7. Discussion

Planners and schedulers are responsible for developing and adapting plans within a dynamic and uncertain working environment. Whereas past research has mainly been focused on developing solution techniques for specific planning and scheduling problems, in this thesis, an alternative approach has been adopted. Because of the influencing role of the human planner on planning performance, the main research objective for this thesis was to investigate the effects of several behavioral and organizational variables on the practice and performance of planning, with a specific focus on coordination in planning. This chapter discusses the main findings of this thesis and their theoretical and practical implications. Several opportunities for future research are proposed.

7.1 Summary of main findings

The results of this thesis can be summarized into three main findings. First, to measure and manage planning performance, firms do not only use measures related to the quality of the plan (i.e., the planning product), but they also use measures related to the performance of the planning process. A focus on process performance measures is especially found in planning situations characterized by a high level of uncertainty in which much information has to be processed (Chapter 2). For that reason, the following chapters focused on understanding this planning process and the management of uncertainty within this process. The second finding is that many reciprocal interdependencies between planning decisions have to be managed by planners, because they are confronted with a variety of plan-disturbing events and a high time pressure. Consequently, communication and coordination are important tasks for the employees involved in planning and scheduling. These tasks require appropriate organizational design (Chapters 3 and 4). Therefore, the consequences of a number of organizational and behavioral variables on planning performance have been studied. The third main finding is that these variables, including physical vicinity, coordination mode, perceived task interdependence, information transparency, and goal sharing, influence performance in quite different ways (Chapters 4, 5, and 6). These main findings will be discussed in more detail in the following subsections.

7.1.1 Planning performance includes planning process performance

In Chapter 2, the use of performance measures for planning in practice was studied. Whereas in literature a focus exists on measures related to the plan as the output of the planning process, it was found that firms use a broad spectrum of measures to assess planning
performance. This spectrum was structured by providing a classification of planning performance measures consisting of three main categories (Fig. 2.1): 1) performance criteria focused on the planning product, 2) performance criteria focused on the planning process, and 3) indirect performance criteria.

In the second study reported in Chapter 2, the conditional influence of uncertainty on a firm’s focus regarding planning performance was investigated. It was found that especially in situations with high information uncertainty the performance of the planning process is deemed important. Feedback from the employees executing the plan and new information from other departments trigger the planner to consider possibilities to repair and improve the plan. Responsiveness is in such situations a critical performance determinant. Such responsiveness is enabled by efficient coordination and communication between the involved employees. Therefore, the thesis continued from Chapter 3 with investigating coordination issues in planning and scheduling.

7.1.2 Coordination requires organizational design, especially during rescheduling

In Chapters 3 and 4, the magnitude of coordination activities of planners was illustrated by means of an in-depth case study at a manufacturer. Coordination is necessary because hierarchical and lateral interdependencies between the planning decisions made by different people require mutual alignment. Many diverse coordination activities were witnessed, especially during the plan adaptation phase in which events are handled. To structure and facilitate the event handling process, a procedure was presented that supports the planner evaluating the urgency and scope of an event and selecting the right group of people to be involved in the event handling process (Fig. 3.2). The evaluation of the use of the procedure in the case company provided evidence for its usability and its positive influence on rescheduling efficiency. This offered an indication for the opportunities to influence and improve coordination in planning. Therefore, the remaining studies focused on several variables influencing coordination behavior and performance in planning.

7.1.3 Coordination in planning is influenced by physical vicinity, coordination mode, goal sharing, information visibility, and perceptions of task interdependence

Within Chapters 4, 5, and 6, five variables influencing coordination in planning were investigated: physical vicinity, coordination modes, perceived task interdependence, goal sharing, and information transparency.
First, in Chapter 4, it was shown that physical vicinity between planners and operators has positive effects on perceptions of plan feasibility and departmental effectiveness. However, a reduction of the physical distance between the planning and shop floor departments did not result in significant changes in coordination behavior. Therefore, it was concluded that the main effect of decreasing the physical distance between planning and manufacturing might be in improving the level of mutual understanding, that is, in increasing the perceived accessibility between planners and operators. This might subsequently have resulted in performance improvements.

Second, in Chapter 5, the influence of different coordination modes on rescheduling performance was studied. The findings indicated that enforced coordination, represented as a group decision-making mode, facilitates coordination between planners in a better way than voluntary coordination, represented as a distributed decision-making mode. While scheduling problems are decomposed to deal with complexity, resulting in the allocation of distributed scheduling tasks to several planners, the findings suggested that rescheduling problems could better be solved by grouping the planners and by enforced group decision-making. Further, the findings showed that within rescheduling, performance is dependent on a behavioral variable: perceived task interdependence (PTI). Perceptions of task interdependence appeared to be positively related with the level of mutual alignment between rescheduling decisions because of the impact of PTI on the planner’s coordination behavior. Further, the variable provided an explanation for the performance differences realized within the two decision-making modes. Therefore, PTI is a potential planning design variable to be manipulated and managed to improve performance.

Third, in Chapter 6, the influence of individual versus group goals and of information transparency on rescheduling performance was studied. The findings indicated that, in contrast to our expectations, individual goals result in better performance than group goals. This outcome was explained by arguing that individual goals direct the planner’s attention to the ‘own plan’ that can be changed, whereas a group goal directs attention to the plans of a fellow-planner that cannot be adapted; communication is necessary to convince the other to make adaptations. Consequently, a lot of time is spent on (asynchronous) communication at the expense of optimizing the own plan. Hence, a group goal could distract the planners from their main responsibility: repairing and optimizing their own plans. Further, the results showed that, given a situation with individual or group goals, the influence of information transparency on performance differs. With individual goals, the level of information transparency made no difference, whereas with a group goal, information transparency
resulted in higher performance than no information transparency. Thus, information transparency seemed to be especially important in situations with a group goal. Similar as with the variables coordination modes and PTI in Chapter 5, the variables goal sharing and information transparency in Chapter 6 appear to be potential planning design variables that can be used to manage and control the planning process, including the coordination activities within this process.

### 7.2 Understanding the needs, possibilities, and performance of coordination

After having addressed the main findings per chapter, several reflective observations will now be discussed that follow from mutual comparison of the main results.

First, within several chapters, the presence of interdependencies was mentioned as the main cause for coordination in planning. However, different types of interdependencies appeared to be present. Figure 7.1 shows three departments with each a scheduler responsible for the departmental schedules.

![Figure 7.1 Three types of interdependence influence coordination in planning](image)

Interdependencies between the schedules are due to decomposition of the overall scheduling problem (Chapter 3). For instance, rescheduling of an order in the cutting schedule requires alignment with the scheduling decisions regarding this order in the sawing and milling schedules. Task interdependencies become apparent when viewing the scheduler’s activities: the cutting scheduler is dependent on the timing and content of the scheduling decisions of the sawing and milling schedulers to perform his task (Chapter 3 and 4).
Especially, if coordination and negotiation are needed, the schedulers are dependent on availability and response speed of each other. Finally, perceptions of task interdependence are present in a situation with multiple planners (Chapter 5). These perceptions influence the coordination behavior of the planners and scheduling performance. It has been stated that “generally, the greater the number of dimensions that define interdependence for a work group, the more complex the interdependence and the greater the need for collaboration and mutual adjustments among group members” (Saavedra et al. 1993: 61). Clearly, coordination in planning earns attention from researchers and practitioners.

Second, the findings from Chapter 2 indicated that planning and scheduling performance and the management of this performance encompass a wider spectrum of measures and measurement methods than has been proposed in literature so far. Planning performance is determined by a variety of product and process criteria that are potentially conflicting, and the organizational context of planning should be considered in determining the relative importance of these criteria. Further, this relative importance will have consequences for the organizational design and management of the planning function within a firm. For instance, the allocation of planning tasks to different planners has important consequences for their coordination needs, during the plan creation as well as during plan adaptation phase. Such coordination needs are further influenced by the type of goals set and the amount of information visible to the planners (Chapter 6). Furthermore, if the performance of the planning process is relatively more important than the optimality of the plans, and if coordination is a crucial part of the planning process, the influence of organizational variables such as the physical location of the planners (Chapter 4) and available coordination modes (Chapter 5) on the performance of the planning process requires managerial attention. However, these and other variables determine the organizational context of planning that had to be considered during planning performance measurement design. Thus, development of planning performance measurement systems and organizational design of planning are two iterative business activities. Furthermore, product- and process-focused measures have effects on planning product- as well as planning process-performance. This becomes for instance especially clear when viewing the relationship between goal setting and the focus of performance measurement. Chapter 6 indicated that product-focused performance measures (minimization of costs due to tardy deliveries) influence planning process performance, because a joint goal leads to different coordination behavior compared to individual goals.

Third, the findings suggested causal relationships between organizational variables and planning performance, sometimes via behavioral variables. Figure 7.2 shows an overview of
the investigated variables in the Chapter 3, 4, 5, and 6, and their (possible) effect on the scheduling performance measures from Chapter 2. For instance, the findings from Chapter 4 suggested that physical vicinity between interdependent employees lead to higher levels of mutual understanding and, thus, improved coordination. In Chapter 5, perceived task interdependence (PTI) appeared to be an important determinant of rescheduling performance. By combining these findings, it can be argued that reducing physical distance will lead to higher levels of PTI that potentially lead to higher performance. Investigation of such causal relationship requires further research. Further, other organizational and behavioral variables will influence planning product and/or planning process performance, as indicated with the dots (and discussed in Section 7.5 below).

Finally, organizational variables are influencing each other; organizational design of planning requires an integrated approach. For instance, the findings from Chapter 5 and 6 illuminated that facilitation of coordination in planning should not remain limited to information sharing facilities, but should also encompass possibilities to manipulate this information and/or to make joint decisions.

**Figure 7.2** Planning process performance influenced by organizational and behavioral variables

In sum, the different chapters contribute to our understanding of the complex relationships between the causes or needs, the opportunities or possibilities, and the actual behavior or performance of coordination in planning (Fig. 7.3). Needs and possibilities have consequences for the design of coordination, including coordination modes, physical distance, and information sharing facilities. Possibilities enable behavior and determine the efficiency of coordination, sometimes via perception variables. Finally, a balance between needs and
performance shapes the quality of coordination: unfulfilled needs as well as too much coordination reduce this quality.

![Diagram](image_url)

**Figure 7.3** The relationships between coordination needs, possibilities, and behavior

### 7.3 Theoretical implications

The findings in this thesis extend different streams of previous research, including research on planning and scheduling, information systems, and (behavioral) operations management.

First, the organizational perspective on planning has provided a fuller understanding of the meaning of planning in practice. The contribution of the planning function within a firm (i.e., the planning department or the planners) is not limited to solving the complex planning puzzle, but encompasses a variety of activities, including communication and coordination. In this way, the thesis extends previous studies showing the diversity of activities performed by human planners (McKay et al. 1995a; MacCarthy and Wilson 2001; Van Wezel et al. 2006a; Berglund and Karltun 2007) by demonstrating the importance and reality of coordination activities. The findings on the use of planning performance measures in practice (Chapter 2) suggest the need to enrich planning and scheduling studies that are focused on the development of advanced solution techniques by investigating their usability and performance with regard to planning process performance criteria. Planning theory needs to consider the fit between the required contribution and performance of the planning function within an organization, and the design of this function, from both an organizational/process as well as a traditional/product perspective.

Second, several chapters have shown how coordination in planning can be facilitated. Theories from psychology and organization science have been adopted to investigate the role of variables such as goal sharing, physical vicinity, perceived task interdependence, and information uncertainty. The chapters demonstrate the value of such theories for planning
studies, but they also indicate that the specific characteristics of planning require careful analysis of their usability. For instance, the hierarchical and lateral interdependencies between planning decisions call for different coordination modes during plan creation and plan adaptation, due to time pressure and constraint complexity. Further, similar terms, such as ‘interdependence’ and ‘collaborative planning’, have dissimilar meanings within planning research (Günter 2007; Nezami Rad 2008; De Snoo et al. 2011b). Careful analysis of these differences and precise positioning are needed to build comprehensive theory integrating theories from other domains in planning research (Günter et al. 2011; De Snoo et al. 2011c).

Third, information systems support for planning has been mainly focused on the development of instruments to store, share, and manipulate large amounts of data, including a variety of algorithms, heuristics, and other techniques to calculate solutions for specific planning problems (Jacobs and Weston 2007; Pinedo 2008). However, a lack of information systems support exists for specific coordination activities in planning that involve joint decision making and negotiation. For instance, the event handling procedure proposed in Chapter 3 calls for system support of collaborative decision making during event handling, including calculation of the costs of constraint violations due to different plan adaptation alternatives. Besides, the findings in Chapter 6 concerning the positive influence of information transparency in case of group goals and the lack of influence in case of individual goals contribute to information systems research, and stimulate further research on plan sharing and communication between planners.

Finally, the thesis adds to operations management literature by showing that coordination between employees, who are important parts of the operations system (see Chapter 1), requires appropriate design and facilitation. This includes coordination between planners, but also coordination between employees from different departments. For instance, the findings in Chapter 4 indicate that understanding and facilitating the communication process between scheduling and manufacturing employees is a key element to improve (re)scheduling and production performance. Therefore, scheduling and manufacturing control theory may be enriched with studies investigating factors enabling or inhibiting coordination between scheduling and shop floor. Behavioral operations management (BOM) studies have started to investigate the influence of behavioral variables on the functioning of the operations system (Bendoly et al. 2006a; Loch and Wu 2007; Gino and Pisano 2008; Bendoly et al. 2010). This thesis contributes to this stream of research by showing the impact of several variables within planning (Fransoo et al. 2011). For instance, the findings in Chapter 5 demonstrate how perceptions of task interdependence enhance collaborative decision-making in planning, in
this way extending BOM-literature examining the impact of task interdependence on performance (Bendoly et al. 2006b; Bendoly et al. 2008). Further, Chapter 5 and 6 confirm the usability of laboratory experiments that have been advocated by BOM-researchers as research methodology to investigate the influence of organizational and behavioral variables within operations management (Bendoly et al. 2006a).

7.4 Practical implications

The findings indicate that the contribution of planning is not limited to providing plans, and that coordination in planning – an important sub-activity of planners – is influenced by a variety of factors. These outcomes have several practical implications that all relate to the question how coordination in planning can be managed. The first step is to understand the causes for coordination activities of planners. It has been shown that interdependencies between the planning decisions taken by different people necessitate them to interact with each other. For instance, postponing a production order in somebody’s plan might invalidate the plan of another planner; then, communication between these planners is necessary to discuss alternative solutions. Therefore, managers, planners, and others involved in the planning process need to have a clear understanding of the different interdependencies between them. These interdependencies differ between the plan creation and plan adaptation phase. Firms should consider the use of IT-instruments such as ‘shared space’ to facilitate the planner’s knowledge and insight into actual interdependencies. Step 2 involves the management of interdependencies. Because of the different interdependencies, both the scheduling and the rescheduling process require organizational design and managerial attention. Chapter 3 has shown that the timing and urgency of events that require plan adaptation determine the number of people to be involved and the method to be used to organize coordination during plan adaptation. The event handling procedure (Fig. 3.4) provides a guideline to structure the event handling process and to avoid unnecessary or inefficient coordination. The procedure demands for IT-support, for instance by means of workflow or case-handling systems. The third step concerns the consideration of the factors influencing the coordination process, including physical vicinity between planners and shop floor operators, information transparency, and goal setting. The findings indicate that these factors have consequences for human perceptions. Therefore, firms should consider mechanisms that influence employee’s perceptions to manage and improve coordination. Probably, group decision-support systems (GDSS) can play a role here. The final step relates
to the development and use of suitable performance measurement systems to assess the performance of planning and of the coordination activities within the planning process. Alongside measures assessing the quality of the plans, managers need to consider measures related to the organizational process of planning and scheduling. The scheduling performance focus matrix (Fig. 2.4) provides an overview of metrics that can be used to assess planning performance. The metrics require firm-specific operationalization, whereas the actual scheduling performance measurement demands for an IT-supported performance dashboard providing relevant performance information both on an individual and on a firm level.

### 7.5 Directions for further research

Within each of the chapters, several limitations have been mentioned which also provide opportunities for further research. Here, we address a few main possibilities for future research shortly. First, based on Chapter 2, further research is encouraged that develops valid and useful metrics for measuring scheduling performance in practice. More studies are also needed to investigate variables influencing a firm’s planning performance focus alongside the factor uncertainty. Second, Chapters 3 and 4 were based on a variety of data sources from one manufacturer. Although the in-depth, longitudinal case study provided many insights into the practice of coordination, the influence of physical vicinity between planners and operators, and event-handling procedures, further research is needed across different industries and within different planning situations to validate and enrich the research findings. Third, Chapters 5 and 6 were based on laboratory experiments with students enabling the investigation of influencing variables with a large amount of data from many subjects with a more or less similar background and level of planning knowledge. Further research is needed to validate the findings in real planning situations, for instance by means of a multiple case study. Fourth, a large part of this thesis has focused on the plan adaptation or rescheduling phase within the planning process. Although a variety of rescheduling techniques has been described in literature, further research and guidelines are needed to enable the efficient use of these techniques during the processing of different events under different time and coordination conditions. Similarly, further information systems research is needed that develops appropriate systems supporting the coordination activities in planning. Finally, only a few variables influencing coordination in planning could be investigated and for these variables, only a few specific values or settings could be used. Further research is needed to understand the consequences of other settings, combinations of settings, and other variables.
In addition, coordination is only one of the many behavioral and organizational factors that influence planning and scheduling. Future research is encouraged that address these factors to extend planning and scheduling theory from a human and organizational perspective.

7.6 Conclusion

The organizational perspective on coordination in planning and scheduling adopted in this thesis illustrates that planning constitutes not only a ‘production process’, in which a plan is created or adapted (Fig. 1.2). It also constitutes a ‘service process’, in which information is collected and delivered, interests and trade-offs are discussed, and constraints or commitments are negotiated, in close cooperation with a variety of stakeholders. This process of coordination in planning results in coordinated plans. Therefore, planning performance is determined by both the quality of the planning process as well as the quality of the planning product. Furthermore, both the planning process and its results will and can be influenced by a variety of organizational and behavioral factors. This thesis has demonstrated the relevance of studying coordination in planning and has made a start with investigating the influence of several variables on this coordination. Hopefully, it inspires future researchers to investigate the effects of other variables.