

Organizational Capability in Production Scheduling

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Abstract. The performance of the production scheduling activities is highly influenced by the organizational factors in a particular manufacturing environment. Based on the analysis of the relevant literature, this paper proposes a capability maturity model for organizational capability in production scheduling. The paper contributes to theory by building upon the results of the field-based studies on human and organizational factors in scheduling, and developing a framework for assessing the organizational maturity in production scheduling. The model can be utilized by the practitioners to map and evaluate the organizational capability in their scheduling practice.

Keywords: Production scheduling · Organizational factors · Capability maturity model

1 Introduction

The production scheduling activities take place in the context of production planning and control (PPC) which aims for aligning demand and capacity, while providing high quality products with maximum time and cost efficiency. The scheduling activities deals with allocating the production orders to limited resources over given time periods, and can be divided roughly into two parts: (1) initial generation of the schedules (2) updating the schedules (i.e. rescheduling) in the face of unscheduled events.

The need to adopt the schedules to unscheduled events is a matter of practical reality. The real life planners spend most of their efforts to monitor and react on problems [1]. These events can change the status of resources, such as material shortage and machine breakdowns, as well as the status of orders, such as rush order, quality problems, and due date changes. They in turn may result in deviations to schedules and plans, and eventually affect the performance [2].

The insights of the field-based scheduling studies indicate that the advanced computer technology can generate the initial schedules; however, the rescheduling process involve additional human logic, information gathering, and organizational efforts to reach at informed effective decisions [2–4]. The rescheduling process often take place with intense time pressure and an unclear overview of the situation [5]. In order to clarify the situation, efforts take place to acquire information from a number of sources that can be humans or different information systems in the organization.

On one hand, these field-based reports generated very valuable and rich insights on human, technological, and organizational factors of scheduling practice from different real life cases. On the other hand, many of the field-based studies have been too broad and unstructured, and have attempted to cover a large human and organizational factors in planning and scheduling domain [6]. The lack of building on each other's findings leads to the lack of frameworks upon which to shape any generalizations. Without generalizable findings, theory and knowledge cannot influence the planning and scheduling practice [6].

In this paper, we have analyzed the field-based reports in literature and listed a set of organizational factors that influence the production scheduling performance. These factors are further adopted to generate a capability maturity model (CMM) for organizational capability and maturity. The model can be utilized to assess the organizational maturity of manufacturing companies in their production scheduling activities.

2 Literature Findings

2.1 Organizational Factors in Production Scheduling

Organizational Structure. The organizational structure of the PPC roles and departments has an influence on scheduler's performance, by for example influencing the possibilities of executing the schedule in its original form [7]. The organizational structure should reflect the requirements of both initial scheduling and rescheduling activities [5]. The rescheduling process necessitates extensive communication and feedback efforts within the organization to clarify and evaluate the situation and take effective rescheduling decisions, as clearly illustrated by the in-depth case study of de Snoo et al. [2]. As such, the structure should reflect the interdependencies and facilitate effective handling of different situations triggered by different types of unscheduled events.

In this respect, the physical location of the scheduler matters due to the vertical, i.e. between planning and control levels, and horizontal, i.e. between the schedules of the shop floor units, interdependencies and communication efforts. Especially, the proximity between the schedulers and the shop floor enables schedulers to more easily obtain information from production and other employees, and, therefore, to effectively handle unscheduled events [4]. A central physical location contributes to the scheduler's role as an information node and problem solver.

Schedulers' Interconnections. As the essence of communication and feedback efforts, relevant and timely information is essential for the scheduler in order to make effective decisions [6]. Gathering the relevant information in a timely manner for effective scheduling/re-scheduling decisions is highly dependent on schedulers' contact points in the organization. A basic example of a scheduler's contact point is that schedulers need situational information about the production from the operators to maintain feasible schedules, while operators need information about production schedules and schedule changes [8]. Depending on the situation and required information, other interconnections for schedulers can be people from purchasing, sales, quality, finance, human resources, and other support groups [7].

In this respect, it is important for the scheduler to be integrated with his/her contacts. A good relation have positive effects on social commitment, cooperation, consensus, and work satisfaction, besides the improved scheduling performance [8]. If they are in an isolated situation without knowledge of the production status and outputs, the expected production outputs will also be uncertain [7]. The scheduler will have some challenges in understanding the requirements of the different departments, trying to strike a compromise, and to convince everyone that the recommended solution is the best one. It is therefore important that the scheduler is well acquainted with his colleagues and will know how and when to utilize these people in the best manner in order to solve problems [9].

Facilitation of the Communication and Coordination Efforts. Communication and information sharing efforts among the parties located in different departments of the organization should be facilitated to improve the timeliness of the information gathered. This can be done by using procedures to guide the communication efforts in different situations as well as suitable information technologies that can facilitate it [10]. Combined with the knowledge of the interconnections, the communication facilitation can ensure an efficient information flow, and thereby result in a positive influence on the production scheduling performance.

A good example of such procedure is provided by de Snoo et al. [2] in order to guide the event handling and rescheduling process with respect to the type of events. Nevertheless such procedures should be supported by providing the relevant information to relevant people in the relevant situation. To achieve this, the fit between the organizational role and the employed information systems plays an important role; which means the consistency between the information systems and the responsibility, authority, and skills of the associated roles [11].

Prior to adjusting the information systems in accordance with the organizational roles, the decision making authorities of different organizational roles in the scheduling activities should also be specified. This issue is especially important to identify the decision making autonomy of the shop floor personnel when reacting on unscheduled events and taking rescheduling decisions. The shop floor personnel play a vital role in rescheduling process, because of being closer to the production processes and problem area [1, 2, 12]. Especially if the shop floor operates outside the working hours of the planners and schedulers, it is basically unavoidable to have the shop floor operators making scheduling decisions [12]. The concept of autonomy relates to how much a unit can decide for themselves, and how strict the commands from their managers are [7]. The more detailed and constrained these instructions and guidelines form the higher authority is, the less autonomy exists [7].

The lack of such clarification of decisional roles may lead to excess coordination and communication efforts which can diminish the timeliness of the rescheduling, as well as inappropriateness of the decisions taken under incomplete information. Accordingly, when fitting the decision support systems for scheduling tasks and roles, it is crucial to define what decisions should be taken by the schedulers and what decisions by the shop floor personnel [12].

Synchronization of the Performance Goals Across the Organization. The theoretical scheduling models are usually driven by one or several pre-defined performance measures that aim for optimizing the shop floor efficiency such as minimization of makespan and/or throughput times of the jobs [13]. More advanced scheduling/rescheduling measures consider the stability, robustness, and instability (nervousness) of the schedules [14].

However, the industrial practice is far from considering such advanced measures. In the scheduling practice optimization might not be a relevant issue, especially in the continuous rescheduling decisions. Most practitioners make re-scheduling decisions based on compromises, balancing the interests of different organizational parties [15]. The scheduling decisions often take place in the middle of conflicting goals and performance criteria from different departments [4, 16, 17]. As such, the most appropriate performance criteria may not be obvious in different situations [17]. Typically one organizational role is far from satisfied with the efforts of the other one [18]. For instance, operators could be dissatisfied with the schedulers' understanding of the actual reality on the shop floor. On the other hand, schedulers could be frustrated by operators not following the schedules or that they are slow to communicate plan disturbances.

Therefore, the organization should focus on common understanding and synchronization of the performance goals of different groups in the organization. The chosen performance measurements should reflect the business' overall goals, and they should work together to achieve an overall improvement.

Training and Continuous Improvement. Lean thinking and continuous improvement are also relevant ideas to enhance the production scheduling performance. There are different means of continuously improving the scheduling performance such as training of the scheduler, and identification and elimination of non-value adding activities in the scheduling tasks.

It is evident that the scheduler should have the essential training or education in the work he/she is going to carry out. This is needed to develop/adopt scheduling methods/mechanisms customized to the production context in which the schedules should be developed and carried out successfully. A step forward in training activities is to ensure that the scheduler has a thorough understanding of the processes, resources, and products they are being asked to schedule [4]. The scheduler should gain the ability to recognize hidden relationships, be aware of possible problems that can occur, and identify possible alternative resource assignments [6].

In this respect, experience and knowledge exchange between the schedulers and the shop floor personnel is of high importance. The operators have plenty of valuable information about the production situation that will benefit the schedulers in their work. Previous shop floor work experience can also be a major benefit for the scheduler in his/her tasks [4]. A well-trained scheduler can anticipate the potential events that can disturb the schedules and produce robust schedules that take the uncertainties of the manufacturing environment into account [6, 10]. Furthermore, he/she can have a better understanding of the communication efforts and actions that needs to be carried out in the rescheduling process.

Another means of continuously improving the scheduling performance is directly linked to the lean thinking, which is basically eliminating the non-value adding activities in the scheduling practice. This can for example be done by identifying and eliminating the compensation tasks that take place within the scheduling activities, but not necessarily adding value to the scheduling task outputs. Jackson et al. [19] defines the compensations tasks as activities that are necessary to compensate for some kind of problem, limitation, or failure in the overall system. Within scheduling and control, this could for instance be; data management because of a poorly designed information systems, use of compensatory systems because the formal system is inadequate, and duplication of effort because of bad coordination [10]. Compensation tasks are non-value adding in the long term and should be identified and eliminated or reduced [17].

Such continuous improvement activities contribute to enhance the organizational factors discussed in the earlier sections, and result in enhanced scheduling and control performance. For instance, identification of the inadequacy of the formal systems to obtain the necessary information for scheduling can trigger improvement activities for a better fit between the roles and information systems. All in all, the organization should establish clear procedures or mechanisms for continuous improvement activities to help the schedulers with analyzing their work, identify the compensation tasks, and eliminate them.

2.2 Capability Maturity Models

A capability maturity model gives a company the opportunity to assess and compare the maturity of its operations relative to an industry best practice [20]. A maturity model consists of a sequence of maturity levels for a class of objects that last from a bottom stage, which represents initial states e.g. characterized by an organization having little capabilities, up to the highest stage of total maturity [21].

Maturity models can be used to assess the competence of IT systems support in specific processes, such as proposed by Powell et al. [22] for ERP support in Lean production. They can also be used to evaluate the maturity of business processes such as proposed by Grimson and Pyke [23] for the assessment of the sales and operations planning process.

These models have been developed on the basis of different suggestions on maturity levels, depending on the topic of interest. In this study, we have adopted the ISO/IEC 15504 standard that defines a reference model for assessing and determining the organizational maturity in a set of organizational processes [24]. Each maturity level encompasses all of the elements of the lower levels. The maturity levels are defined as follows.

- Level 0. Incomplete: The process is not implemented or fails to achieve its process outcomes
- Level 1. Performed: Achieves the fundamental process outcomes.
- Level 2. Managed: The process is executed in managed fashion (planned, tracked, verified, and adjusted).
- Level 3. Established: The process is managed with clearly defined principles and procedures.

- Level 4. Predictable: The established process is consistently performed within defined limits to achieve its outcomes.
- Level 5. Optimizing: The predictable process dynamically changes and adopts to effectively meet relevant current and projected goals.

3 CMM for Organizational Capability in Production Scheduling

The performance of the production scheduling process can be influenced by many different factors (e.g. the characteristics of the manufacturing environment, implemented technologies). However, the scope of this study and proposed CMM contains the essential organizational elements for effective production scheduling and rescheduling activities. On the basis of the analysis of literature findings on organizational factors, the model in Fig. 1 is proposed with maturity levels and corresponding organizational elements.

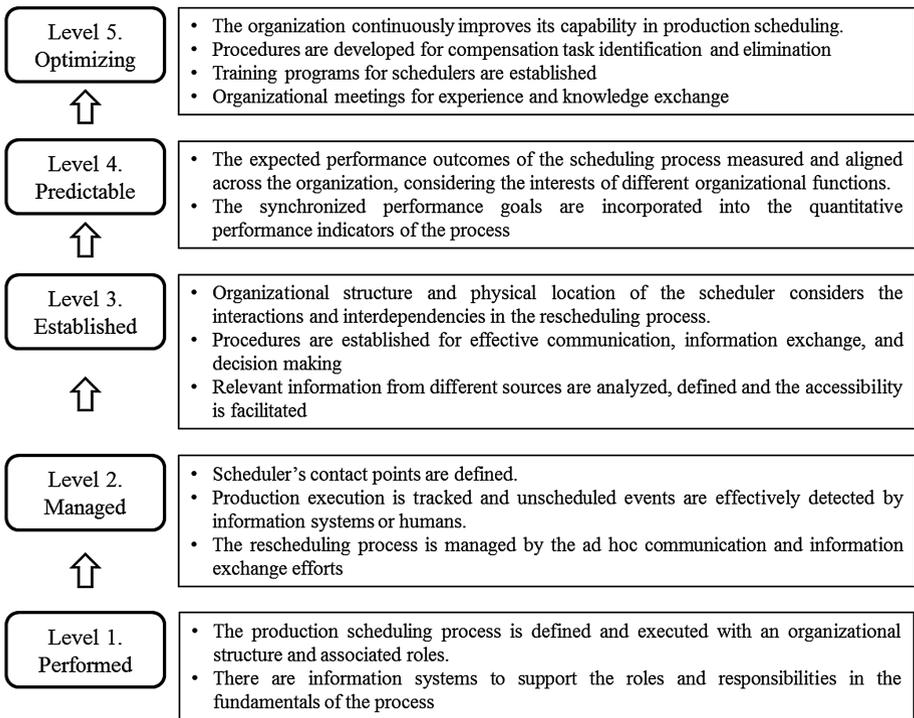


Fig. 1. CMM for organizational capability in production scheduling

4 Conclusion

This study investigated the organizational factors that influence the performance of the production scheduling activities. A capability maturity model (CMM) with a five level

scale for the organizational maturity in the production scheduling activities were developed, on the basis of the organizational elements identified through the literature findings. The developed model can act as a catalyst to assess the organizational capability and maturity of a manufacturing company in its production scheduling activities as well as can provide guidelines for improvements in this respect. Further work should apply and test the CMM in multiple case studies of varying industrial settings, in order to test its validity and generalizability.

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