

# Measuring Management Using NLP Methods

Mapping the Dynamics of Management Styles: Evidence from German Survey Data

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## Study of management in economics

- For 20+ years economists have studied and measured management
- Established a (causal) link between management and productivity across various domains
- Substantial management heterogeneity in crosssection

### **Research Question:**

**How does management evolve over time?**

Related:

What governs the adoption of new (structured) practices?

# Contribution

## Methodology

- Leverage machine learning to detect patterns in management survey data in the spirit of Bandiera et al. (2020)
- No prior conception of what is “good” or “bad” management

## Contribution

- Provide an overview of management in German firms
- Leverage panel structure to analyze how firms adjust management over time
- Use linked employee survey to analyze employees' perspective of management

**Data**

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## Linked Personnel Panel – IAB (Institute for Employment Research)

- Linked survey of both firms and employees, phone interviews
- Sample is representative of the population of German firms with at least 50 employees
- Four survey waves: 2012, 2014, 2016 and 2018 (2020)
- Firm survey ( $N = 3526$ )
  - Personnel related management practices
  - HR planning and recruitment, HR development, Remuneration structure, Commitment, values and corporate culture
- Employee survey ( $N = 12,500$ )
  - Experienced quality of work, corporate culture, work attitude and behavior, personal characteristics, socio-demographics

# Estimating Management Styles

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# Estimation of latent styles

## Latent Dirichlet Allocation (Blei et al. 2003)

- Firms' behavior is a mix of a small number of latent management styles, which are bundles of practices that appear together
- LDA provides two probability distributions
  - Style is a distribution over practices (loadings of practices)
  - Management is a distribution over styles (style intensities)
- Unsupervised; does not force practices/styles to explain outcomes
- 2 Styles: Interpretability, retained flexibility, cross-validation **CV**
- Estimation: 41 practices (binary), 3526 firm-year observations
- Simple alternative: Share of adopted practices (SAP)
  - Advantage LDA: Practices that discriminate across firms

# Discussing styles: Top practices

**Table 1** *Most characteristic style-practices*

Rank	Style 1	Style 2
<b>Ranked by practice loadings</b>		
1	Development plans	Inefficiency: Discussions (high)
2	Employee surveys	Internal training
3	Development plans: Evaluation	On-the-job training
4	Appraisal interviews	Attending lectures
5	Development plans: Management	Inefficiency: Dismissal (high)

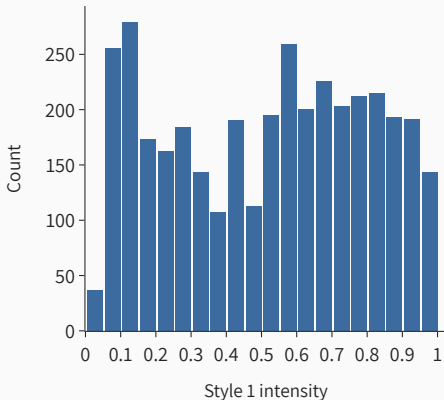
**Notes:** This table shows the most characteristic practices for both styles. Practices are ranked from highest to lowest according to loadings in Style 1 and Style 2.

→ Style 1 reflects forward-looking, structured management approach

Practice loadings

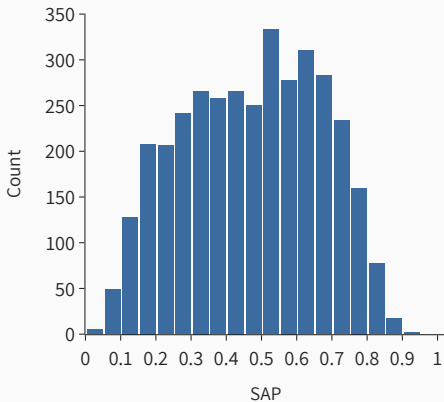


## Discussing styles: Style 1 distribution



**Notes:** Shown is the observed distribution of Style 1 intensity of the full sample ( $N = 3526$ ).  $\text{Corr}(\text{Style 1 intensity}, \text{SAP}) = 0.6$

# SAP distribution



**Notes:** Shown is the observed distribution of the SAP of the full sample ( $N = 3526$ ).  $\text{Corr}(\text{Style 1 intensity, SAP}) = 0.6$

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# Results

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# Management Style 1 correlates – Summary

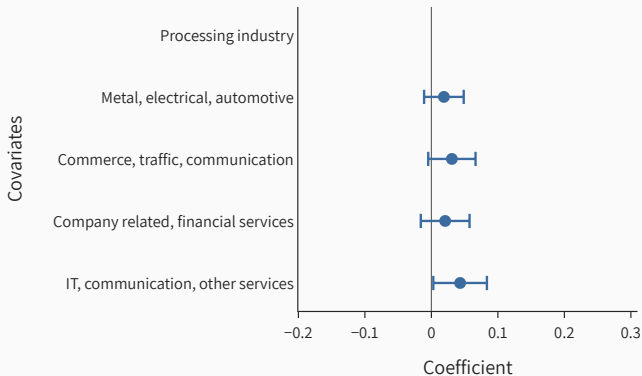
## Cross-section correlates: How are German firms managed?

⇒ Mostly similar to previous findings (i.e. WMS)

- **Size:** Larger firms → higher Style 1 intensity
- **Industry:** No systematic variation
- **Ownership structure:** Lowest: family/founder; highest: investor, stock market listed
- **Other:** Multiplant firms & works councils → high Style 1 intensity
- **Competition:** No systematic variation, but self-reported

# Management Style 1 correlates

## Management Style 1 – Industry



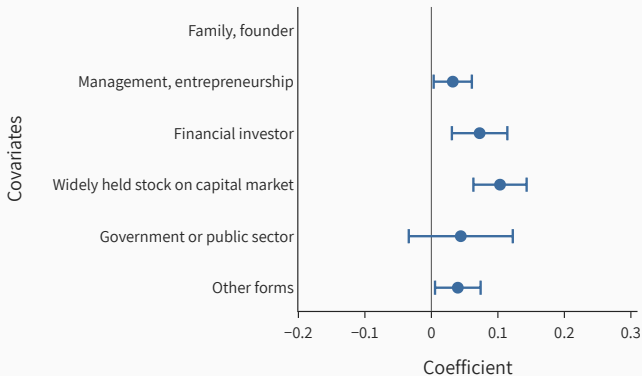
**Notes:** Figure plots coefficients and 95% CIs from an OLS regression of Style 1 intensity on firm characteristics.  $N = 3508$

Summary

SAP

# Management Style 1 correlates

## *Management Style 1 – Ownership*



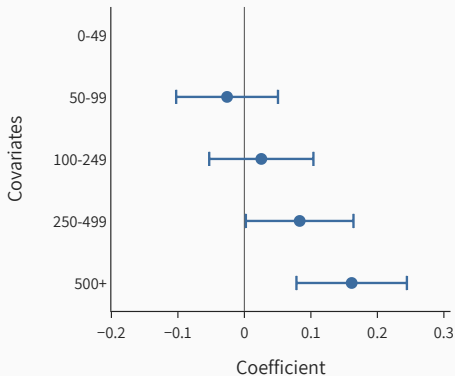
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Summary

SAP

# Management Style 1 correlates

## *Management Style 1 – Workforce size*



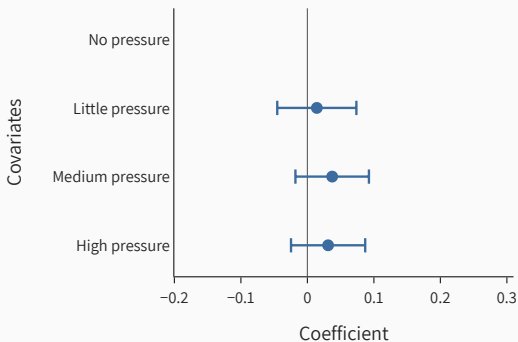
**Notes:** Figure plots coefficients and 95% CIs from an OLS regression of Style 1 intensity on firm characteristics.  $N = 3508$

Summary

SAP

# Management Style 1 correlates

## *Management Style 1 – Competition (self-reported)*



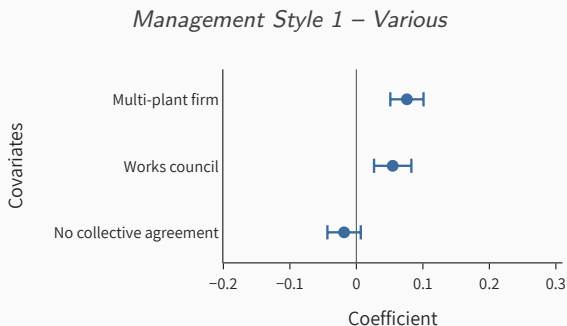
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Summary

SAP



# Management Style 1 correlates



**Notes:** Figure plots coefficients and 95% CIs from an OLS regression of Style 1 intensity on firm characteristics.  $N = 3508$

Summary

SAP

## Management Style 1 correlates – Firm & employee outcomes

**Should firms adopt management Style 1?**

# Management Style 1 correlates – Firm & employee outcomes

Table 2 *Firm & employee outcomes*

	Dependent variable		
	Firm-level	Employee-level	
	Profit	Turnover intention	Job satisfaction
Style 1 intensity	0.022** (0.008)	-0.040* (0.016)	0.056*** (0.014)
Firm controls	X	X	X
Employee controls		X	X
Adj. R <sup>2</sup>	0.044	0.098	0.037
Observations	3,453	11,472	11,475

**Notes:** All specifications include year-fixed effects and Style 1 intensity is z-score standardized. Standard errors are clustered at the firm level / firm-employee level and reported in parentheses. \*\*\*, \*\*, \* indicate significance at 1%, 5% and 10%.

# Management Style 1 correlates – Firm & employee outcomes

**Should firms adopt management Style 1?**

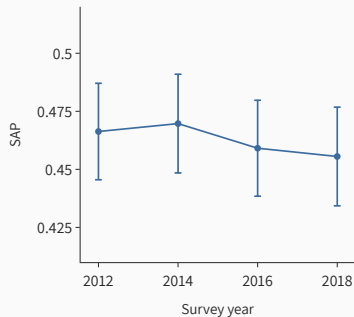
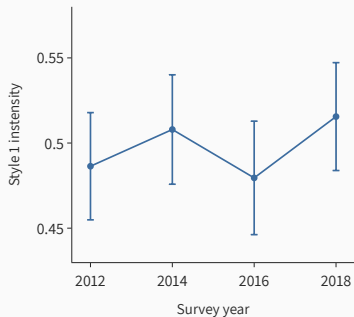
**Yes!**

Positive correlation with profits and employee satisfaction

**How does management evolve over time?  
Are firms moving toward Style 1?**

# Management dynamics

## Management dynamics – Panel sample



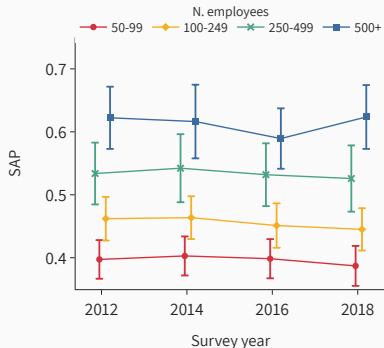
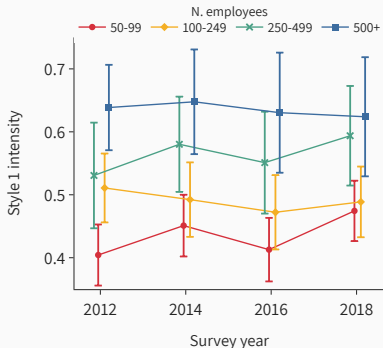
**Notes:** Figure plots coefficients and 95% CIs from an OLS regression of Style 1 intensity on survey-wave dummies.  $N = 1288$

Repeated cross-section

⇒ No secular trend toward Style 1

# Management dynamics – Size

## Management dynamics – Size



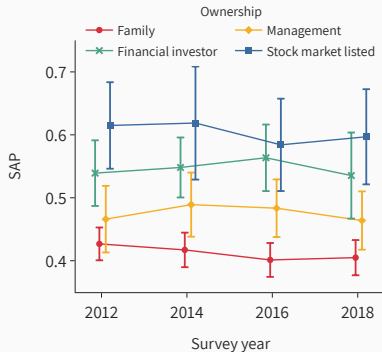
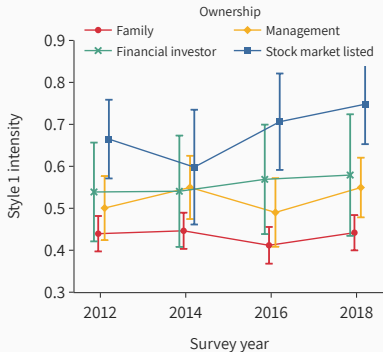
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Multiplant firms

Growing firms

# Management dynamics – Ownership

## Management dynamics – Ownership



**Notes:** Figure plots coefficients and 95% CIs from an OLS regression of Style 1 intensity on survey-wave dummies.  $N = 1288$

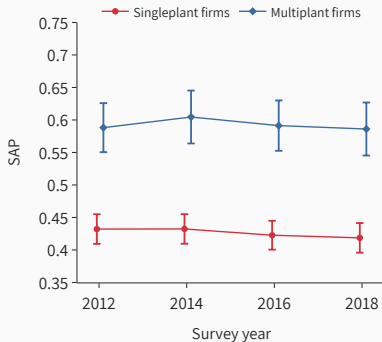
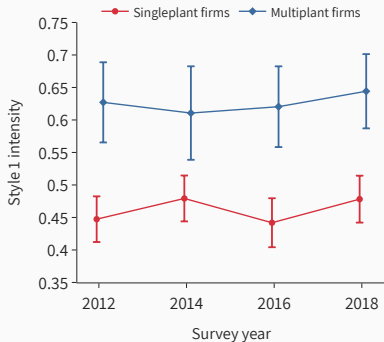
Ownership/Management change

Competition



# Management dynamics – Singleplant and Multiplant firms

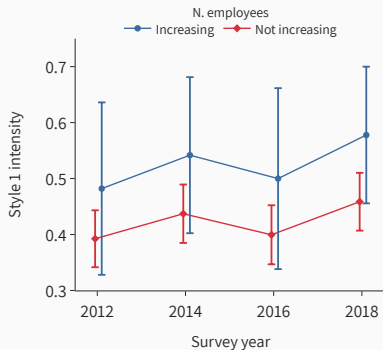
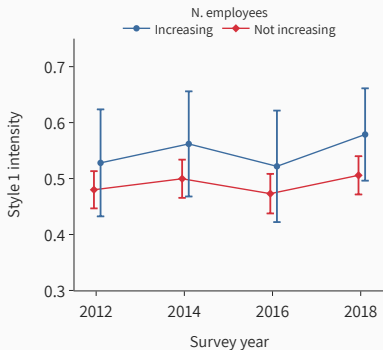
## Management dynamics – Singleplant and Multiplant firms



**Notes:** Figure plots coefficients and 95% CIs from an OLS regression of Style 1 intensity on survey-wave dummies.  $N = 1288$

# Management dynamics – Growing firms

## Management dynamics – Growing firms



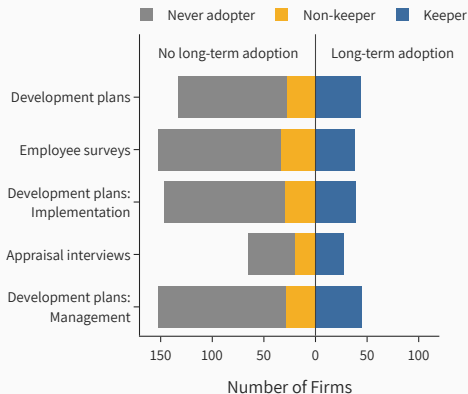
**Notes:** Figure plots coefficients and 95% CIs from an OLS regression of Style 1 intensity on survey-wave dummies. The right panel restricts the sample to firms starting in the lowest size category.

We find no secular trend toward management Style 1.

**Is there really nothing going on?**

# Style 1 practices – Adopters

## Style 1 practices – Adopters



**Notes:** This figure shows patterns of adopting the five most characteristic practices of management Style 1. Shown are the number of firms that adopt and keep (blue), adopt but drop again (yellow) or never adopt (gray) the respective practice.

# Mapping the Dynamics of Management – Summary

## Mapping the Dynamics of Management

- We use ML to measure management at scale
- Firms differ systematically in the way they are managed
- Positive correlation between management and profits & satisfaction
- Little to no dynamics; differences are persistent
- Experimentation but often new practices are discontinued

⇒ **Need to better understand reasons for rigidity!**

## Need to better understand reasons for rigidity

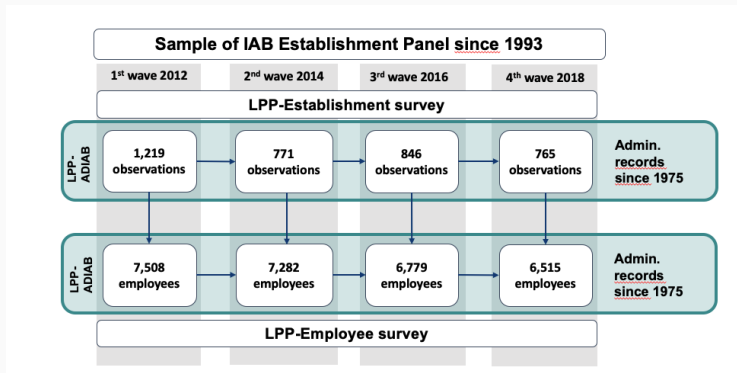
- Steady state, firms have chosen optimal configuration
  - Unlikely; positive correlation with profits & satisfaction
- Little dynamics in times of high economic stability (2012–2018)
  - Use 2020 and future waves of LPP; Covid-Crisis
- Information frictions Bloom et al. (2019)
- Misperceived cost-benefit trade-offs:
  - Costs are immediately noticeable, benefits maybe not
  - Bloom et al. (2012, 2020)
- (Missing) complementary “assets”:
  - Synergy effects with corporate culture? **Culture**

# Appendix

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# Overview of LPP survey waves

## LPP Overview



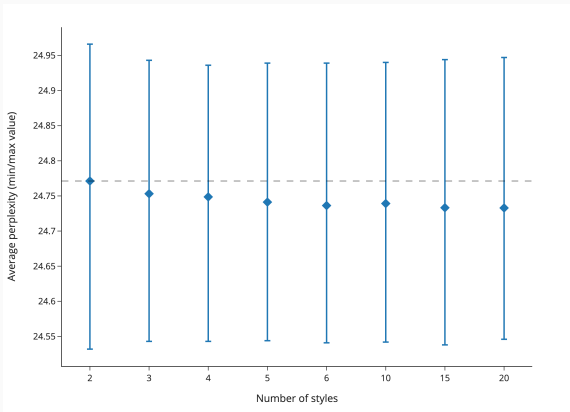
→ Number of total firms:  $N = 1746$

→ 4 year panel firms:  $N = 322$



# Number of styles – Cross validation

*Perplexity for different numbers of styles*

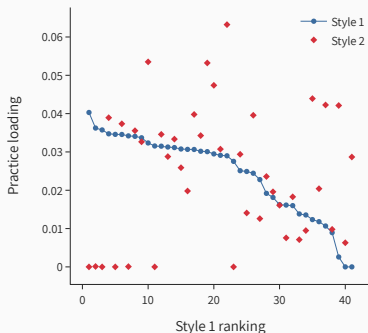


This figure plots the average perplexity of 10-fold cross-validated LDA models that vary only in the number of latent styles. The split between training data and test data is two-thirds to one-third. Perplexity measures the out of sample fit and lower values indicate a better goodness-of-fit. The dashed line indicates the mean perplexity of the specification with 2 styles. The lower and upper ends of the error bars show the minimum and maximum values of perplexity, respectively.

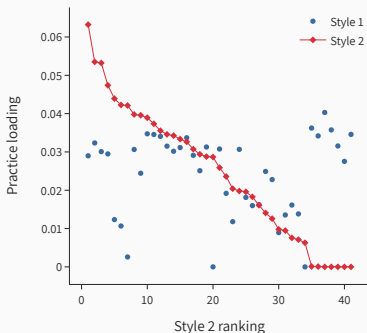
# LDA: Practice loadings

## Practice loadings

(a) Style 1

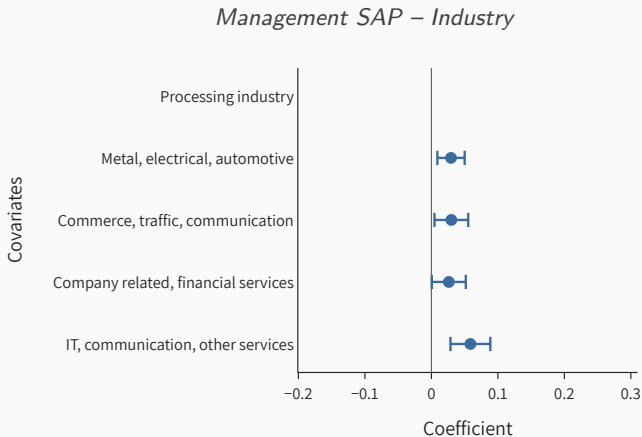


(b) Style 2



**Notes:** Shown are practice loadings of Style 1 and Style 2. Loadings are strictly positive and the sum of all loadings within a style equals 1.

# Management SAP correlates

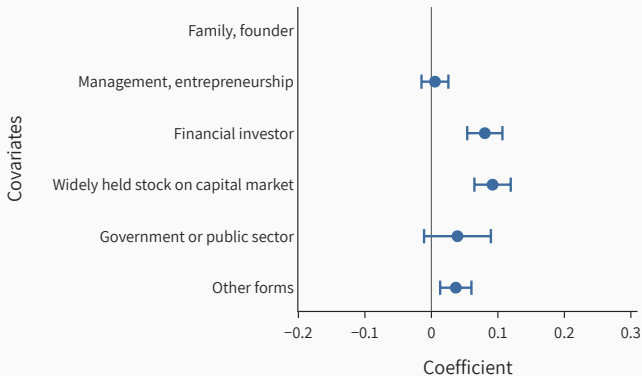


**Notes:** Figure plots coefficients and 95% CIs from an OLS regression of SAP on firm characteristics.  $N = 3508$

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# Management SAP correlates

## Management SAP – Ownership

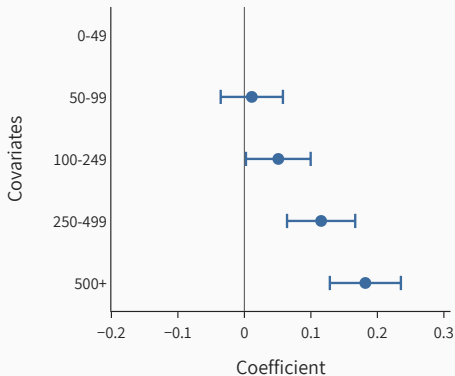


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# Management SAP correlates

## *Management SAP – Workforce size*

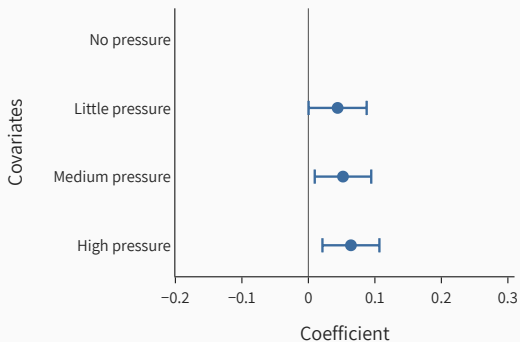


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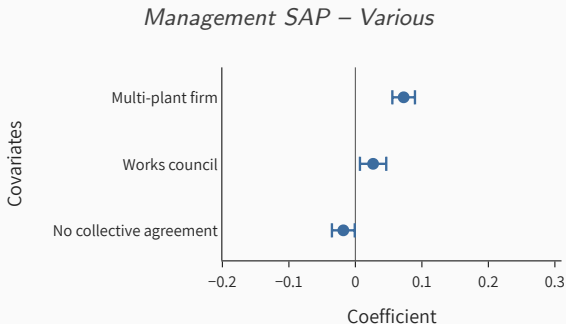
# Management SAP correlates

## *Management SAP – Competition (self-reported)*



**Notes:** Figure plots coefficients and 95% CIs from an OLS regression of SAP on firm characteristics.  $N = 3508$

# Management SAP correlates



**Notes:** Figure plots coefficients and 95% CIs from an OLS regression of SAP on firm characteristics.  $N = 3508$

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# Management SAP – Firm & employee outcomes

**Table A1** *Firm & employee outcomes*

	Dependent variable			
	Firm-level		Employee-level	
	Profit	Loss	Turnover intention	Employee satisfaction
SAP	0.054*** (0.009)	-0.029*** (0.006)	-0.080*** (0.016)	0.070*** (0.015)
Firm controls	X	X	X	X
Employee controls			X	X
Adj. R <sup>2</sup>	0.055	0.043	0.101	0.037
Observations	3,453	3,453	11,472	11,475

**Notes:** All specifications include year-fixed effects and the SAP intensity is z-score standardized. Standard errors are clustered at the firm level / firm-employee level and reported in parentheses. \*\*\*, \*\*, \* indicate significance at 1%, 5% and 10%.



# Management dynamics – Change of ownership or management

**Table A2** *Style 1 – change of ownership or managers*

	Dependent: Total change of Style 1 intensity		
	(1)	(2)	(3)
Change of ownership	0.004 (0.044)	-0.002 (0.050)	-0.016 (0.028)
Change of management	-0.019 (0.036)	-0.015 (0.041)	0.016 (0.026)
Controls		<b>X</b>	<b>X</b>
Adj. R <sup>2</sup>	-0.005	0.014	-0.016
Observations	322	318	318

**Notes:** The dependent variable is the total change of Style 1 intensity from 2012 to 2018. Robust standard errors are reported in parentheses. \*\*\*, \*\*, \* indicate significance at 1%, 5% and 10%.

# Management dynamics – Change of ownership or management

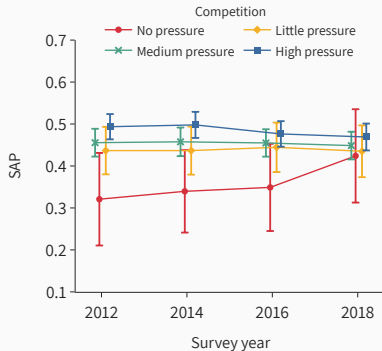
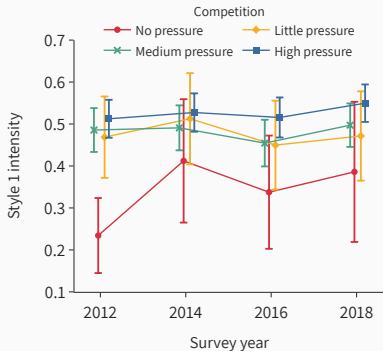
**Table A3** *SAP – change of ownership or managers*

	Dependent: Total change of SAP		
	(1)	(2)	(3)
Change of ownership	-0.045* (0.022)	-0.046* (0.023)	0.008 (0.017)
Change of management	0.027 (0.019)	0.021 (0.022)	-0.016 (0.015)
Controls		<b>X</b>	<b>X</b>
Adj. R <sup>2</sup>	0.009	0.014	0.002
Observations	322	318	318

**Notes:** The dependent variable is the total change of SAP from 2012 to 2018. Robust standard errors are reported in parentheses. \*\*\*, \*\*, \* indicate significance at 1%, 5% and 10%.

# Management dynamics – Competition

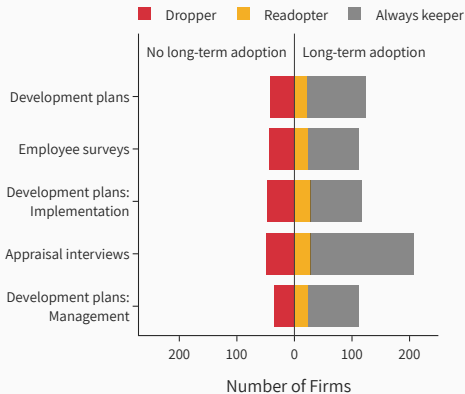
## Management dynamics – Competition



**Notes:** Figure plots coefficients and 95% CIs from an OLS regression of Style 1 intensity on survey-wave dummies.  $N = 1288$

# Style 1 practices – Droppers

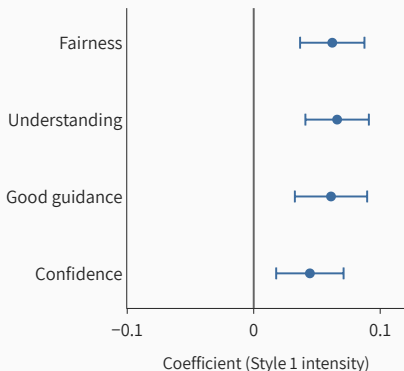
## Style 1 practices – Droppers



**Notes:** This figure shows patterns of adopting the five most characteristic practices of management Style 1. Shown are the number of firms that dropped (red), dropped but readopted (yellow) or always kept (gray) the respective practice.

# Management correlates – Corporate culture

## *Style 1 synergies – Supervisor qualities*



**Notes:** Specifications include employer & employee controls and year-fixed effects. Management and dependent variables are z-score standardized. Original range from one (fully agree) to five (fully disagree): *Fairness*: My direct supervisor treats me fairly in all aspects of work. *Understanding*: Supervisors show understanding for employees. *Guidance*: Supervisors offer good guidance to employees.

# Management correlates – Supervisors

**Table A4** *Management synergies: corporate culture*

	Dependent variable: Supervisor qualities		
	Fairness	Understanding	Guidance
Style 1 intensity	0.062*** (0.013)	0.066*** (0.013)	0.061*** (0.015)
Firm controls	X	X	X
Employee controls	X	X	X
Adj. R <sup>2</sup>	0.019	0.027	0.039
Observations	11,451	11,463	11,457

**Notes:** Specifications include employer & employee controls and year-fixed effects. Management and dependent variables are z-score standardized. Standard errors are clustered at the employee-firm level and reported in parentheses. \*\*\*, \*\*, \* indicate significance at 1%, 5% and 10%. Original range from one (fully agree) to five (fully disagree): *Fairness*: My direct supervisor treats me fairly in all aspects of work. *Understanding*: Supervisors show understanding for employees. *Guidance*: Supervisors offer good guidance to employees.

# Management correlates – Supervisors

**Table A5** *Management synergies: corporate culture*

	Dependent variable: Supervisor qualities		
	Fairness	Understanding	Guidance
SAP	0.080*** (0.014)	0.091*** (0.014)	0.088*** (0.015)
Firm controls	X	X	X
Employee controls	X	X	X
Adj. R <sup>2</sup>	0.020	0.029	0.041
Observations	11,451	11,463	11,457

**Notes:** Specifications include employer & employee controls and year-fixed effects. Management and dependent variables are z-score standardized. Standard errors are clustered at the employee-firm level and reported in parentheses. \*\*\*, \*\*, \* indicate significance at 1%, 5% and 10%. Original range from one (fully agree) to five (fully disagree): *Fairness*: My direct supervisor treats me fairly in all aspects of work. *Understanding*: Supervisors show understanding for employees. *Guidance*: Supervisors offer good guidance to employees.

**Table A6** *Overview of management practices*

Practice	Question text
Development plans	Are there any development plans for employees in your establishment/office?
Employee surveys	Does your establishment/office regularly conduct employee surveys?
Development plans: Implementation	Do you systematically review the implementation of the development plans?
Appraisal interviews	Do you conduct structured appraisal interviews in your establishment/office at least once a year?
Development plans: Management	For whom are development plans available? (management staff)
Staffing plan	Does your establishment/office have a staffing plan?
Development plans: Non-management	For whom are development plans available? (employees without management responsibility)
Appraisal interviews: Management	With whom do you conduct the structured appraisal interviews? (management staff)
Target agreements	Does your establishment have target agreements?
Internal training (IAB BP)	For which of the following internal or external training courses did your establishment release staff and cover the expenses in full or in part? Internal training courses, seminars or workshops
Employee surveys: Communicated to employees	Are the results of the survey communicated to all employees?
Performance appraisal	Is a review of the performance of the employees carried out by the respective supervisor in your establishment/office at least once a year?
Target agreements: Management	For whom are the target agreements available? (management staff)
Appraisal interviews: Non-management	With whom do you conduct the structured appraisal interviews? (employees without management responsibility)
Performance appraisal: Management	For whom are the annual performance appraisals issued? (management staff)



## Table A7 *Overview of management practices*

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Practice	Question text
Inefficiency: HR development measures (high)	How do you and your management staff deal with employees, whose performance is not satisfactory? HR development measures are purposefully offered to correct performance problems.
Analysis of age structure	Do you systematically analyze the age structure of employees in your establishment/office?
Promotion of higher educational qualification	Have you actively promoted employees' qualification activities leading to a higher educational qualification, e.g. by releasing from work or partially bearing costs? This includes e.g. further training to master craftsmen, technician, postgraduate program, MBA, doctorate.
On-the-job training (IAB BP)	For which of the following internal or external training courses did your establishment release staff and cover the expenses in full or in part? Further training on the job (instruction, familiarization training)
Attending lectures (IAB BP)	For which of the following internal or external training courses did your establishment release staff and cover the expenses in full or in part? Participation in lectures, symposia, fairs, etc.
Performance appraisal: Non-management	For whom are the annual performance appraisals issued? (employees without management responsibility)
Inefficiency: Discussions (high)	How do you and your management staff deal with employees, whose performance is not satisfactory? The management staff openly discusses the problems with the employee in question.
Employee surveys: Develop solutions	Is there a systematic process to develop solutions for flaws, which were identified in the employee surveys?
Conduction of performance appraisal	Is the performance appraisal generally conducted by just one superior or collectively by a group of superiors (evaluation round), meaning not only by one superior?
Target agreements: Non-management	For whom are the target agreements available? (employees without management responsibility)
Variable remuneration	Does your establishment/office have a salary system with variable proportions?
Self-directed study (by media)	For which of the following internal or external training courses did your establishment release staff and cover the expenses in full or in part? Self-directed study (e.g. by means of computer-aided self-learning programs or reference books)

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**Table A8** *Overview of management practices*

Practice	Question text
Increase of women in management set as goal	Do you pursue the goal to increase the proportion of women in management positions?
Recruitment: Social networks	Have you directly addressed applicants employed by another company via social networks such as Xing, LinkedIn etc. in the past two years?
Recruitment: Private agency	Have you recruited applicants in the past two years, who were employed by another company, with the help of a private recruitment agency or HR consulting?
Quality/workshop meeting (IAB BP)	For which of the following internal or external training courses did your establishment release staff and cover the expenses in full or in part? Quality circles, workshop circles, learning workshop, continuous improvement teams
Inefficiency: Another position (high)	How do you and your management staff deal with employees, whose performance is not satisfactory? We try to find another position in the establishment/office if there are permanent performance problems.
Job rotation (IAB BP)	For which of the following internal or external training courses did your establishment release staff and cover the expenses in full or in part? Job rotation
Recruitment agency: Management	Have you recruited applicants in the past two years, who were employed by another company, with the help of a private recruitment agency or HR consulting? (management staff)
Inefficiency: Dismissal (high)	How do you and your management staff deal with employees, whose performance is not satisfactory? Employees who permanently show poor working performance will be dismissed or urged to leave the establishment/office.

## Table A9 *Overview of management practices*

Practice	Question text
Inefficiency: Dismissal (low)	How do you and your management staff deal with employees, whose performance is not satisfactory? Employees who permanently show poor working performance will be dismissed or urged to leave the establishment/office.
HR at highest management level	On which level is the management of the human resources (HR) located in your company? On the first management level, that means executive board or management?
Recruitment agency: Non-management	Have you recruited applicants in the past two years, who were employed by another company, with the help of a private recruitment agency or HR consulting? (employees without management responsibility)
Inefficiency: Another position (low)	How do you and your management staff deal with employees, whose performance is not satisfactory? We try to find another position in the establishment/office if there are permanent performance problems.
Inefficiency: Discussions (low)	How do you and your management staff deal with employees, whose performance is not satisfactory? The management staff openly discusses the problems with the employee in question.
Inefficiency: HR development measures (low)	How do you and your management staff deal with employees, whose performance is not satisfactory? HR development measures are purposefully offered to correct performance problems.
Advanced training measures (IAB BP)	Did your establishment/office support training courses in the first half of this year?
External training (IAB BP)	For which of the following internal or external training courses did your establishment release staff and cover the expenses in full or in part? External training courses, seminars or workshops
Distribution recommendation for performance appraisal	Do you have recommendations regarding distribution of performance appraisal? Recommendations regarding performance appraisal include information on what percentage of employees should, for instance, receive the best performance appraisal, the second-best performance appraisal etc.
Distribution recommendation: Non-management	Do you have recommendations regarding distribution of performance appraisal? Recommendations regarding performance appraisal include information on what percentage of employees should, for instance, receive the best performance appraisal, the second-best performance appraisal etc. (employees without management responsibility)
Distribution recommendation: Management	Do you have recommendations regarding distribution of performance appraisal? Recommendations regarding performance appraisal include information on what percentage of employees should, for instance, receive the best performance appraisal, the second-best performance appraisal etc. (management staff)

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