Maturity Analysis of Safety Performance Measurement

Aki Jääskeläinen[1], Sari Tappura[1] and Julius Pirhonen[1]

[1] Tampere University, Management and Business, FI-33014 Tampereen yliopisto, Tampere, Finland
{aki.jaaskelainen, sari.tappura, julius.pirhonen}@tuni.fi

Abstract. Organizations have several indicators for their safety performance. However, the use of performance indicators often fails to create overall insights on the level of safety and the various factors affecting it. Performance indicators could be better utilized in safety-related decision-making. Maturity models have been presented in many different managerial fields, but no such models for safety performance measurement can be identified. Maturity analysis can provide information on why performance measurement utilization is flawed and how can it be improved. The aim of this paper is to design and test a maturity model for safety performance measurement. The study presents an approach for evaluating maturity which combines written descriptions of best practices, the overall satisfaction of employees in the evaluated aspects, and the experienced level of safety performance.

Keywords: Performance Measurement · Safety Performance · Maturity analysis

1 Introduction

Existing research classifies safety performance indicators into various dimensions, such as leading and lagging [1,2]. Organizations have several indicators for their safety performance. However, it is often difficult to materialize the potential of performance measurement [3,4]. The current use of performance indicators rarely creates overall insights on the level of safety and the various factors affecting it. Hence, performance indicators could be better utilized in safety-related decision-making [5].

In the recent decades, maturity models have been presented in many different managerial fields such as information management, strategy management, and performance management [6,7,8]. These models have been designed both for managerial and academic purposes. Maturity models typically define maturity levels which assess the completeness of the analyzed objects via different sets of multi-dimensional criteria, and describe essential attributes that would be expected to characterize an organization at a particular maturity level [9]. Maturity models can be used both as an assessment tool and as an improvement tool [9,10]. There is indication in the literature that maturity models can improve organizational performance [11] by presenting desirable characteristics for operating.

Performance measurement literature has presented several models for the maturity analysis of organizational performance measurement [6,7,8]. In regard to safety management, maturity models for safety culture and risk management have been presented

[12,13,14]. However, to the best of our knowledge, no one has applied maturity models for analyzing the status of safety performance measurement. The aim of this research is to design a maturity model for safety performance measurement based on literature review and analysis.

2 Materials and Methods

This study utilizes a design science approach in which the intention is to both develop scientific knowledge and solve practical problems [15]. Since the aim of this study is to design a maturity model for safety performance measurement and to give guidelines for its future implementation, design science is an obvious approach for this aim. The six main phases of design science process [16] can be found in Figure 1. This study follows the first three steps while testing, deploying and maintaining are not in the scope.

Fig. 1. Main phases in constructing a maturity model [16].

In the first phase, the scope and target population of the model are defined. In this study, the scope was related to the safety performance measurement practices, commitment and culture supporting performance measurement and performance measurement usage. The model can be applied in different organizations without industry limitations.

The second phase consists of the definition of evaluation variables and execution plans. Evaluation variables can be identified both analytically (top-down) or by combining the existing literature (bottom-up). This study applied bottom-up approach and identified the evaluation variables based on appropriate literature. The analysis is designed to be implemented as a self-evaluation survey addressed to managers, supervisors and safety experts. The managerial perspective is deemed important in order to obtain a more reliable picture on the status safety performance measurement.

The main content of the model is defined in the third phase. A survey instrument was designed with maturity levels describing the alternative practices in each of the evaluated variables. In the fourth phase the model is tested. In our study, four persons of the intended population first evaluated the evaluation tool. Then it was further tested by two fellow scholars. Finally, a web-based survey tool was designed and tested with four persons of the intended population.

This study is mostly based on literature review and analysis. The performance measurement maturity model by Jääskeläinen and Roitto [6] was taken as a starting point and complemented by other existing performance measurement maturity models. The adjustment of the model into safety management context was supported by the review of literature on safety management and safety culture maturity models and by the expertise of safety scholars.

3 Results

3.1 Maturity model framework

The model framework was divided into three main themes: safety performance measurement practices, commitment and culture to safety performance measurement and use of safety performance measurement. These reflect the three lifecycle perspectives of performance measurement including design, implementation and use [17]. In addition, the level of safety in an organization is measured.

In the following presentation, the number of evaluated items is presented alongside with the main themes of the model framework. Safety performance measurement practices represents performance measurement design and includes the most established content of the model. There are maturity several models concentrating the design of performance measurement. Performance measurement practices is further divided into two categories: performance measurement (10 items) and information systems (IS) (4 items). The importance of IS has been emphasized in parallel with the content of performance measurement [18].

Commitment and culture related to performance measurement is widely seen as an important success factor of performance measurement implementation [19,20]. It is important that both managers (2 items) and employees (2 items) are committed to safety performance measurement. This aspect is closely related to safety culture [21].

There is no established definition on the content of performance measurement usage [22] which is also reliant on the field of management (e.g. safety management). In the actual usage of safety performance measurement, the first perspective of the presented model is communication of measurement results (2 items) which facilitate information flows and use of measurement information [19]. The extent of using performance measurement at different levels of the organization is also included with one item. The actual use of performance information in different managerial tasks is divided into use of information in planning (ex-ante perspective, 3 items) and management (ex-post perspective, 6 items). The management items were selected with a balanced approach related to the three perspectives: resource allocation (financial management), benchmarking and supply chain (processes) and competencies and rewarding (learning and growth).

Table 1 provides examples of items and related references in the three main dimensions of the model. Each of the three main perspectives is also evaluated in terms of a respondent's satisfaction towards the status of the perspective. By capturing satisfaction, the designed new model highlights purposeful objectives of developing safety performance measurement. It acknowledges that also more elementary measurement techniques may suffice if employees are satisfied. In this way, the model takes different contextual criteria for knowledge management practices into account.

Table 1. Exemplifying illustration of the maturity model framework.

Dimension	Example item	References
A. Performance measurement practices	Links between occupational safety performance measurement objects	[7,12,23,24,25]

Dimension	Example item	References
B. Commitment and culture related to performance measurement	Employee commitment to occupational safety performance measurement	[12,23,26,27]
C. Use of performance measurement	Defining action plans related to occupational safety	[3,7,12,14,23,25,26,28]

3.2 Evaluation instrument

The evaluation of the items in the model is carried out with four-step maturity levels representing the sophistication level in each item. This means written descriptions for the four evaluation levels (Table 2). The descriptions were based on the literature on best practices of performance measurement and management [e.g. 29,30] and safety management [e.g. 12,28]. In alignment with Maier et al. [10], the best and weakest practices were defined first. Authors's own expertise was needed in defining the levels 2 and 3.

Table 2. Example of written evaluation criteria in maturity levels.

Level	Item: links between safety performance measurement objects
Level 1	Linkages between measurement objects have not been considered.
Level 2	Linkages between measurement objects are discussed.
Level 3	Factors explaining the main measurement results are partially identified.
Level 4	Linkages between measurement objects are analyzed and modeled (e.g. with a strategy map). There is a common understanding in the organization regarding the factors that should be improved in order to affect the main measurement results.

Written evaluation criteria were chosen to differentiate the model from some earlier maturity surveys using Likert scales. The following benefits in written evaluation levels have been identified. First, written maturity levels provide clearer and more objective alternatives for the respondents in comparison to Likert scales [23]. Second, presentation of written maturity levels raises awareness of best practices, generates discussion and facilitates the identification of development areas already during the completion of the survey [31]. Third, written maturity levels decreases the need to use external consultants and knowledge on practices outside the own organization in the evaluation [32].

4 Discussion

The main contribution of this paper is a presentation of maturity model which can be utilized as a checklist in analyzing safety performance measurement. The model evaluates maturity by combining written descriptions of best practices, the overall satisfaction of employees in the evaluated aspects, and the experienced level of safety performance. Sophisticated performance measurement practices are useless if they are not beneficial for an organization. The perspective of employee satisfaction towards performance measurement acknowledges the need to fit the practices into contextual needs. The specific characteristics of the model is its balance between rigor (literature

derived items) and relevance (written evaluation levels) reflecting the main idea of design science. To the best of our knowledge, the presented model is the first one specifically designed for the purposes of evaluation safety performance measurement.

The resulting model will benefit both the research and practice of safety management. Researchers may use the model in large-scale survey research (e.g. in identifying links between safety performance and the level of safety) and practitioners may utilize it in auditing performance management practices, for example, through group interviews or workshops. Based on the results, improvement means can be generated and prioritized in order to reach higher maturity levels [9]. The combination of maturity levels and satisfaction may be used in defining various profiles for the status of performance measurement in an organization, e.g. as follows: ”Novice” (Low employee satisfaction and basic practices), ”Facilitator” (High employee satisfaction and basic practices) , ”Experimenter” (Low employee satisfaction and advanced practices) and ”Advanced exploiter” (High employee satisfaction and advanced practices). The profiling allows an easy way to position an organization in relation to other organizations in the three main perspectives of the model. Further research should test the presented model in practice and report the experiences of using the model in practice.

Acknowledgments. The authors acknowledge the research funding provided by the Finnish Work Environment Fund, participating companies, and Tampere University.

References

1. Podgórski, D.: Measuring operational performance of OSH management system –A demonstration of AHP-based selection of leading key performance indicators. Safety Science 73, 146--166 (2015)
2. Reiman, T., Pietikäinen, E.: Leading indicators of system safety – Monitoring and driving the organizational safety potential. Safety Science 50, 1993--2000 (2012)
3. Bititci, U.S., Ackermann, F., Ates, A., Davies, J., Garengo, P., Gibb, S., MacBryde, J., Mackay, D., Maguire, C., van der Meer, R., Shafti, F., Bourne, M., Firat, S.U.: Managerial processes: business process that sustain performance, Int. J. Operations & Production Management 31(8), 851--891 (2011)
4. Bourne, M., Franco-Santos, M., Kennerley, M., Martinez, V.: Reflections on the role, use and benefits of corporate performance measurement in the UK. Measuring Business Excellence 9(3), 36--41 (2005)
5. Tappura, S., Sievänen, M., Jussila, A., Heikkilä, J., Nenonen, N.: A management accounting perspective on safety. Safety Science 71, Part B, 151--159 (2015)
6. Jääskeläinen, A., Roitto, J. M.: Designing a model for profiling organizational performance management. Int. J. Productivity and Performance Management 64(1), 5--27 (2015)
7. Van Aken, E.M., Letens, G., Coleman, G.D., Farris, J., Van Goubergen, D.: Assessing maturity and effectiveness of enterprise performance measurement systems. Int. J. Productivity and Performance Management 54(5/6), 400--418 (2005)
8. Wettstein, T., Kueng, P.A.: A maturity model for performance measure systems. In: Brebbia, C., Pascola, P. (eds.) Management Information Systems: GIS and Remote Sensing, pp. 113--122. WIT Press, Southampton (2002)
9. Goncalves Filho, A.P., Waterson, P.: Maturity models and safety culture: A critical review. Safety Science 105, 192--211 (2018)
10. Maier, A.M., Moultrie, J., Clarkson, P.: Assessing organizational capabilities: reviewing and guiding the development of maturity grids. IEEE Trans. Eng. Man. 59(1), 138--159 (2012)

11. Bititci, U.S., Garengo, P., Ates, A., Nudurupati, S.S.: Value of maturity models in performance measurement. Int. J. Production Research 53(10), 3062--3085 (2015)
12. Goncalves Filho, A.P., Andrade, J.C.S., Marinho, M.M.O.: A safety culture maturity model for petrochemical companies in Brazil. Safety Science 48, 615--624 (2010)
13. Kaassis, B., Badri, A.: Development of a Preliminary Model for Evaluating Occupational Health and Safety Risk Management Maturity in Small and Medium-Sized Enterprises. Safety 4(5) (2018)
14. Parker, D., Lawrie, M., Hudson, P.: A framework for understand the development of organizational safety culture. Safety Science 44, 551--562 (2006)
15. Van Aken, J.E.: Design science and organization development interventions aligning business and humanistic values. J. Applied Behavioral Science 43(1), 67--88 (2007)
16. De Bruin, T., Rosemann, M., Freeze, R., Kulkarni, U.: Understanding the main phases of developing a maturity assessment model. In: Campbell, B., Underwood, J., Bunker, D. (eds.) Australasian Conference on Information Systems (ACIS), Nov. 30 – Dec. 2, Sydney (2005)
17. Bourne, M., Mills, J., Wilcox, M., Neely, A., Platts, K.: Designing, Implementing and Updating Performance Measurement Systems. Int. J. Operations & Production Management 20(7), 754--771 (2000)
18. Nudurupati, S.S., Bititci, U.S., Kumar, V., Chan, F.T.: State of the art literature review on performance measurement. Computers & Industrial Engineering 60(2), 279--290 (2011)
19. Jääskeläinen, A., Sillanpää, V.: Overcoming challenges in the implementation of performance measurement: case studies in public welfare services. Int. J. Public Sector Management 26(6), 440--445 (2013)
20. Kennerley, M., Neely, A.: A framework of the factors affecting the evolution of performance measurement systems. Int. J. Operations & Production Man. 22(11), 1222--1245 (2002)
21. Fernández-Muñiz, B., Montes-Peón, J., Vázquez-Ordás, C.: Safety Culture: analysis of the causal relationships between its key dimensions. J. Safety Research 38, 627--641 (2007)
22. Tangen, S.: Demystifying productivity and performance. Int. J. Productivity and Performance Management 54(1), 34--46 (2005)
23. Cocca, P., Alberti, M.: A framework to assess performance measurement systems in SMEs. Int. J. Productivity and Performance Management 59(2), 186--200 (2010)
24. Das, A., Pagell, M., Behm, M., Veltri, A.: Toward a theory of the linkages between safety and quality. J. Operation Management 26 (4), 521--535 (2008)
25. Marx, F., Wortmann, F., Mayer, J.H.: A maturity model for management control systems. Business & Information Systems Engineering 4(4), 193--207 (2012)
26. Brondino, M., Silva, S.A., Pasini, M.: Multilevel approach to organizational and group safety climate and safety performance: Co-workers as the missing link. Safety Science 50, 1847--1856 (2012)
27. Tung, A., Baird, K., Schoch, H.P.: Factors influencing the effectiveness of performance measurement systems. Int. J. Operations & Production Management 31(12), 1287--1310 (2011)
28. Fernández-Muñiz, B., Montes-Peón, J., Vázquez-Ordás, C.: Relation between occupational safety management and firm performance. Safety Science 47, 980--991 (2009)
29. Neely, A., Mills, J., Platts, K., Richards, H., Gregory, M., Bourne, M., Kennerley, M.: Performance measurement system design: developing and testing a process-based approach. Int. J. Operations & Production Management 20(10), 1119--1145 (2000)
30. Najmi, M., Rigas, J., Fan, I.: A framework to review performance measurement systems. Business Process Management J. 11(2), 109--122 (2005)
31. Maier, A.M., Eckert, C.M., Clarkson, J.P.: Identifying requirements for communication support: a maturity grid-inspired approach. Exp. Syst. Applic. 31(4), 663--672 (2006)
32. Garengo, P., Biazzo, S., Bititci, U.S.: Performance measurement systems in SMEs: a review for a research agenda. Int. J. Management Reviews 7(1), 25--47 (2005)