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Lean and job satisfaction: the mediating role of how employees perceive implemented lean methods

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ABSTRACT

Lean is a management philosophy that aims to ensure the continuous improvement of value creation in companies. In order to implement Lean Management optimally, all employees of the company must be involved. Previous research, however, mainly looks at the implementation of the methods, the perception and attitude of the employees often get into the background. The aim of the paper is to examine a possible influence of perceived lean degree on the relationship between implemented lean methods and job satisfaction. An online survey was conducted with 264 participants to collect data. A partial least squares (PLS) approach to structural equation modelling (SEM) was used to test the hypotheses of the study. We are able to determine that some lean implementation factors are indeed fully mediated with their impact on job satisfaction. The results imply that lean implementation factors should be accompanied with supporting activities to ensure positive effects on job satisfaction. This is the first article to examine the relationship of actually implemented lean methods in relation to employee perception of lean on their job satisfaction.

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KEYWORDS
Lean management; job satisfaction; perceived lean degree

Introduction

Companies must constantly balance efficiency, customer focus, and employee satisfaction. Lean management is an established philosophy to achieve both efficiency and customer focus, and thus promising in this regard, but is short in considering the view of employees. Since employees perceive the effect of implemented lean measures, this perception might be more important to determine the effects on job satisfaction and to identify how to maintain the balance for sustainable implementation.

Lean management has the purpose to ensure continuous improvement of value creation in companies by engaging all employees (Womack and Jones Daniel 2003). It provides methods to identify waste and uses a number of tools and principles to minimise or remove waste (Mandujano et al. 2016). It allows companies to 'specify value, line up value-creating actions in the best sequence, conduct these activities without interruption whenever someone requests them, and perform them more and more effectively' (Womack and Jones 1996).

While often mistakenly associated with pure streamlining, automation, and outsourcing, lean management instead aims, at least indirectly, to improve employees' perceptions of and affective responses to value creation, work processes, and process-oriented teamwork (Wang and Chen 2010). The implementation of lean management has an impact on different areas of the organisation, including performance, but also customer satisfaction and employee satisfaction (Poksinska, Fialkowska-Filipek, and Engström 2017; Goshime, Kitaw, and Jilcha 2019; Sunder, Mahalingam, and Krishna 2020; Chavez et al. 2020). Regarding employee satisfaction, Leyer, Reus, and Moormann (2021) showed that the perception of lean management can have a significant impact on employee job satisfaction. Their results indicate that efficiency gains by applying lean can especially be balanced with regard to job satisfaction by supporting adequate supervisory roles and separate lean from staff reduction. In addition, the actual used work methods and execution of the work also influence job satisfaction (Raziq and Maulabakhsh 2015). It is, therefore, reasonable to assume that the individual perception of the degree of lean in the workplace influences the effect of introduced lean methods on job satisfaction. However, there is a gap in the scientific literature in this regard, which we are addressing with the following research question: How do employee perceptions of lean influence the relationship between actual methods used and job satisfaction?

In order to address the research question, we conduct a survey that gathers lean methods existing in the workplace, perceived lean degree, and job satisfaction of participants in the workplace. The survey is conducted in various industries, including both services and manufacturing. The contribution of this paper is to identify what significant relationships exist between the lean methods used, job satisfaction, and the perceived lean degree as a mediator. Thereby a holistic picture can be generated, which can give new implications

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especially for the practice, concerning the approach and the implementation of lean methods in different areas of the company. The article contributes also to a better understanding of which lean methods in detail have an impact on employee job satisfaction.

The article is organised as follows: The second section examines the theoretical background and previous work on lean management and job satisfaction. Based on the findings of previous work, various hypotheses are formulated. In the third section, the methodology is presented. Sections four and five present and discuss the results of the work. The final section contains a conclusion and implications of the work.

Theoretical background

Lean management

The historical roots of lean management can be found in lean manufacturing. Lean manufacturing is a philosophy derived from the Toyota Production System (TPS) in the 1990s (Womack, Jones, and Roos 1991). TPS is considered to be the first system working in accordance with the guidelines of lean (Dekier 2012). The basic five implementation principles of lean thinking are (Womack and Jones 1996):

(1) *Specify Value*: Value can only be defined by the costumer and is only distorted by pre-existing organisations, which need to understand the customer needs.
(2) *Identify the Value Stream*: The Value Stream contains all actions needed to bring a product to the customer.
(3) *Flow*: Make value-creating processes flow. Eliminate single-task processes on large batches to minimise delay.
(4) *Pull*: Let the customer pull the production from you.
(5) *Pursue Perfection*: Improve the process of reducing time, space, cost and mistakes continuously.

Additionally, to the five principles on the implementation level, there are three more principles at the self-awareness level. This second level deals with the self-awareness of the employees and can be seen as management infrastructure as well as attitude and behaviour perceived by lean within an organisation (Leyer and Moormann 2014). In detail, the principles are:

(6) *Leadership style*: How leaders guide and coach their employees regarding the company goals (Jolayemi 2008).
(7) *Individual responsibility*: The degree of personal responsibility of employees within their operational activities (Radnor and Johnston 2013).
(8) *Continuous improvement culture*: The striving of employees for a continuously and long-term improvement of all value streams (Bhasin 2011).

In practice, it is necessary to distinguish between the perception of lean methods and the implementation of lean methods. The goal of lean management is, among other things, to influence the perception of employees and to improve value creation through improved work processes (Wang and Chen 2010). Workers generally perceive lean methods as positive if they understand how these methods fit into lean thinking (Tan et al. 2013). The perception of lean methods, therefore, plays a crucial role in explaining the effect of implemented lean methods.

There are numerous methods for lean management, some well-known are Just in Time, 5S or FMEA (Panizzolo 1998). The methods can be classified in different ways with recent classifications of methods, but those often only consider individual sectors (Parkhi 2019) or process steps (Plenert 2010; Wu and Low 2012). The classification, according to Panizzolo (1998) refers to how lean implementations affect different areas of a company and is therefore still relevant, despite the ongoing development of specific methods. This grouping provides an entire view on all the different areas of production processes in lean companies, instead of focussing only on production itself. Hence, we draw on the grouping of Panizzolo (1998) who grouped the improvement programmes of lean management into six different categories, representing different areas of diverse companies:

- Process and equipment (e.g. set up reduction, flow lines, error proof equipment)
- Planning and control (e.g. synchronised scheduling, small lot sizing, pull flow)
- Human Resources (e.g. multifunctional workers, worker training, flexibility)
- Product design (e.g. part standardisation, mushroom concept, phase overlapping)
- Supplier relationships (e.g. KIT deliveries, open orders, quality at the source)
- Customer relationships (e.g. reliable deliveries, flexibility, customer needs)

How well and quickly the respective lean methods can be implemented depends on many factors, including the speed of the production rhythm. Companies with a high production rhythm can implement methods comparatively faster than companies with a slower rhythm (Netland, Schloetzer, and Ferdows 2021).

Job satisfaction

One of the first definitions of job satisfaction described the construct as combination of psychological, physiological and environmental circumstances that lead a person to say truthfully: I am satisfied with my work (Hoppock 1935). Another fundamental definition describes job satisfaction as a pleasant or positive emotional state that results from evaluating one's work or work experiences (Locke 1975). Job satisfaction is characterised by intrinsic as well as extrinsic job elements (Ali et al. 2014).

The multifaceted effects of job satisfaction have been investigated in many studies. A positive correlation was found between job satisfaction and employee performance at both the supervisor and employee levels (Shaju and Subhashini 2017). Job satisfaction also influences loyalty and

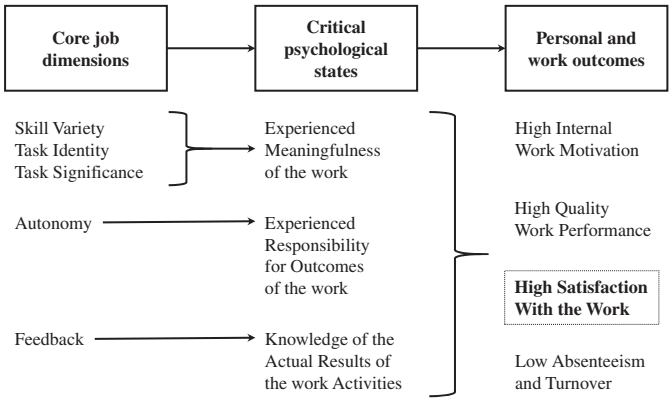

Figure 1. Job characteristics model according to Hackman and Oldham (1974).

abstinence (Aziri 2011) or attitude towards work and organisational commitment (Ahmad, Ahmad, and Shah 2010). Job satisfaction also has a high impact on private life. Various literature indicate a consistent relationship between job satisfaction and a variety of conceptualizations of life satisfaction in general (Rain, Lane, and Steiner 1991).

Job characteristics model

If we want to understand how which antecedents lead to the establishment of job satisfaction, a closer look on the job characteristics model as an underlying theory is required. Hackman and Oldham defined five core job dimensions that influence different critical psychological states and various personal and work outcomes: Skill variety, task identity, task significance, autonomy and feedback (Hackman and Oldham 1974). The relationship between the core dimensions and job satisfaction according to the Job Characteristics Model is presented in Figure 1.

According to the job characteristics model, the five core dimension influence three different critical psychological states (experienced meaningfulness of work, experienced responsibility for work outcomes and knowledge about the actual outcomes of work activities. Ultimately, those three psychological states affect the personal and work outcomes (Hackman and Oldham 1974). Those work outcomes are defined by internal work motivation, the quality of work performance, job satisfaction, as well as absenteeism and turnover. Job satisfaction is therefore one of several outcomes that can be determined through the five core job characteristics. To do this, Hackman and Oldham developed the Job Diagnostic Survey (JDS). The survey represents a standardised questionnaire to assess the job characteristics, employee's satisfaction with their jobs and work context and the growth need strength of respondents (Hackman and Oldham 1976).

Related work

Various studies have found a positive correlation between lean management and customer satisfaction, especially in service-oriented industries (Poksinska, Fialkowska-Filipek, and Engström 2017; Goshime, Kitaw, and Jilcha 2019). The integration of lean methods leads, for example, to increased patient satisfaction in hospitals by reducing turnaround time (Sunder, Mahalingam, and Krishna 2020; Persis et al. 2020). Also, a positive impact of internal lean practices on environmental performance and social performance was found (Chavez et al. 2020). Furthermore, it was found that the degree of lean performance is positively related to Human Factors and Ergonomics (Sakthi Nagaraj and Jeyapaul 2021). Research shows that when implemented properly, Lean can lead to improved process efficiency, customer experience and higher general employee satisfaction (Smith, Paton, and MacBryde 2018).

There are also a number of studies that relate to job satisfaction or lean management separately, but only a few investigate a possible correlation. Even before the introduction of lean manufacturing, however, it was indicated that job characteristics largely accounted for the relationship between technology and organisational behaviour (Rousseau 1978). However, with few exceptions, the role of job characteristics has not been explicitly studied in relation to lean manufacturing. Minh et al. (2019) conducted a study, the results of which indicated that customer relationship, human resources, and product design practices had positive indirect effects on job satisfaction via job characteristics, while process and equipment practices had a negative indirect effect (Minh et al. 2019). Other research states that increasing employee responsibilities and capabilities through different implementation methods on the front lines is called empowerment, which in turn is said to increase job satisfaction (Vidal 2007). However, this study only referred to lean manufacturing; lean management in service companies was not included further.

Leyer, Reus, and Moormann (2021) analysed the impact of perceived lean degree on job satisfaction in back-office environments in the financial services industry. Considering the perception of employees is important in order to see the actual impact of changes in the company (Clampitt and Downs 1993; Santos and Stuart 2003). Employee perceptions are not only a goal of lean implementations, they also have an influence on the impact of introduced lean methods (Wang and Chen 2010; Leyer, Reus, and Moormann 2021). The role of supervisors is particularly important in separating the implementation of Lean from staff reductions, which can lead to a negative employee perception of Lean implementations (Leyer, Reus, and Moormann 2021). Results of the study by Leyer, Reus, and Moormann (2021) show a positive correlation between the perceived degree of lean and job satisfaction. A more detailed analysis of the eight lean principles showed that 'individual responsibility' is a key indicator of job satisfaction (Leyer, Reus, and Moormann 2021). However, that study only referred to the degree of lean as perceived by employees. The actual use of lean methods in the organisation was not included in the data collection.

Building on the findings of Leyer, Reus, and Moormann (2021), this paper will determine the extent to how the actual use of lean management methods (divided into the six lean categories: Process and equipment, planning and control, human resources, product design, supplier

relationships and customer relationships) influences the relationship between perceived lean degree and job satisfaction.

Hypotheses

Employee satisfaction is an important element in lean management, but empirical evidence to support this relationship is still missing (Leyer, Reus, and Moormann 2021). Individuals from a lean manufacturing company were characterised by positive affect at work and cognitive job satisfaction compared to a company mass production structures (Lipińska-Grobelny and Papieska 2012). Vidal (2007) found through qualitative interviews that implementing lean production tools does not necessarily increase job satisfaction, but it can. The results of these studies suggest that the implementation of lean measures have an influence on job satisfaction. However, in order to remove the last doubts, it should be confirmed again to provide a basis for further hypotheses. Therefore, we first want to investigate whether introduced lean methods have an impact on the job satisfaction of the employees working in the company. In order to get a detailed insight, the different types of lean methods (Panizzolo 1998) are considered separately.

H1: Implemented lean methods of the different categories (1: Process and equipment 2: Planning and control 3: Human Resources 4: Product design 5: Supplier relationships 6: Customer relationships) have a positive influence on job satisfaction.

The results of previous studies have shown a positive correlation between perceived lean degree and job satisfaction, underlining the importance of the role of supervisors in deciding on the use of lean methods (Leyer, Reus, and Moormann 2021; Lipińska-Grobelny and Papieska 2012; Vidal 2007). According to Vidal (2007), it is primarily individual preferences that determine the effect on job satisfaction. This suggests that the individual perception of employees needs to be considered, not just whether lean methods have been implemented or not. Other studies have also found employees' individual perceptions of aspects within the company to be influential (Raab 2020; Maan et al. 2020). The findings suggest that the individual perception of Lean implementation has an influence on job satisfaction, however, this relationship has never been investigated in detail.

H2: The perceived lean degree has a positive influence on job satisfaction.

Also, it is not evident from the literature what type of lean methods lead to the increased job satisfaction. Therefore, the assumption that the perceived lean degree is influenced by the actually implemented lean methods will be tested for each category of lean methods in H3. Here, too, a distinction is made between the six categories of lean methods.

H3: Implemented lean methods of the different categories (1: Process and equipment 2: Planning and control 3: Human Resources 4: Product design 5: Supplier relationships 6: Customer relationships) have a positive influence on the perceived lean degree.

Since personal perception has often been found to be a mediator between two constructs in other studies as well (Gadassi and Rafaeli 2015; Perini, Abbott, and Rapee 2006; Acuña-Rivera, Brown, and Uzzell 2014), tests should be conducted to create a complete picture. Based on the direct hypotheses, we can formulate the mediating hypotheses: If the use of lean methods influences both the perceived lean degree and job satisfaction, it is possible that the perceived lean degree acts as a mediator between lean methods and job satisfaction. Hypothesis 4, therefore, deals with the assumption that the implementation of lean methods influences job satisfaction via the perceived degree of lean. Here, too, the implementation of lean methods is divided into the six previously used categories.

H4: The perceived lean degree mediates the relationship between actual used lean methods and job satisfaction positively.

H4.1: The perceived lean degree mediates the relationship between actual used lean methods of category 'Process and equipment' and job satisfaction positively.

H4.2: The perceived lean degree mediates the relationship between actual used lean methods of category 'Planning and control' and job satisfaction positively.

H4.3: The perceived lean degree mediates the relationship between actual used lean methods of category 'Human Resources' and job satisfaction positively.

H4.4: The perceived lean degree mediates the relationship between actual used lean methods of category 'Product design' and job satisfaction positively.

H4.5: The perceived lean degree mediates the relationship between actual used lean methods of category 'Supplier relationships' and job satisfaction positively.

H4.6: The perceived lean degree mediates the relationship between actual used lean methods of category 'Customer relationships' and job satisfaction positively.

Figure 2 provides an overview on the research model.

Methodology

Participants and procedure

We sent out a quantitative questionnaire to gather empirical evidence regarding the hypotheses. The questionnaires were answered anonymously, however using an individual but anonymous participant number, in order to ensure honest answers (Alsmadi, Almani, and Jerisat 2012). After a few weeks, the part of the questionnaire concerning the dependent variable (job satisfaction) was sent repeatedly to the same participants. The individual but anonymous participant number ensured that we could connect the answers from the first and second questionnaire. Using the data from the second questioning prevents common method bias due to temporally independent questioning of the independent and dependent variable. For the analysis, only results from participants with full data sets at both time points were included.

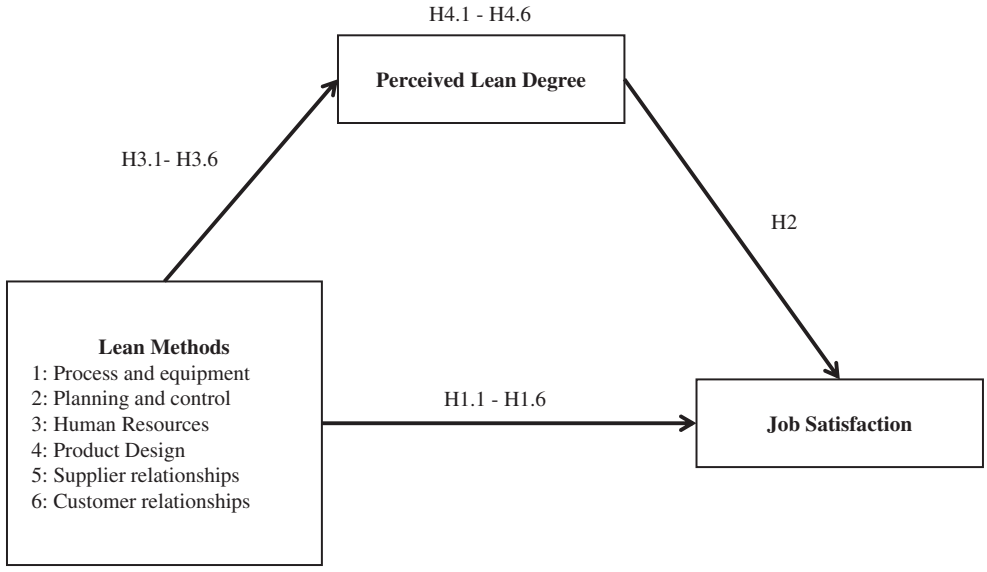

Figure 2. Research model.

A total of 264 participants answered the questionnaire completely at both round 1 and round 2 and could be included in the analysis. We tested the answers of participants from round 1 who did not participate with the ones who participated for the second time and did not find any statistical differences. The relevant demographic data of the participants is shown in Table 1.

Measures

The questionnaire contained questions regarding the independent, the mediating and the dependent variable as well as the demographics. The independent variable sets the lean methods used, categorised into six different areas. The dependent variable is job satisfaction. The mediator in our model is the perceived lean degree.

First, the dependent variable, participants' job satisfaction, was addressed. For this purpose, we used the Job Diagnostic Survey (JDS) according to Hackman and Oldham Greg (1980) similar to the work of Leyer, Reus, and Moormann (2021). A total of 50 indicators were used to determine satisfaction across different dimensions. The expression of the items was determined in seven-point Likert scales.

To measure the independent variable, the questionnaire contained questions regarding the use of lean methods. The questionnaire differentiated between the six categories described by Panizzolo (1998). Based on literature findings, Panizzolo has assigned different improvement programs in the form of lean methods to each category of lean implementations. We have also adopted these lean methods for our questionnaire. To ensure that both service and manufacturing employees can answer the questionnaire correctly, generalised descriptions have been added to the lean methods. The respondents were asked to indicate whether or not these were used in their company. In addition, they were given the option of not answering a question if they were not sure whether such a method was used. All methods of a category were summarised to a single indicator, which represents how much the methods of the respective lean category are implemented in the work environment of respondents.

In order to measure the mediating variable, the perceived lean degree, we adopted the questionnaire from Leyer and Moormann (2014). This is the only questionnaire that focuses on addressing employees regarding the perception of lean in their direct work environment. The scale consists of 37 items, which are measured with five-point Likert scales. The complete questionnaire is shown in Appendix A1.

Data analysis

A partial least squares (PLS) approach to structural equation modelling (SEM) was used to test the hypotheses of the study (Hair, Ringle, and Sarstedt 2011). This allows both formative (perceived lean degree) and reflective (job satisfaction) as well as single indicators (implemented lean methods) measurements to be included. To evaluate our model, we used SmartPLS 3.3.3, estimated our weights using a path method, and determined the significance of the path coefficients using the bootstrapping procedure with 5000 samples. We followed the requirements of Hair, Ringle, and Sarstedt (2011) to test our model. The test was performed with a one-tailed analysis with a significance level of 0.05.

Regarding job satisfaction, internal consistency reliability was tested and confirmed using composite reliability (Appendix A2). The convergent validity in terms of the reflective variables was also confirmed (Appendix A2). The discriminant validity of our measures was investigated and confirmed using heterotrait–monotrait (HTMT) ratios (Appendix A3). Since all requirements have been met, we can assume that the reliability and validity of the properties of the measurements regarding the reflective variable are adequate.

Table 1. Main demographics of the participants.

Industry	6% Plant engineering/mechanical engineering
	5% Automotive manufacturer/automotive supplier
	9% Bank/insurance/financial services
	3% Chemistry
	6% Electronics
	3% Energy supply
	8% Health and social services
	9% Trade
	9% IT/Telecommunications
	3% Consumer goods manufacturers
	3% Metal production and processing
	12% Public institutions
	2% Pharmaceuticals
	8% Transportation/Logistics
	14% Other
Years since the first education degree	Minimum: 0 years
	Maximum: 42 years
	Mean: 13.29 years
	Median: 10 years
Years in the current function	Minimum: 0 years
	Maximum: 40 years
	Mean: 5.89 years
	Median: 4 years
Department	11% Processing/Production
	5% Audit/Quality management/ Environment – health – safety
	3% Purchasing
	11% Finance and accounting
	8% IT
	15% Customer service
	8% Logistics
	4% Marketing
	3% Human Resources management
	1% Process engineering/Business organisation
	6% Product development/R&D
	2% Product management
	5% Project management
	0% Corporate development
	8% Sales and distribution
	10% Other
Position within the company	0% Board of directors/Management (or equivalent)
	5% Division manager (or equivalent)
	0% Head of department (or equivalent)
	5% Team leader (or equivalent)
	94% Employee/Team member

Also, the criteria for the formative variable of perceived lean degree have been tested and confirmed. The variance inflation factor (VIF) was used to check for multicollinearity among the indicators regarding the perceived lean degree variables. The values are in line with the requirements (Appendix A4). The criteria regarding heterogeneity between indicators were met according to the original scale.

In order to test and interpret the predictive power of the individual indicators of the mediation variable, we used PLS Predict. The implementation followed the guidelines of Shmueli et al. (2019). 42 of 47 Q2 predict values correspond to a value above 0 and can thus be used for further evaluation. The prediction errors are symmetrically distributed, so we used RSME values to compare and check the predictive power. With 36 of the 42 values, a high majority could withstand the check, suggesting a medium predictive power of the mediator's indicators (Appendix A5).

Results

The descriptive statistics and correlations for our sample are given in Table 2.

The results of our analysis are presented as an overview in the research model in Figure 3.

H1 suggested that each of the lean method categories implemented had a positive impact on job satisfaction. This can only be confirmed for the category 'Human Resources' ($ß = .154$, $p < .05$); all other categories have no significant influence (Process and equipment: $ß = -.005$, ns, Planning and control: $ß = .008$, ns, Product design: $ß = .029$, ns, Supplier relationships: $ß = .043$, ns, Customer relationships: $ß = -.087$, ns). H2 can be empirical supported, i.e. the perceived lean degree has a positive influence on job satisfaction ($ß = .317$, $p < .001$).

H3 suggested that each of the lean method categories implemented has a positive impact on perceived lean degree. This can only be confirmed for the categories 'Process and equipment' ($ß = .188$, $p < .01$), 'Planning and control' ($ß = .209$, $p < .01$) and 'Product design' ($ß = .158$, $p < .05$). A significant influence of the other categories cannot be confirmed (Human Resources: $ß = .092$, ns, Supplier relationships: $ß = .052$, ns, Customer relationships: $ß = -.070$, ns).

The sub-hypotheses of H4 investigated whether the perceived lean degree of the six different categories would mediates the relationship between actual used lean methods and job satisfaction positively. H4.1 can be confirmed, i.e. the perceived lean degree mediates the relationship between actual lean methods used of category 'Process and equipment' and job satisfaction positively ($ß = .060$, $p < .05$). There is a total mediation, that means, the positive effect of the lean methods of the category 'Process and equipment' on job satisfaction is completely intervened by the perceived lean degree and there is no direct effect of the lean category on job satisfaction, as can be seen also in Figure 3. H4.2 can be confirmed, i.e. the perceived lean degree mediates the relationship between actual lean methods used of category 'Planning and control' and job satisfaction positively ($ß = 0.66$, $p < .05$). Again, there is a total mediation, the positive effect of the lean methods of the category 'Planning and control' on job satisfaction is completely intervened by the perceived lean degree and there is no direct effect of the lean category on job satisfaction. H4.3 cannot be confirmed, i.e. the perceived lean degree does not mediate the relationship between actual lean methods used of category 'Human Resources' and job satisfaction positively ($ß = .029$, ns). H4.4 can be confirmed, i.e. the perceived lean degree mediates the relationship between actual lean methods used of category 'Product design' and job satisfaction positively ($ß = .050$, $p < .05$). In this case, too, there is total mediation, as can be seen in Figure 3. H4.5 cannot be confirmed, i.e. the perceived lean degree does not mediate the relationship between actual lean methods used of category 'Supplier relationships' and job satisfaction positively ($ß = .031$, ns). H4.6 can also not be confirmed, i.e. the perceived lean degree does not mediate the relationship between actual lean methods used of category 'Customer relationships' and job satisfaction positively ($ß = -.022$, ns).

Discussion

In our investigation, we examined how the use of different Lean methods affects job satisfaction, and what role the perceived Lean degree has as a mediator. Looking at the

Table 2. Descriptive statistics for the overall sample and correlations among variables.

Variable	Mean	SD	1	2	3	4	5	6	7	8
1	.427	.261	–	.652**	.615**	.615**	.631**	.603**	.429**	.235**
2	.367	.267		–	.532**	.606**	.614**	.547**	.402**	.226**
3	.532	.293			–	.617**	.461**	.621**	.386**	.405**
4	.395	.311				–	.605**	.655**	.414**	.213**
5	.371	.314					–	.648**	.376**	.165**
6	.501	.328						–	.423**	.187**
7	3.319	.513							–	.313**
	4.956	1.08								–

$N = 264$; *Notes*: $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$; one-tailed tests.
Number assignment: 1 = Process and equipment; 2 = Planning and control; 3 = Human Resources; 4 = Product design; 5 = Supplier relationships; 6 = Customer relationships; 7 = Perceived lean degree; 8 = Job satisfaction.

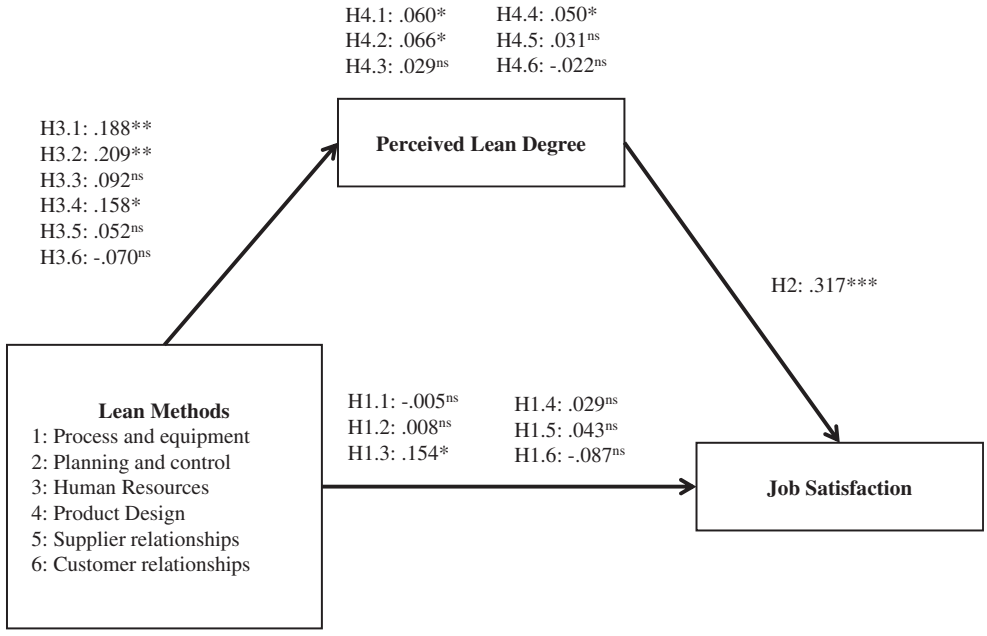

Figure 3. Results of the research model ($^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$; one-tailed tests).

different categories of lean methods, it is noticeable that only one of the six categories has a significant influence on job satisfaction – lean management methods from the area of human resources. One reason could be that methods are directly implemented here, which directly affect the personnel and the way they are dealt with.

The perceived level of lean has a significant influence on job satisfaction has already been noted in a previous study (Leyer, Reus, and Moormann 2021) and was confirmed again in this study. It is, therefore, not only the implementation of the method itself but also the personal perception of the individual employees about the use of Lean, how much the job satisfaction is influenced. This emphasises the importance of people as part of the organisation, which is essential to consider when planning lean environments.

Three of the six categories have a significant influence of the methods on the perceived lean level: Process and equipment, planning and control, and product design. A common characteristic of the three categories is the absence of the human factor, or human relationship. The other three categories (human resources, supplier and customer relationship) do not have a significant influence on the perceived level of lean. It is therefore possible that it is primarily methods that influence the work, production or activity itself that influence the perceived lean degree.

Although it was found that only one category of lean methods has a direct impact on job satisfaction, this study showed that there are further influences on job satisfaction through the use of lean methods. To recognise this, it is important to look at the perceived level of lean as a mediator between the use of lean methods and job satisfaction. The perceived lean degree mediates between three of the six categories and job satisfaction (process and equipment, planning and control, and product design), in all cases total mediation is found. This finding also shows that all categories of lean methods that have a significant impact on the perceived lean level also have a further impact on job satisfaction mediated by the perceived lean level. If only direct effects were considered, this effect would not have been noticed at all. Here again a commonality of the significant categories is the absence of the human factor, or human relationship.

Looking at all the results, it is the categories without human factors that have an indirect influence on job satisfaction. Lean methods in the Human Resources category, on the other hand, have a direct influence on job satisfaction.

Lean methods that are used in relation to supplier and customer relationships have no significant influence on job satisfaction.

Conclusion

This article is the first to examine the relationship of actually implemented lean methods on employee job satisfaction. Based on theory, our results show that the perceived level of lean is a mediator between lean methods and job satisfaction, however depending on different conceptual aspects. Our study showed that lean implementation can have an impact on the job satisfaction of a company's employees, but it is important to distinguish between the different lean methods or categories. The study also showed that the perceived lean degree has a direct impact on job satisfaction. These results are consistent with findings in the literature Leyer, Reus, and Moormann (2021). Additionally, our results however emphasise the role of the perceived lean degree as a mediator between some lean categories and job satisfaction.

As the first study in this context, we investigated the impact of different categories of lean methods instead of remaining on a general level of lean implementation. In detail, it is the lean categories 'Process and equipment', 'Planning and control' and 'Product design' which, mediated by the personally perceived lean degree, have a significant positive influence on job satisfaction. For the other categories 'Human Resources', 'Supplier relationships' and 'Customer relationships', on the other hand, no mediation by the perceived lean degree could be confirmed. All three categories, which mediate the relationship between lean methods and job satisfaction through the perceived lean degree, relate to the product or service that is to be provided. The Lean categories that relate to social interactions (Supplier and Customer Relationships, Human Resource) do not have mediation by the perceived Lean degree. The reason whether lean methods, mediated by the perceived lean degree, influence job satisfaction may therefore be related to how strong the direct relation of the lean method is to the product or service to be created. However, this assumption was not tested in our work.

Theoretical contributions

Our results have several theoretical implications. First, our findings extend the research of how lean management and job satisfaction are related. Previous research had only addressed the impact of the perceived level of lean on job satisfaction but had not considered the actual methods used in the company (Leyer, Reus, and Moormann 2021). Based on theory, we conceptualise how the lean implementation is having an impact in combination with the perception of employees. Second, our empirical results show in which area in companies the use of lean methods has a significant influence on job satisfaction. Therefore, it is possible to identify the lean methods introduced as determinants of the expression of satisfaction. Third, this work has expanded research in the domain of lean and job satisfaction, so that all relevant concepts are considered in which all the correlations between lean methods used, perceived lean levels and job satisfaction can be seen holistically. This study helps to see Lean implementations not only in terms of specific methods, but also regarding their impact across similar methods. Even if the specific assessment of individual methods continues to be highly relevant, an overall view is also necessary to make more general statements. In addition, a classification according to impact concerning individual company areas makes it easier to give practical recommendations.

Practical contributions

Our results also allow for practical implications, especially for leaders from operational and strategic areas who can use the newly gained knowledge to further influence employees' job satisfaction in a targeted manner. First, we have created an understanding that it is possible to increase the job satisfaction of employees with the targeted use of lean methods in the categories 'Process and equipment', 'Planning and control', 'Human Resources' and 'Product design'.

Exemplary methods in the 'Process and equipment' category are introducing a continuous flow line or working at flexible workplaces. Specific methods such as 'Jidoka' can help detect and eliminate faults earlier through (partial) automation of plants. The '5S' method ensures an organised workplace, reducing time wasted searching for work equipment, among other things. Other Lean tools for this category include 6 Sigma, Single-Minute Exchange of Die (SMED), and Value Stream Mapping (VSM). Managers are recommended to use these methods not only to reduce waste but also to increase employee satisfaction. 'Planning and control' include production smoothing or superimposed production. Here, for example, 'Heijunka' can be applied. The method ensures a reduced lead time due to smaller batches and consecutively produced product variants. The application of 'Kanban' also ensures a redirection of the flow of goods through the pull system and eliminates overproduction and waste of stock. Lean methods in 'Product design' can be modularisation of performance or the composition of multifunctional teams. In detail, Failure Modes and Effects Analysis (FMEA) or Quality Function Deployment (QFD) can be applied in practice in organisations to optimise product design according to Lean methods prior to the start of production.

However, implementing lean methods is not enough, as their perception plays a significant role in the above categories. This is possible, for instance, through simplified access to the lean methods, increased attention to the application of the methods, or the presentation of the methods and their functions during their introduction.

Limitations and future research

As with any study, our results come with limitations. First, the various methods were grouped into Lean categories with equal weighting. This assumes that each lean method has an equal impact on the perception of the lean group. In

practice, however, it is often the case that different methods have a different impact. Second, we did not capture specific methods in the survey. In order not to query specific lean methods, the implementation of lean principles and ideas were described and assigned to the categories. The descriptions enabled study participants without specialist knowledge to identify whether or not lean approaches were being used in the respective areas. In addition, the use of lean methods is surveyed as comprehensively as possible, so there is no risk of individual methods being forgotten in the survey. However, each categorisation also contributes to a generalisation. Some detailed information about which specific methods contribute to a category has thus not been collected. Third, we did not consider the specific context of the respondents in terms of their service or manufacturing environment. Hence, it could be investigated whether the use of lean methods has different effects depending on whether services are performed or manufacturing is undertaken. Fourth, according to the focus of our study, we did not specifically include reasons for lean implementations. Thus, to deepen our understanding in this regard, it would be interesting to find out in an in-depth analysis why some lean categories, meditated by perceived lean degree, affect job satisfaction and others do not.

Disclosure statement

The authors report there are no competing interests to declare.

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References

Acuña-Rivera, Marcela, Jennifer Brown, and David Uzzell. 2014. "Risk Perception as Mediator in Perceptions of Neighbourhood Disorder and Safety about Victimisation." *Journal of Environmental Psychology* 40: 64–75. doi:10.1016/j.jenvp.2014.05.002.

Ahmad, Habib, Khursheed Ahmad, and Idrees Ali Shah. 2010. "Relationship between Job Satisfaction, Job Performance Attitude towards Work and Organizational Commitment." *European Journal of Social Sciences* 18 (2): 257–267.

Ali, Syukrina Alini Mat, Noor Azzah Said, Noor'ain Mohamed Yunus, Sri Fatiany Abd Kader, Dilla Syadia Ab. Latif, and Rudzi Munap. 2014. "Hackman and Oldham's Job Characteristics Model to Job Satisfaction." *Procedia - Social and Behavioral Sciences* 129: 46–52. doi:10.1016/j.sbspro.2014.03.646.

Alsmadi, Majed, Ahmad Almani, and Rula Jerisat. 2012. "A Comparative Analysis of Lean Practices and Performance in the UK Manufacturing and Service Sector Firms." *Total Quality Management & Business Excellence* 23 (3–4): 381–396. doi:10.1080/14783363.2012.669993.

Aziri, Brikend. 2011. "Job Satisfaction: A Literature Review." *Management Research & Practice* 3 (4): 77–86.

Bhasin, Sanjay. 2011. "Performance of Organisations Treating Lean as an Ideology." *Business Process Management Journal* 17 (6): 986–1011. doi:10.1108/14637151111182729.

Chavez, Roberto, Wantao Yu, Muhammad Shakeel Sadiq Jajja, Yongtao Song, and Walid Nakara. 2020. "The Relationship between Internal Lean Practices and Sustainable Performance: exploring the Mediating Role of Social Performance." *Production Planning & Control* : 1–18. doi:10.1080/09537287.2020.1839139.

Clampitt, Phillip G., and Cal W. Downs. 1993. "Employee Perceptions of the Relationship between Communication and Productivity: A Field Study." *The Journal of Business Communication* 30 (1): 5–28. *(*1973*)* doi:10.1177/002194369303000101.

Dekier, Łukasz. 2012. "The Origins and Evolution of Lean Management System." *Journal of International STUDIES* 5 (1): 46–51. doi:10.14254/2071-8330.2012/5-1/6.

Gadassi, Reuma, and Eshkol Rafaeli. 2015. "Interpersonal Perception as a Mediator of the Depression–Interpersonal Difficulties Link: A Review." *Personality and Individual Differences* 87: 1–7. doi:10.1016/j.paid.2015.07.023.

Goshime, Yichalewal, Daniel Kitaw, and Kassu Jilcha. 2019. "Lean Manufacturing as a Vehicle for Improving Productivity and Customer Satisfaction: A Literature Review on Metals and Engineering Industries." *International Journal of Lean Six Sigma* 10 (2): 691–714. doi:10.1108/IJLSS-06-2017-0063.

Hackman, J. Richard, and Greg R. Oldham. 1974. "The Job Diagnostic Survey: An Instrument for the Diagnosis of Jobs and the Evaluation of Job Redesign Projects." https://files.eric.ed.gov/fulltext/ED099580.pdf

Hackman, J. Richard, and Greg R. Oldham. 1976. "Motivation through the Design of Work: Test of a Theory." *Organizational Behavior and Human Performance* 16 (2): 250–279. doi:10.1016/0030-5073(76)90016-7.

Hackman, J. Richard, and R. Oldham Greg. 1980. *Work Redesign*. Reading, MA: Addison-Wesley.

Hair, Joe F., Christian M. Ringle, and Marko Sarstedt. 2011. "PLS-SEM: Indeed a Silver Bullet." *Journal of Marketing Theory and Practice* 19 (2): 139–152. doi:10.2753/MTP1069-6679190202.

Hoppock, Robert. 1935. *Job Satisfaction, by Robert Hoppock*. New York and London: Harper and Brothers.

Jolayemi, Joel K. 2008. "Hoshin Kanri and Hoshin Process: A Review and Literature Survey." *Total Quality Management & Business Excellence* 19 (3): 295–320. doi:10.1080/14783360701601868.

Leyer, Michael, and Jürgen Moormann. 2014. "How Lean Are Financial Service Companies Really? Empirical Evidence from a Large Scale Study in Germany." *International Journal of Operations & Production Management* 34 (11): 1366–1388. doi:10.1108/IJOPM-06-2013-0296.

Leyer, Michael, Mareike Reus, and Jürgen Moormann. 2021. "How Satisfied Are Employees with Lean Environments?" *Production Planning & Control* 32 (1): 52–62. doi:10.1080/09537287.2020.1711981.

Lipińska-Grobelny, Agnieszka, and Ewelina Papieska. 2012. "Readiness for Change and Job Satisfaction in a Case of Lean Management application – A Comparative Study." *International Journal of Occupational Medicine and Environmental Health* 25 (4): 418–425. doi:10.2478/S13382-012-0044-4.

Locke, E. A. 1975. "Personnel Attitudes and Motivation." *Annual Review of Psychology* 26 (1): 457–480. doi:10.1146/annurev.ps.26.020175.002325.

Maan, Annum Tariq, Ghulam Abid, Tahira Hassan Butt, Fouzia Ashfaq, and Saira Ahmed. 2020. "Perceived Organizational Support and Job Satisfaction: A Moderated Mediation Model of Proactive Personality

and Psychological Empowerment." *Future Business Journal* 6 (1): 1–12. doi:10.1186/s43093-020-00027-8.

Mandujano, Maria, Luis Alarcon, John Kunz, and Claudio Mourgues. 2016. "Identifying Waste in Virtual Design and Construction Practice from a Lean Thinking Perspective: A Meta-Analysis of the Literature." *Revista de la Construcción* 15 (3): 107–118. doi:10.4067/S0718-915X2016000300011.

Minh, Khaw, Suhaiza Zailani, Mohammad Iranmanesh, and Shima Heidari. 2019. "Do Lean Manufacturing Practices Have Negative Impact on Job Satisfaction?" *International Journal of Lean Six Sigma* 10 (1): 257–274. doi:10.1108/IJLSS-11-2016-0072.

Netland, Torbjørn H., Jason D. Schloetzer, and Kasra Ferdows. 2021. "Learning Lean: rhythm of Production and the Pace of Lean Implementation." *International Journal of Operations & Production Management* 41 (2): 131–156. doi:10.1108/IJOPM-02-2020-0092.

Panizzolo, Roberto. 1998. "Applying the Lessons Learned from 27 Lean Manufacturers: The Relevance of Relationships Management." *International Journal of Production Economics* 55 (3): 223–240. doi:10.1016/S0925-5273(98)00066-8.

Parkhi, Shilpa Shekhar. 2019. "Lean Management Practices in Healthcare Sector: A Literature Review." *Benchmarking: An International Journal* 26 (4): 1275–1289. doi:10.1108/BIJ-06-2018-0166.

Perini, Sarah J., Maree J. Abbott, and Ronald M. Rapee. 2006. "Perception of Performance as a Mediator in the Relationship between Social Anxiety and Negative Post-Event Rumination." *Cognitive Therapy and Research* 30 (5): 645–659. doi:10.1007/s10608-006-9023-z.

Persis, Jinil, S. Anjali, Vijaya Sunder, G. Rejikumar, Raja Sreedharan, and Tarik Saikouk. 2020. "Improving Patient Care at a Multi-Speciality Hospital Using Lean Six Sigma." *Production Planning & Control* : 1–19. doi:10.1080/09537287.2020.1852623.

Plenert, Gerhard. 2010. *Reinventing Lean: Introducing Lean Management into the Supply Chain*. Cham: Elsevier.

Poksinska, Bozena Bonnie, Malgorzata Fialkowska-Filipek, and Jon Engström. 2017. "Does Lean Healthcare Improve Patient Satisfaction? A Mixed-Method Investigation into Primary Care." *BMJ Quality & Safety* 26 (2): 95–103. doi:10.1136/bmjqs-2015-004290.

Raab, Roman. 2020. "Workplace Perception and Job Satisfaction of Older Workers." *Journal of Happiness Studies* 21 (3): 943–963. doi:10.1007/s10902-019-00109-7.

Radnor, Zoe, and Robert Johnston. 2013. "Lean in UK Government: Internal Efficiency or Customer Service?" *Production Planning & Control* 24 (10–11): 903–915. doi:10.1080/09537287.2012.666899.

Rain, Jeffrey S., Irving M. Lane, and Dirk D. Steiner. 1991. "A Current Look at the Job Satisfaction/Life Satisfaction Relationship: Review and Future Considerations." *Human Relations* 44 (3): 287–307. doi:10.1177/001872679104400305.

Raziq, Abdul, and Raheela Maulabakhsh. 2015. "Impact of Working Environment on Job Satisfaction." *Procedia Economics and Finance* 23: 717–725. doi:10.1016/S2212-5671(15)00524-9.

Rousseau, Denise M. 1978. "Characteristics of Departments, Positions, and Individuals: Contexts for Attitudes and Behavior." *Administrative Science Quarterly* 23 (4): 521–540. doi:10.2307/2392578.

Sakthi Nagaraj, T., and R. Jeyapaul. 2021. "An Empirical Investigation on Association between Human Factors, Ergonomics and Lean Manufacturing." *Production Planning & Control* 32 (16): 1337–1351. doi:10.1080/09537287.2020.1810815.

Santos, Amalia, and Mark Stuart. 2003. "Employee Perceptions and Their Influence on Training Effectiveness." *Human Resource Management Journal* 13 (1): 27–45. doi:10.1111/j.1748-8583.2003.tb00082.x.

Shaju, M., and D. Subhashini. 2017. "A Study on the Impact of Job Satisfaction on Job Performance of Employees Working in Automobile Industry." *Journal of Management Research* 17 (2): 74–83.

Shmueli, Galit, Marko Sarstedt, Joseph F. Hair, Jun-Hwa Cheah, Hiram Ting, Santha Vaithilingam, and Christian M. Ringle. 2019. "Predictive Model Assessment in PLS-SEM: Guidelines for Using PLSpredict." *European Journal of Marketing* 53 (11): 2322–2347. doi:10.1108/EJM-02-2019-0189.

Smith, Marisa, Steve Paton, and Jillian MacBryde. 2018. "Lean Implementation in a Service Factory: Views from the Front-Line." *Production Planning & Control* 29 (4): 280–288. doi:10.1080/09537287.2017.1418455.

Sunder, Vijaya, Sanjay Mahalingam, and Sai Nikhil Krishna. 2020. "Improving Patients' Satisfaction in a Mobile Hospital Using Lean Six Sigma – A Design-Thinking Intervention." *Production Planning & Control* 31 (6): 512–526. doi:10.1080/09537287.2019.1654628.

Tan, Kim Hua, Paul Denton, Rosalind Rae, and Leanne Chung. 2013. "Managing Lean Capabilities through Flexible Workforce Development: A Process and Framework." *Production Planning & Control* 24 (12): 1066–1076. doi:10.1080/09537287.2011.646013.

Vidal, Matt. 2007. "Lean Production, Worker Empowerment, and Job Satisfaction: A Qualitative Analysis and Critique." *Critical Sociology* 33 (1–2): 247–278. doi:10.1163/156916307X168656.

Wang, Fu-Kwun, and Kao-Shan Chen. 2010. "Applying Lean Six Sigma and TRIZ Methodology in Banking Services." *Total Quality Management & Business Excellence* 21 (3): 301–315. doi:10.1080/14783360903553248.

Womack, James, and Daniel Jones. 1996. "Lean Thinking: Banish Waste and Create Wealth in Your Corporation." *Journal of the Operational Research Society* 48 (11): 1–8.

Womack, James P, and T. Jones Daniel. 2003. *Lean Thinking: Banish Waste and Create Wealth in Your Corporation*. New York: Free Press.

Womack, James P. Daniel T. Jones, and Daniel Roos. 1991. *The Machine That Changed the World: The Story of Lean Production – Toyota's Secret Weapon in the Global Car Wars That Is Revolutionizing World Industry*. New York, NY: HarperPerennial.

Wu, Peng, and Sui Pheng Low. 2012. "Lean Management and Low Carbon Emissions in Precast Concrete Factories in Singapore." *Journal of Architectural Engineering* 18 (2): 176–186. doi:10.1061/(ASCE)AE.1943-5568.0000053.

Appendix A1. Questionnaire.

Job satisfaction	Please provide your personal opinion about your current job.		
	JS1	It doesn't matter to me whether I do my job right or not.	7 Point Likert scale
	JS2	My opinion of myself gets better when I do my job well.	Do not agree at all (1)
	JS3	In general, I am very satisfied with my job.	Fully agree (7)
	JS4	Many of my work tasks seem trivial.	
	JS5	I usually know if my work results are satisfactory.	
	JS6	I feel great personal satisfaction when I do my job well.	
	JS7	My work has a high sense of purpose for me.	
	JS8	I feel a high level of personal responsibility for my work.	
	JS9	I often think about quitting my job.	
	JS10	I feel bad when I find out that my work results are not good.	
	JS11	I often have trouble figuring out if I am bad or good at my job.	
	JS12	I feel personally responsible for my work results.	
	JS13	I am generally satisfied with the nature of my activities.	
	JS14	My own feelings are generally not affected by how good or bad my work results are.	
	JS15	Whether I perform my work well or poorly is clearly my sole responsibility.	
	How satisfied are you with …		
	JS16	… the safety of your workplace?	7 Point Likert scale
	JS17	… your salary?	Extremely dissatisfied (1)
	JS18	… the opportunities for personal development?	
	JS19	… the colleagues you deal with in your work?	Extremely satisfied (7)
	JS20	… respect from your superior?	
	JS21	… the feeling of personal satisfaction in your work?	
	JS22	… the opportunity to get to know other people in the company?	
	JS23	… of support from your supervisor?	
	JS24	… Your salary compared to your work contribution in the company	
	JS25	… the proportion of independence in your activities?	
	JS26	… the security of your future development in your company?	
	JS27	… the possibility to support colleagues?	
	JS28	… the share of challenges in your activities?	
	JS29	… the basic leadership quality for your activities?	
	Most people in this job …		
	JS30	… feel great personal satisfaction when they do their job well.	7 Point Likert scale
	JS31	… are generally very satisfied with their jobs.	Do not agree at all (1)
	JS32	… find their work tasks trivial.	Fully agree (7)
	JS33	… feel a high level of personal responsibility for their work.	
	JS34	… usually know whether their work results are satisfactory.	
	JS35	… see your work as meaningful.	
	JS36	… clearly feel responsible for yours, whether they do their job well or poorly.	
	JS37	… often think about quitting their jobs.	
	JS38	… feel bad when they find out that their work results are not good.	
	JS39	… have problems figuring out whether they are good or bad at their job.	
	How much do you want the following in your current job?		
	JS40	Respect from my supervisor.	7 Point Likert scale
	JS41	Challenges in my activities.	Would like having this only a moderate amount or less (1)
	JS42	Opportunities for independence in the conduct of my activities.	
	JS43	High security of my job.	Would like having this extremely much (7)
	JS44	Very friendly colleagues.	
	JS45	Opportunities to learn new things in my work.	
	JS46	High salary.	
	JS47	Opportunities to be innovative in my work.	
	JS48	Fast promotions.	
	JS49	Opportunities for personal development.	
	JS50	Sense of personal satisfaction in work.	

Appendix A1. Continued.

Lean improvement programs	Please indicate now which of the following Lean initiatives have been implemented and are being applied in your work environment. The improvement programs mentioned here relate to process execution and equipment at their point of operation.			
	Process and equipment	PE1	Reduction of changeover time: reduction of the changeover time of the workstation from the last step of the previous activity to the first step of the next activity	Is applied/exists Is not applied/does not exist I do not know
		PE2	Continuous flow line: Allows to continue working on a single product/service in all process steps to be performed, without grouping them into batches.	
		PE3	Working at a production island/flexible workstation at which all part elements or process components can be integrated	
		PE4	Regular preventive maintenance and servicing of work equipment	
		PE5	'Fault-proof' equipment: faults either do not occur at all or are immediately apparent when they do occur	
		PE6	Progressive use of new process technologies	
		PE7	Regular order and cleaning of work equipment and environment	
		PE8	Continuous reduction of the cycle time	
		PE9	Permanent improvement of activities, processes, procedures or products by all employees of the company	
		PE10	Structured workplace design: Fixed arrangement for work tools and equipment	
	Please indicate which of the following Lean initiatives have been implemented and are being applied in your work environment. The improvement programs mentioned here relate to the planning and control of production or service delivery.			
	Planning and control	PC1	Production smoothing: minimising idle time and congestion by estimating future demand	Is applied/exists Is not applied/does not exist I do not know
		PC2	Synchronised scheduling: Synchronised schedule from production/execution and shipping schedules (or coordinated flow of several processes of services).	
		PC3	Mixed model planning: creation of several model/service variants on one assembly line/one activity area without workstation changeover	
		PC3	Undercapacity planning: scheduling additional time for non-productive tasks	
		PC4	Small batch sizes per manufacturing run (no mass production/ mass processing)	
		PC5	Visual control: Visual highlighting of work areas/processes (e.g.: by coloured tape markings)	
		PC6	Superimposed production: execution of different processes at the same time	
		PC7	Pull-flow production: production/processing only begins when customer demand is received	
		PC8	Adherence to daily schedule: Schedules are controlled daily	
	Please indicate which of the following Lean initiatives have been implemented and are being applied in your work environment. The improvement programs mentioned here relate to the area of human resources.			
	Human resource	HR1	Multifunctional employees: employees can perform various process activities, no pure specialisation in a single activity/service	Is applied/exists Is not applied/does not exist I do not know
		HR2	Cross-functional teams: composition of employees with different skills	
		HR3	Self-directed work teams: forming teams with employees who combine skills and talents and work towards a goal without the usual supervision of a manager	
		HR4	Expansion of the autonomy and responsibility of individual employees	
		HR5	Few management levels or flat hierarchy in the company	
		HR6	Involvement of employees in continuous quality improvement	
		HR7	Flexibility of working hours of employees	
		HR8	Decision making and problem solving in teams	
		HR9	Implementation of employee training	
		HR10	Innovative systems for performance appraisal and performance-related pay	
		HR11	Identification of employees with the organisation and its goals	
	Product design	PD1	Simplification of the product or services	Is applied/exists Is not applied/does not exist I do not know
		PD2	Parts/activity or service standardisation	

(*continued*)

Appendix A1. Continued

		PD3	Modularisation: Service or product subdivision into different units that can also be used for other services/products (modular system)	
		PD4	Passing on relevant information to employees (in order to educate the employee to be carried out about the purpose or objectives and reasons).	
		PD5	Design for manufacturing: design of the product takes into account the selected manufacturing process or planning of the services takes into account the selected implementation process	
		PD6	Phase overlap: new service/product creation can start before previous one is finished	
		PD7	Multifunctional design teams: people with different expertise work on common goal	
	Please indicate which of the following Lean initiatives have been implemented and are now being applied in your work environment. The improvement programs mentioned here relate to the company's relationship with suppliers.			
	Supplier relations	SR1	Just-in-time deliveries of product/service components	Is applied/exists Is not applied/does not exist I do not know
		SR2	Flexible commissioning to suppliers/sources of supply	
		SR3	First quality check is already done at source by suppliers/ sources of supply	
		SR4	Involvement of suppliers/sources in quality improvement programs.	
		SR5	Early exchange of information about production plans with the supplier/sources of supply	
		SR6	Involvement of suppliers/sources in service/product design and development.	
		SR7	Reduction of the number and distances of suppliers/ supply sources	
		SR8	Agreeing long-term contracts	
		SR9	Evaluation of suppliers according to the total costs incurred	
	Please indicate which of the following Lean initiatives have been implemented and are now being applied in your work environment. The improvement programs mentioned here relate to the company's relationship with customers.			
	Customer relations	CR1	Reliable and prompt deliveries/service provision	Is applied/exists Is not applied/does not exist I do not know
		CR2	Commercial measures to stabilise and influence demand	
		CR3	Sales network with high competence and various skills	
		CR4	Obtaining information about customer needs at an early stage	
		CR5	Flexibility in meeting customer requirements	
		CR6	Creating service-oriented products	
		CR7	Involvement of the customer in service/product design	
		CR8	Customer involvement in quality programs	
Work tasks	Line span	The questions that now follow relate to their professional tasks.		
		LS1	How many colleagues (number of persons including you) are managed by your direct manager? Please estimate the number if you cannot give an exact figure.	
		LS2	How many employees (number of persons) are you responsible for as a manager? If you are not a direct manager yourself, please enter '0'.	→ Filter if not 0
		LS3	How many people work in the company where you are employed?	→ Filter, out if below 50
	Working time	WT1 WT2 WT3 WT4 WT5	How are your working hours typically divided? Please add up to 100 (%).	- Contact with executives (e.g. planning, meeting). - Project activities - Operational activities (including time with clients) (Note: If you only work on projects, then your operational activities may be zero). - Administrative activities (e.g. filing) (if LE2 no filter question: answer options for executives!)

(*continued*)

Appendix A1. Continued

	Operational activity	OA1 OA2 OA3 OA4	What percentage of your OPERATIVE activities are accounted for by the following types of activities? Please add up to 100(%)!	- Activities with established work instructions that I can perform routinely - Activities with fixed work instructions where I have to think more intensively - Activities without defined work instructions that I can perform routinely - Activities without fixed work instructions, where I have to think more intensively
	Please now answer further questions about the lean management principle: Identifying value			
Lean management	Value	In my line of work …		5 Scale
		VA1	… I know the benefits of my activities for external customers.	Strong rejection Does not agree Neither/Nor Agrees Strong agreement
		VA2	… I continuously think about the benefits of my activities for external customers.	
		VA3	… I know how satisfied external customers are with the products I am involved in creating.	
	Please now answer further questions about the lean management principle: identify value stream			
	Value stream	VS1	In my field of work, I know which products my activities contribute to.	5 Point Likert scale
		VS2	I know the broad strokes of the activities required to complete these products for external customers.	
		VS3	I continuously coordinate with all relevant stakeholders, also outside my work area, for the processing of these products.	
		VS4	There are metrics for my activities that are based on external customer satisfaction.	
		VS5	In my work area, we mainly perform activities for one product group.	
	Please now answer further questions about the lean management flow principle			
	Flow	FL1	Reducing the lead time (not processing time) of customer orders together with my colleagues involved is an important goal of my daily work.	5 Point Likert scale
		FL2	I collect similar orders for my activities to work off in a block.	
		FL3	My workstation is set up by default so that I can complete my work steps quickly (e.g. without search times).	
		FL4	There are rules for response times for internal requests.	
		FL5	There is ongoing coordination with all relevant parties (including those outside my work area) on the products I work on to avoid work backlogs.	
		FL6	Substitution arrangements exist for the most important activities in my work area.	
		FL7	In case of ambiguities in the execution of my activities, there are clear decision-making powers of my manager or other colleagues	
	Please now answer further questions about the lean management pull principle			
	Pull	In my line of work …		5 Point Likert scale
		PU1	… I only work on request from internal/external customers.	
		PU2	… the scheduling is based on the demand from internal/external customers.	
	Please now answer further questions about the lean management principle: perfection			
	Perfection	PF1	I always check my work results in detail.	5 Point Likert scale Strong rejection Does not agree Neither/Nor Agrees Strong agreement
		PF2	My work results are not checked again by colleagues or managers – except in the case of legal requirements.	
		PF3	There are markings for my work (e.g. plausibility checks in software programs, clear colour markings, …) that help me to avoid typical mistakes.	
		PF4	Information on the execution of my activities (e.g. work instructions) is visualised at my workplace.	
		PF5	If I notice opportunities for improvement, I implement them or inform the person responsible.	

(*continued*)

Appendix A1. Continued

		PF6	In my work area, we use documented customer complaints to make workflow improvements.	
		PF7	In my work area, implemented improvements to work processes are continuously reviewed.	
		PF8	Information on goal achievement in my work area is visible to all employees in that area.	
	Please now answer further questions about the lean management principle: leadership			
	Leadership	LE1	My direct manager models changes that affect my work area.	5 Point Likert scale
		LE2	I have a long way to go (spatially speaking) to my manager.	
		LE3	Hypothesis is tested with the information provided by the surveyed managers on the distribution of their working hours.	
		LE4	In my area of work, there are regular discussions between managers and employees during the year with the aim of personal development.	
		LE5	I know the connection between the goals of my work area and the company goals.	
		LE6	The management of activities in my work area is based on key figures.	
	Please now answer further questions about the lean management principle: ownership			
	Individual responsibility	IR1	I am responsible for the result of my daily work.	5 Point Likert scale
		IR2	I have the opportunity during my working hours to implement new ideas to improve the activities in my work area.	
		IR3	We regularly discuss the results of our current activities as a team.	
		IR4	We regularly discuss the goals of the upcoming activities in the team.	
	Please now answer further questions about the lean management principle: continuous improvement culture			
	Continuous improvement culture	In my line of work …		5 Point Likert scale
		CI1	… I continuously consider how the existing activities can be improved.	
		CI2	… the most important thing when errors occur is that the identified culprit bears the consequences.	
		CI3	… there are regular meetings to discuss the prevention of the most common problems.	
		CI4	… measures to avoid occurring errors are identified with the relevant stakeholders.	
		Finally, please answer a few questions about your professional activities.		
Control variables		CV1	Which industry can your company be assigned to?	Plant construction/mechanical engineering, Automotive manufacturers/automotive suppliers, Banking/ insurance/financial services, Chemicals, Electronics, Energy supply, Health care and social services, Trade, IT/ telecommunications, Consumer goods manufacturing, Metal production and processing, Public-sector institutions, Pharmaceuticals, Transport/logistics, Other with free text field
		CV2		
		CV3	How many years ago did you complete your first education (vocational training or university degree)?	
		CV4	How many years have you held your current position in your company?	
		CV5	In which field do you work?	Processing/Production, Audit/ Quality Management/ Environment - Health - Safety, Purchasing, Finance and Accounting, IT, Customer Service, Logistics, Marketing, Human Resources Management, Process Engineering/Business Organisation, Product Development/R&D, Product Management, Project Management, Corporate Development, Sales, Other (with free text)
		CV6		

(*continued*)

Appendix A1. Continued

	CV7	What is your position in your company?	Executive board/management (or equivalent), division manager (or equivalent), department manager (or equivalent), team leader (or equivalent), employee/ team member

Many thanks for your participation!

Appendix A2. Construct reliability and validity.

	Cronbach's alpha	rho_A	Composite reliability	Average variance extracted (AVE)
Continuous improvement culture		1.000		
Customer relationships	1.000	1.000	1.000	1.000
Flow		1.000		
Human Resources	1.000	1.000	1.000	1.000
Individual responsibility		1.000		
Job satisfaction	0.807	0.844	0.794	0.456
Leadership		1.000		
Perceived lean degree	0.915	0.929	0.915	0.237
Perfection		1.000		
Planning and control	1.000	1.000	1.000	1.000
Process and equipment	1.000	1.000	1.000	1.000
Product design	1.000	1.000	1.000	1.000
Pull		1.000		
Supplier relationships	1.000	1.000	1.000	1.000
Value		1.000		
Value stream		1.000		

Appendix A3. Heterotrait–monotrait ratio (HTMT).

	Customer relationships	Human Resources	Job satisfaction	Perceived lean degree	Planning and control	Process and equipment	Product design	Supplier relationships
Customer relationships	–							
Human Resources	0.029	–						
Job satisfaction	0.069	0.300	–					
Perceived lean degree	0.113	0.312	0.434	–				
Planning and control	0.132	0,.71	0.235	0.445	–			
Process and equipment	0.183	0.418	0.257	0.442	0.490	–		
Product design	0.171	0.298	0.226	0.424	0.494	0.531	–	
Supplier relationships	0.106	0.274	0.224	0.374	0.417	0.450	0.465	–

Appendix A4. VIF values.

Item	VIF
Process and equipment	2.435
Planning and control	2.133
Human Resources	2.089
Product design	2.351
Supplier relationships	2.291
Customer relationships	2.418

Appendix A5. PLSpredict.

	Q^2_predict	RMSE PLS	RMSE LM
CI2	0.008	1.108	1.107
CI1	0.051	0.919	0.929
CI4	0.193	0.934	0.934
CI3	0.130	0.993	1.004
FL5	0.078	0.897	0.900
FL2	0.023	1.172	1.185
FL6	0.073	1.090	1.101
FL7	0.120	1.001	1.002
FL4	0.006	1.143	1.130
FL1	0.039	1.028	1.033
FL3	0.105	0.926	0.929
IR2	0.075	0.975	0.985
IR4	0.166	1.016	1.016
IR3	0.130	1.066	1.067
IR1	0.042	0.831	0.838
JS9	0.046	1.426	1.428
JS9rev	0.034	1.699	1.706
JS31	0.002	1.218	1.221
JS42	0.013	1.354	1.354
JS48	0.041	1.276	1.270
LE3	0.066	0.854	0.858
LE6	0.022	1.060	1.072
LE2	−0.006	1.296	1.310
LE1	0.094	1.052	1.064
LE4	0.050	1.153	1.163
LE5	0.142	0.936	0.941
VS1	0.135	0.760	0.766
PF3	0.080	1.118	1.123
VS2	0.105	0.931	0.935
PF6	0.015	1.149	1.155
VS5	−0.020	1.212	1.226
PF8	0.115	1.063	1.077
PF1	0.069	0.828	0.839
PF5	0.122	0.898	0.903
VA3	0.054	1.034	1.044
VS3	0.029	0.953	0.958
VA2	0.002	1.128	1.137
PU1	−0.003	1.165	1.163
PF2	−0.005	1.184	1.180
PU2	0.012	1.138	1.155
PF4	0.057	1.158	1.155
PF7	0.090	0.950	0.963
VS4	0.073	1.109	1.127
VA1	0.110	0.859	0.864
PF3	0.080	1.118	1.123
VS5	−0.020	1.212	1.226
VS1	0.135	0.760	0.766