Operational excellence in process industries: In search of effective implementation patterns

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Abstract

Many manufacturing firms launch operational excellence programs. However, there is still a lack of understanding of the managerial factors that influence their effective implementation. In this paper, we use survey data from a global manufacturing firm in the process industries to examine the effects of 28 different management practices on the implementation of an operational excellence program. Through a principal component analysis, we identify four sets of inter-related and internally consistent management practices. We empirically validate the effects of the four sets of practices on program implementation.

Keywords: Operational excellence, management control, process industries

Introduction

In order to keep up with global competition, manufacturing companies implement operational excellence programs. In the process industries, companies introduced total productive maintenance (TPM) programs already in the 1970s (Abdullah and Rajgopal, 2003; Bhadury, 2000). Since the 1990s, these firms have pursued more holistic production improvement programs, integrating TPM with the ideas from the Toyota Production System (TPS) and lean production (Netland, 2013). Over the last three decades, a lot of research has documented the operational practices of these programs (Hines et al. 2004; Holweg, 2007; Stone, 2012), and their expected effect on performance (e.g., Womack et al., 1990; Womack and Jones, 1996; Shah and Ward, 2003). Yet, despite all the research and efforts, companies still struggle with the implementation of these programs (Pay, 2008).

It has been documented that a key reason for disappointing results is a lack of sustained commitment among managers. Therefore, recent studies have investigated the characteristics of management behaviors that lead to successful implementation. In the popular literature on lean production, several books emphasizing leadership behaviors have been published in the last years (e.g., Rother, 2010; Liker and Convis, 2011; Ballé and Ballé, 2014). In the academic literature, Netland et al. (2015) analyzed the relationship between the use of certain management control practices and the implementation of operational excellence programs in a global manufacturing network, and Camuffo and Gerli (2018) built on broad case evidence to identify a set of lean management behaviors that drive lean implementation. But despite these and other recent efforts, further research is called for (Netland et al, 2015; Camuffo and Gerli, 2018).

We ask the following research question: *What management practices help to effectively implement an operational excellence program?* We contribute to the field of operational excellence by adding evidence of effective leadership practices from a process industry perspective. We empirically investigate the use of 28 different management practices in a global process industry firm by performing principal component analysis (PCA) to identify patterns among the practices. Thereupon, we analyze how they relate to the successful conduction of a global production improvement program. The results present four different sets of management practices, out of which three show a significant, positive effect on the implementation of operational practices.

Theoretical background

In the following, we briefly review the literature on operational excellence before discussing the role of the management system in lean implementations.

Operational excellence framework

Although there exists a large number of conceptually different definitions of *operational excellence* (e.g. as a methodology, philosophy, capability, etc.), still most parts of the literature define it as an ideal state that organizations can reach (Noland and Anderson, 2015; Isaar and Navon, 2016). It is the consequence of company-wide practices based on principles from different dimensions, comprising among others the organizational culture or the continuous improvement of processes plus their alignment to the corporate strategy (Rusev and Salonitis, 2016).

To close the gap between current operations and the state of operational excellence, manufacturing firms employ different improvement programs, whereby most of them are associated with practices from known philosophies like TQM, Six Sigma, or lean management (Netland, 2013). Especially, the latter has become one of the most widely accepted manufacturing paradigms in our modern times (Holweg, 2007). Lean management is generally about defining the purpose that an organization is trying to achieve, creating the processes that deliver this purpose, and organizing the people to manage these processes (Womack and Jones, 1996).

We build on Lyons et al. (2013) to propose an extended operational excellence implementation framework (see Figure 1). The framework describes how management through implementation of certain operational practices is able to realize operational principles, ultimately leading to operational excellence. Our study focuses on the first part of this framework.

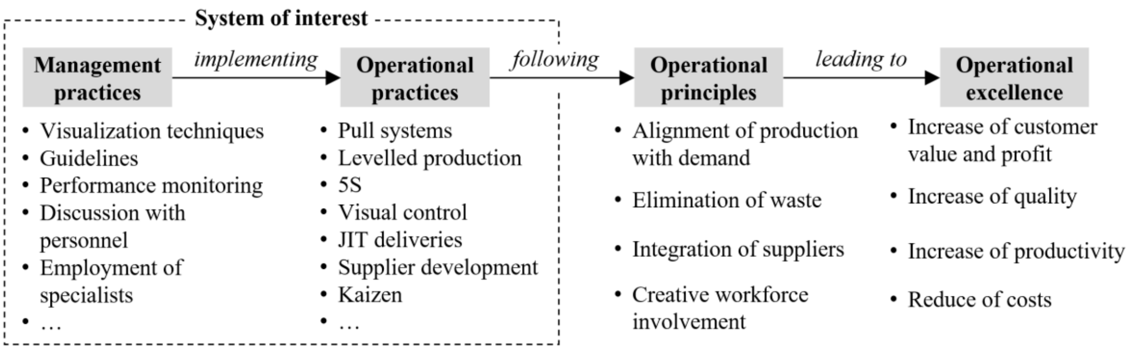

Figure 1 – Extended operational excellence framework based on Lyons et al. (2013)

Despite several big differences between manufacturing of discrete and non-discrete goods (King, 2009), like the continuity of operations or physical characteristics of the products, previous research has shown that lean practices can be applied in varying degrees to process industries (Abdulmalek et al., 2006; Lyons et al., 2013). Even in the extreme case of highly rigid and fully automated production processes, lean thinking can be applied to non-production-related activities such as logistics. In addition, process industries have a "discretization point" where the non-discrete product becomes discrete (e.g. through filling or packing), which consequently allows for the application of practices usually followed in the discrete sector. Against this backdrop, we consider the abovementioned framework for the next steps of this study.

The role of the management system

Production systems can be defined as socio-technical systems (Shah and Ward, 2007), where human resources (and technical elements) interact to perform different work practices. These interactions, which among others comprise the adoption of operational practices, rely on the underlying philosophy of the organization (De Menezes et al., 2010). Since both theoretical and practical studies recognize leadership as a key mechanism for embedding the relevant cultural values and norms into an organization (Schein, 1983; Womack et al. 1990; Waldman 1993; Liker 2004), management is considered a key enabler for the implementation of operational practices.

To create a better understanding of this phenomenon and identify the role of management, Anand et al. (2009) apply organizational learning theory to continuous improvement (CI) initiatives. Within their organizational infrastructure framework, which they categorize by *purpose*, *process*, and *people*, management has an essential effect on the sustainability of the CI initiative. Regarding the organizational purpose, they create the infrastructure necessary for the formulation and communication of common goals. Additionally, they support the adoption of methods required for discovering and executing improvements (process category). Lastly, they are responsible for training and motivating employees to participate in the CI initiative (people category). This way, management provides a vision throughout all hierarchical to steer the organization in a unified strategic direction and to create new operational capabilities (Nonaka, 1988; Anand et al., 2009).

Mann (2012) takes a closer look at the interplay between management, the lean management system comprised of lean principles and practices, and the production system. In his perspective, management takes on the role of a "bridge" between the two other systems and guarantees consistency among them (Camuffo and Gerli, 2018). It captures the expectations for executing lean practices and eliminates guesswork for floor managers and team leaders, whereby it helps to successfully implement lean practices. Further studies (Poksinska et al., 2013; Laureani and Antony, 2016) support this line of reasoning and find transformational leadership behaviors that incorporate cultural values and objectives to be effective when implementing production improvement programs (Waldman et al., 1998).

A systematic way to categorize management practices is provided by Kennedy and Widener (2008). They propose a conceptual framework consisting of *social-*, *behavioral-* and *output* controls. Social control mechanisms aim at supporting the personnel, on either an individual or group-level. Examples are the use of visualization techniques (Banker et al., 1993), creating peer pressure (Ezzamel and Willmott, 1998), or empowerment of the employees (Lind, 2001). Behavioral control mechanisms are characterized by standard operating procedures and rules (Kennedy and Widener, 2008). These are not seen as strict instructions but rather as systematic descriptions of the activities employees need to perform, helping them to reach an output in both the desired quantity and quality (Nielsen et al., 2018). Output control mechanisms comprise financial and non-financial measurement and reward systems, which can be used to motivate employees on all factory levels to commit to change programs (Merchant and Stede, 2012; Netland et al., 2015).

Overall, all studies recognize that the pursuit of an operational excellence program is a journey that takes time and needs to be guided by the management. Further, it is the management's responsibility to motivate and inspire employees for participation through establishing an organizational culture that welcomes and realizes the implementation of operational practices (Taylor and Wright, 2003; Hilton and Sohal, 2012).

Research gap

Since the implementation of operational practices is contingent upon various factors like the firm's strategy, culture, size, and the stage of implementation (Camuffo and Gerli, 2018), research is needed to create a thorough understanding of such a complex field of investigation. However, so far, only few studies have contributed to the understanding of the specific characteristics of management systems that successfully lead to the implementation of operational practices (Netland et al., 2015; Camuffo and Gerli, 2018; Nielsen et al., 2018).

Therefore, in this study, we first aim at identifying patterns within management practices by grouping them into sets of variables based on their correlation (Step 1). Thereby, we define unique sets of management practices. Further, we aim at establishing the effects that the pursuit of these sets of management practices has on the implementation of operational practices in the process industry (Step 2). The following figure depicts the conceptual reasoning of this research.

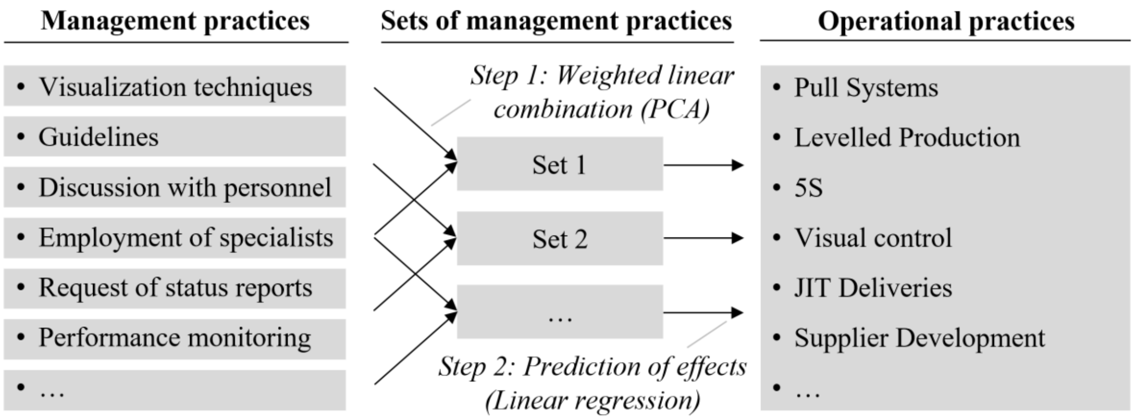

Figure 2 – Specification of the research framework

Research methodology

As this research aims at identifying patterns of management behavior, we decided to take an exploratory approach, investigating a set of management practices applied throughout an operational excellence program and trying to find subsets within those. Further, we aim at establishing relationships between those subsets and the successful implementation of operational practices.

Data collection

To achieve this research goal, we teamed up with a global manufacturer in the process industry ("Process Inc"). Process Inc. has been implementing a global operational excellence program in its nearly 40 globally dispersed factories over the last three years.

We administered a survey in the firm asking about the strategic priority and the actual level of implementation of operational excellence program practices in 2017, as well as the use of specific management practices. For this study, we used close-ended questions on a 5-point Likert scale to operationalize the use of managerial practices (from *1 = never*, to *5 = very frequently*) and the implementation level of operational practices (from *1 = low*, to *5 = high*). We obtained 272 responses (average of 8 respondents per plant), whereby the respondents were represented mainly by production supervisors, operations managers, production planners or managers, and general managers.

Data analysis

To identify the underlying relationships between variables, we performed a principal component analysis (PCA) on all management practices. To determine the principal components to be included in the model, we used the eigenvalues-greater-than-one rule as it was proposed by Kaiser (1960). Varimax rotation was used to extract orthogonal components and after running the factor analysis on 28 variables, four components were extracted and found to have eigenvalues > 1. These were then validated using reliability analysis (Cronbach α). For every component, Cronbach α was above the acceptable threshold of 0.6. Exceptionally, one item ("Managers' reward with financial remuneration") was found to increase the Cronbach α of its corresponding component (*Collaboration*) when being deleted. Additionally, it did not show much consistency with the other items of the component, which is why it was excluded from further analysis.

After conducting another, final PCA with the remaining 27 items, we obtained four components with eigenvalues > 1 explaining 69.6% of the variance. The factor loadings of each variable describe the correlation coefficient related to the respective component, thus indicating the percentage of variance of each variable explained by each factor. This allowed us to group management practices according to their loadings around the resulting components (sets of management practices). The results are shown in Table 1.

Finally, we used multiple linear regression to predict the overall implementation level of operational excellence practices which was measured as the mean implementation level of various practices including continuous improvement, competence development, stable processes, maintenance, etc. We used this technique to assess the incremental effect of the different identified sets of management practices by controlling for the effects of respondent's work experience, plant characteristics (unionization and age), and different product types being produced by Process Inc. (see Table 2).

Table 1 – Principal component analysis: rotated component matrix

Management practice	**Factor loadings**			
	PC 1 (*Communication*)	PC 2 (*Organization*)	PC 3 (*Collaboration*)	PC 4 (*Commitment*)
Instructions are displayed at the shop-floor	**0,742**	0,311	0,020	0,215
Management speaks to employees about implementation	**0,738**	0,407	0,043	0,272
Operational excellence training for shop-floor personnel	**0,736**	0,354	0,111	0,145
Personnel meets to discuss implementation	**0,687**	0,482	0,018	0,193
Internal marketing efforts (intranet, magazines, etc.)	**0,677**	0,188	0,450	0,137
Operational excellence training for top-management	**0,643**	0,264	0,257	0,419
Personnel visits other plants for experience sharing	**0,641**	0,186	0,402	0,181
Personnel from other plants visits and shares experience	**0,620**	0,193	0,407	0,211
Implementation performance is benchmarked	**0,579**	0,358	0,349	0,181
Implementation performance charts are used	**0,571**	0,561	-0,024	0,189
Management asks for status reports	**0,564**	0,532	0,067	0,395
Headquarter makes more investments possible	**0,554**	0,340	0,316	0,125
Personnel and teams are rewarded with non-financial benefits	**0,552**	0,441	0,209	0,150
Organized teams of dedicated employees	0,232	**0,795**	0,117	0,253
Shop-floor improvement teams are established	0,327	**0,780**	0,183	0,059
Dedicated employee who leads and supports implementation	0,223	**0,698**	0,335	0,161
Decisions are taken through an established hierarchy	0,430	**0,672**	0,022	0,341
Documents provide guidelines for implementation	0,462	**0,618**	0,069	0,289
Internal assessments/audits are undertaken	0,512	**0,609**	0,083	0,258
Sufficient cost budgets are allocated to the implementation	0,329	**0,547**	0,124	0,421
Implementation performance is monitored at headquarter	0,265	**0,545**	0,244	0,169
Specialists from group-functions are employed on shop-floor	0,150	0,043	**0,885**	0,063
Managers or specialists from other plants are employed	0,228	0,065	**0,859**	0,086
External consultants are hired	0,024	0,232	**0,741**	0,047
Top-management is actively and hands-on involved	0,222	0,230	0,100	**0,840**
Top-management explicitly mandates implementation	0,266	0,298	0,119	**0,819**
Top-management makes periodic visits to the shop-floor	0,476	0,461	0,127	**0,522**
Eigenvalue	14.255	2.317	1.152	1.068
Initial percent of variance explained	52.8	8.58	4.27	3.96
Rotation sum of squared loadings	6.84	5.78	3.24	2.94
Percent of variance explained	25.32	21.39	12	10.89
Cronbach α	0.950	0.922	0.849	0.831

Extraction method: principal component analysis. Rotation converged in 7 iterations

Table 2 – Results from hierarchical linear regression analysis with program implementation level as dependent variable

	Standardized β coefficients	
	Model 1	Model 2
Work experience at Process Inc.	0.105	0.071
Union	-0.204**	-0.112
Plant age	-0.039	-0.047
Product type 1	0.067	0.069
Product type 2	0.076	0.078
Product type 3	-0.035	-0.054
PC 1 (*Communication*)		0.250***
PC 2 (*Organization*)		0.434***
PC 3 (*Collaboration*)		-0.016
PC 4 (*Commitment*)		0.299***
R^2	0.057	0.378
Adjusted R^2	0.033	0.346

* P < 0.05
** P < 0.01
*** P < 0.000.

Findings

According to the loadings from the PCA, the 27 individual management practices were assigned to different components. Disregarding only a few exceptions, the combinations resulted in four distinctive and internally-consistent sets of management practices.

The largest category consists of a combination of 13 practices related to the *communication* within the organization. The items with the highest loadings reflected the instruction of personnel on the shop-floor, for example by visualizing information about the program (1) or by training the employees (3, 6). Other items of this category also included exchange of information with other plants (7, 8) or performance reports (10, 11).

Practices related to the formalization of organizational relationships and processes were combined to *organization* practices. These include practices such as dedicated implementation teams or employees (14, 16), hierarchical decision-making structures (17), or internal audits (19).

The set of *collaboration* practices explicitly refers to the collaboration with specialists that can either be drawn from other departments or plants of the respective company (22, 23), or be employed as external consultants (24).

The fourth set relates to the *commitment* of the top-management and describes how well it is involved in the implementation process. Here, top-management is either hands-on involved (25), makes periodic visits to the plant (27), or at least mandates the implementation of the operational practices explicitly (26).

Regression analysis

The multiple linear regression with the overall implementation level of operational practices as the dependent variable showed that the control variables (different product types manufactured by Process Inc., the work experience of the respondent, the plant age, and the unionization status of the plant) only account for a small amount of variance (adjusted $R^2 = 0.033$). The inclusion of the identified sets of practices (Model 2) results in a change of the adjusted R^2 of 0.313. Overall, the model explains 37.8% of the variance.

We find that three out of four sets are positively associated with the implementation level of operational practices, even showing high significance ($p < 0.001$). We did not find significant results from the use of *collaboration* practices.

Discussion

This study provides empirical evidence for the managerial pursuit of four distinct sets of practices by analyzing the use of a diverse set of managerial practices in the process industry. Thereby, our research represents a further step towards the exploration of the role of management within operational excellence programs concomitant with the implementation of operational practices. The fact that three out of four of the identified sets showed a significant, positive effect on the overall implementation level of operational practices supports the results from previous studies. Accordingly, management plays an important role in successfully carrying out operational excellence programs (Nielsen et al., 2018). Furthermore, it has been shown that management needs to be aligned to the firm's individual situation by emphasizing different sets of management practices (Marodin and Saurin, 2015; Camuffo and Gerli, 2018).

The first set we postulate consists of managerial practices that are related to the communication within an organization on many levels. However, managerial practices supporting the instruction of employees on the shop-floor showed particularly high loadings in the results of the PCA. We therefore suggest that managerial support in terms of providing necessary information to the personnel responsible for operating the production system is of major importance. This is underlined by the positive and significant regression coefficient of this set on the implementation level.

Regarding the next set, our results suggest that the formalization of organizational relationships is also crucial for the adoption of operational practices. It is represented by managerial establishment of rules and standards to coordinate processes and people. Further, it showed the highest regression coefficient and thus seems to be the most effective set of managerial practices to be followed. The reason for this high leverage on the implementation might be the fact that this set included the designated use of dedicated implementation teams resp. employees. However, our results indicate that most importantly managers should purposefully create an organizational infrastructure to ensure that the implementation of a new production system is carried out successfully.

Notably, the collaboration with specialists, including both internal experts and external consultants, showed no significant effect in the regression analysis. Hence, it appears arguable if the merely temporary use of other people's expert knowledge is favorable for long-term programs as the implementation of a new production system. It appears to be rather beneficial if employees learn themselves about new practices, in order to better reach and maintain an implementation status.

Managerial commitment to the implementation of operational practices is the last set of practices we introduce. It encompasses different ways how management can involve in the implementation process. Similarly to the first two sets, it also supports the implementation positively, showing a significant effect. This appears reasonable and to be in line with the literature which is generally supporting an active role of management.

The empirical results proved to be relatively strong in terms of their validity. The four components of the PCA showed high internal consistency with regard to the incorporated practices. Additionally, the regression model managed to explain a relatively high amount of the variance (37.8%), which gives overall strong support for our theses.

Summarizing, this study contributes to a growing field of research in two ways: On the one hand, it builds a conceptual bridge between the management system and the lean thinking framework by Lyons et al. (2013) by elucidating the relationships between managerial practices and operational practices. On the other hand, it proposes a set of four empirically validated sets of management practices including their effectiveness towards the implementation of operational practices, which helps to prioritize the work of managers in operational excellence programs.

Conclusion

This research presents two findings. First, it identifies four distinct key sets of practices management can pursue when implementing operational practices throughout production improvement programs. These encompass the emphasis on communication, the organization of processes as well as people, the collaboration with specialists, and the management commitment to implementation. Second, it establishes the effects these sets of practices have on the implementation. Communication, organization, and commitment showed a significant, positive impact on the implementation. Notably, collaboration with specialists was not found to be effective when implementing operational practices in this research setting, suggesting the importance of building up knowledge independently.

Thereby, this study contributes to the research field of operational excellence by adding one block of knowledge about effective management in the process industry. However, still more research is required, taking more contingent variables into account, to extend this understanding to a broader scale.

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