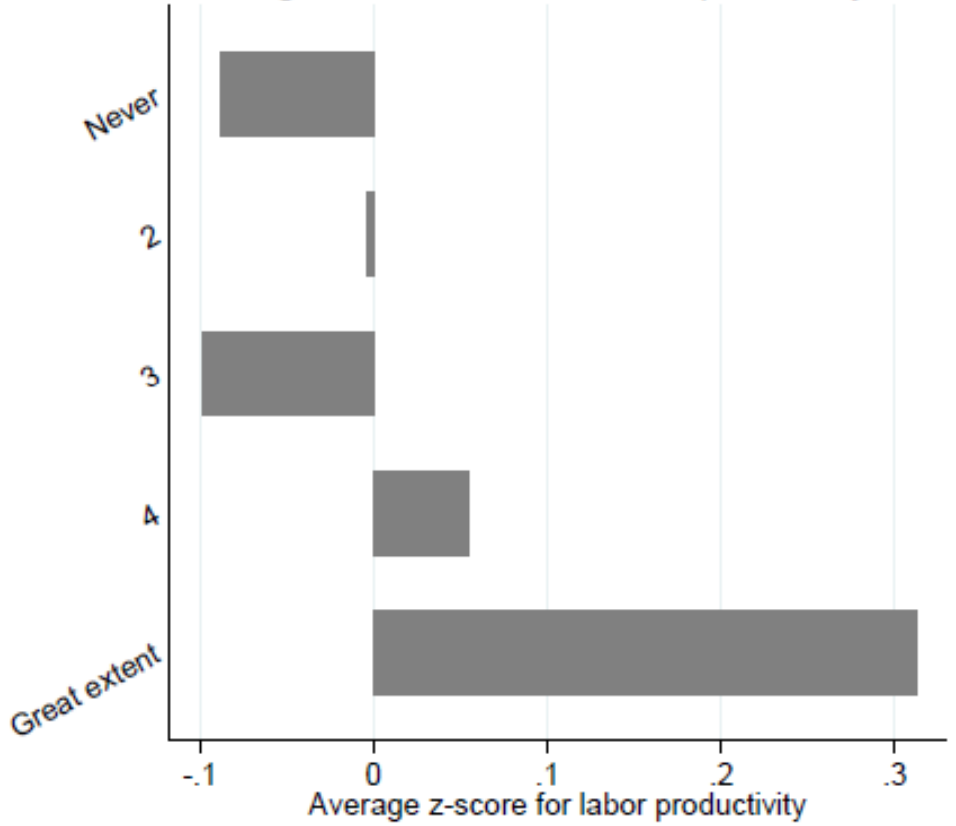


Fig. 6.6:Use of TPM and labor productivity



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Register data

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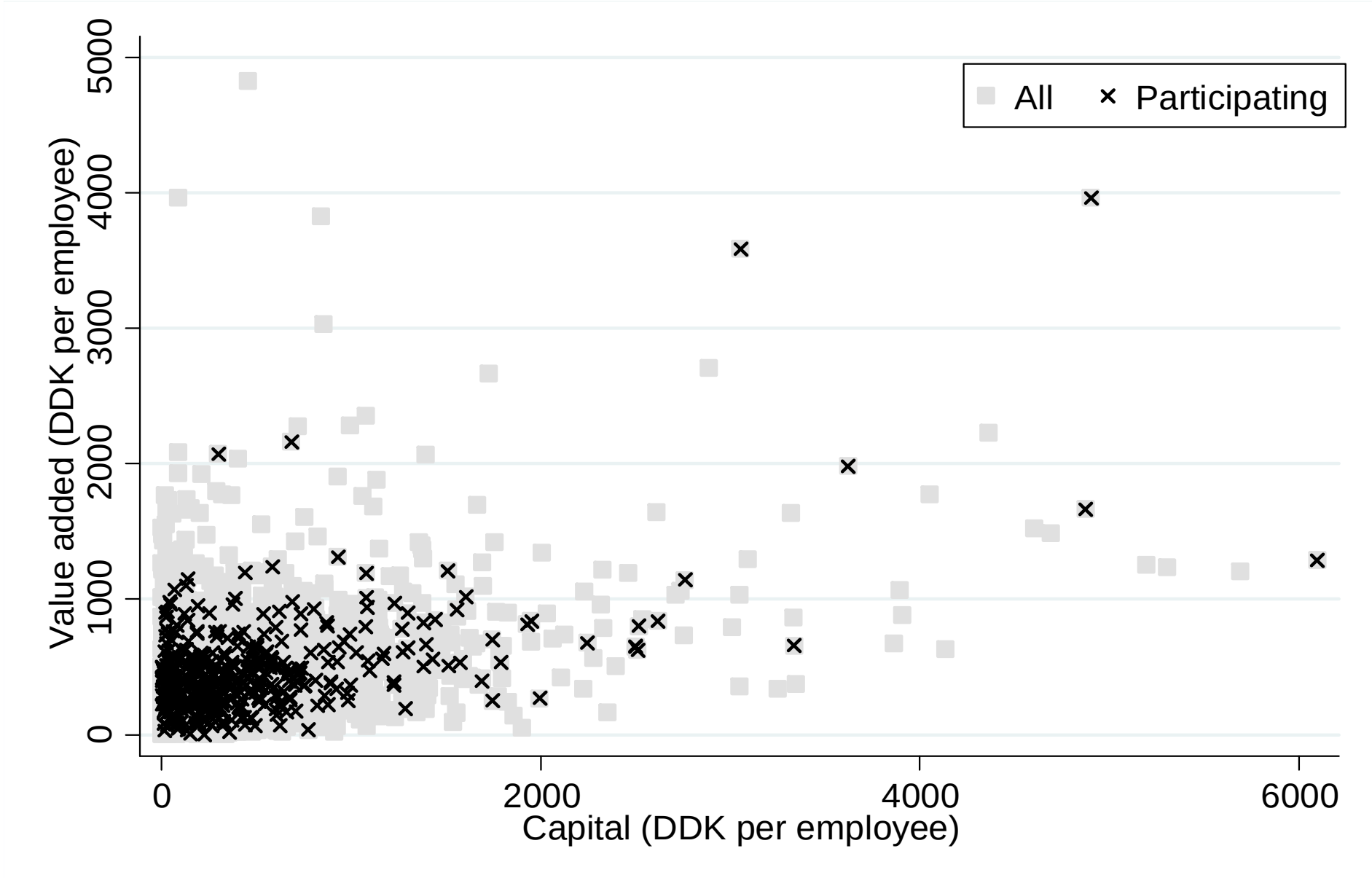
Which firms are participating?



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Individual effects and Synergitic effects on firm performance

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Table A8.1 DIFFERENT ESTIMATION METHODS, 2005-2010

	OLS b/se	FE b/se	LP b/se	SYSGMM b/se	SYSGMM b/se
ln_emp	0.892***	0.659***	0.833***	0.413***	0.733***
	(0.02)	(0.07)	(0.03)	(0.08)	(0.10)
edu_14_andel	0.617**	_0.342	0.806***	0.386*	0.782***
	(0.28)	(0.48)	(0.24)	(0.21)	(0.29)
edu_16_18_~l	0.825***	0.505	0.836***	0.745***	0.950***
	(0.24)	(0.51)	(0.25)	(0.19)	(0.24)
ln_cap	0.110***	0.064***	0.079***	0.075***	0.072***
	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)
ln_age_firm	0.040**	0.138***	0.035*	0.029	0.040
	(0.02)	(0.04)	(0.02)	(0.02)	(0.03)
automation~m	0.052***	0.124***	0.037***	0.052***	0.080***
	(0.01)	(0.04)	(0.01)	(0.02)	(0.02)
Observations	1383	1385	1329	2248	918

* Significant at 10%. ** Significant at 5%. *** Significant at 1%

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	bb1 b/se	bb2 b/se	bb3 b/se	bb4 b/se	bb5 b/se	bb6 b/se	bb7 b/se
Employees	0.441***	0.442***	0.433***	0.436***	0.449***	0.442***	0.436***
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
Midle range	0.374*	0.383**	0.373*	0.361*	0.380**	0.394**	0.363*
education	(0.20)	(0.19)	(0.19)	(0.19)	(0.19)	(0.20)	(0.19)
Long range	0.778***	0.757***	0.776***	0.752***	0.747***	0.787***	0.743***
education	(0.18)	(0.18)	(0.19)	(0.18)	(0.18)	(0.18)	(0.18)
Capital	0.081***	0.079***	0.081***	0.083***	0.079***	0.081***	0.082***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Firm age	0.031	0.032	0.034	0.029	0.030	0.034	0.027
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Mechanization	0.046***						
	(0.01)						
Manufacturing		0.013					
		(0.01)					
Assembly			0.034**				
			(0.01)				
Inventory				0.039***			
				(0.01)			
Handling/feeding					0.040***		
					(0.01)		
Changeover						0.039***	
						(0.01)	
Inspection							0.032**
							(0.01)
Observations	2686	2686	2686	2686	2686	2686	2686
Firms	462	462	462	462	462	462	462

* Significant at 10%. ** Significant at 5%. *** Significant at 1%

Digitalization score

Value added (emp., capital, firm age, education shares, industry and year dummies are included)

Digitalization score	0.046***				
	(0.01)				
execution		0.042***			
		(0.01)			
process control			0.045***		
			(0.01)		
tracking				0.027**	
				(0.01)	
phasing-in of new products					0.026**
					(0.01)

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Deltagelse

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Interactive Benchmarking

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?

Interaktiv Benchmarking

Brugernavn:

Adgangskode:

Sprog: Danish

Login

Generel information om Interactive Benchmarking

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○ Traditionel model ◉ Mekanisering af processer ○ Anvendelse af IT ○ Mekanisering af processer ver 2
○ Anvendelse af IT ver 2 ○ Anvendelse af mekanisering og af IT

I denne model betragtes virksomhederne som an transformabonr af to input til ét output

INPUT (ressourcer)
Antal_Ansatte_midtpunkt
Automatiserings_indeks1 (mekanisering af processor)

OUTPUT (services; cost-drivers)
Bruttofortjeneste_1000 kr

Modellen bestemmer bedste praksis ved at kombinerer virksomheder med sigte model at anvende færrest mulige input til at producere flest mulige output.

Effekten af automatisering kan studeredes ved at undersøge hvorledes automatiseringsgraden kan øge bruttofortjenesten og erstatte arbejdskraften.

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MinEnhed: 1032 Forbilled-Gruppe: Alle Eff: Normal Asp.%: 0 Skala: IRS L: 0.7 U: 1.2 ExOutlier Ex

Variabel	Retning		Aktuelle Værdi	Benchmark	Præstation	Type
Antal_Ansatte_midtpunkt		100	7.00	7.00	100%	I
Automatiserings_indeks1		100	9.00	9.00	100%	I
Bruttofortjeneste_1000 kr		100	3,172.00	3,172.00	100%	O

MinEnhed: 1068 Forbilled-Gruppe: Alle Eff: Normal Asp.%: 0 Skala: IRS L: 0.7 U: 1.2 ExOutlier ExS

Variabel	Retning		Aktuelle Værdi	Benchmark	Præstation	Type
Antal_Ansatte_midtpunkt		100	35.00	18.94	54%	I
Automatiserings_indeks1		100	5.00	2.71	54%	I
Bruttofortjeneste_1000 kr		100	26,172.00	38,178.44	69%	O

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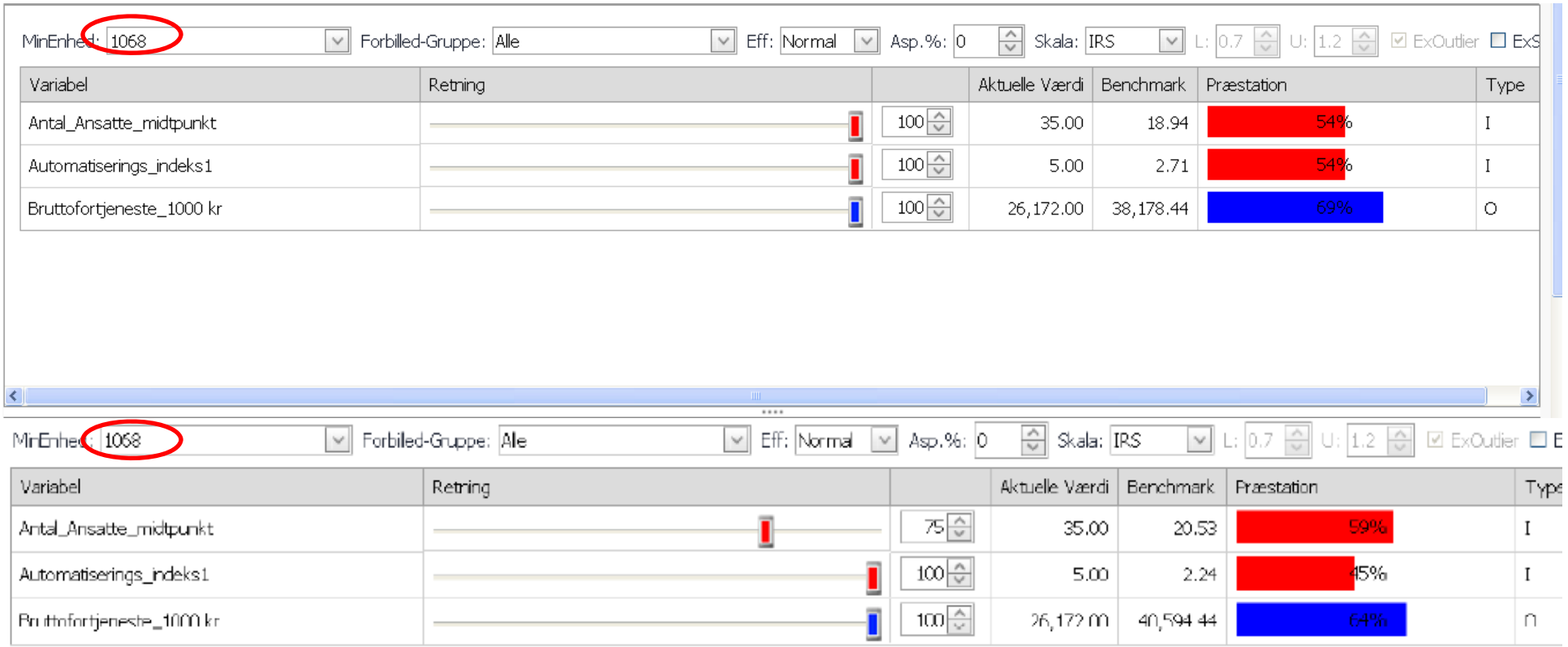

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