Coordination in planning and scheduling
Snoo, Cornelis de

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version
Publisher's PDF, also known as Version of record

Publication date:
2011

Citation for published version (APA):

Copyright
Other than for strictly personal use, it is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license (like Creative Commons).

Take-down policy
If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Downloaded from the University of Groningen/UMCG research database (Pure): http://www.rug.nl/research/portal. For technical reasons the number of authors shown on this cover page is limited to 10 maximum.
1. Introduction

This chapter introduces the topic of the thesis and provides an overview of the thesis structure. After shortly discussing the emerging interest in the study of organizational and behavioral factors within Operations Management, two practical illustrations of planning are described that show a variety of research questions to be answered. Subsequently, the research topic is discussed in more detail. Finally, research objectives and research methods are shortly explained and a brief synopsis of the main points addressed in the various chapters is provided.

1.1 Behavioral Operations Management

Since the beginning of the 21st century, an increasing interest is seen in research on human aspects within Operations Management (OM) resulting in the new research domain called ‘Behavioral Operations Management’ (BOM) (Boudreau et al. 2003; Bendoly et al. 2006a; Loch and Wu 2007; Gino and Pisano 2008; Bendoly et al. 2010). OM is the multidisciplinary field that investigates the design, management, and improvement of operations systems. These operations systems are devoted to the production and delivery of products and services (Slack et al. 2007; Heizer and Render 2008), and include the material, machine, and capital resources, as well as the humans, processes and work structures that are needed to realize this production and delivery. Planning and scheduling are important processes within this system because they define operational performance and productivity (Vollmann et al. 2005; Sule 2008) (Pinedo 2008). Much research in OM is focused on prescribing how operations systems should work in an optimal (that is, most efficient and most effective) way. However, human behavior plays an important role within these systems; its influence on functioning and performance can be considerable. BOM-studies investigate how behavioral factors influence operations systems. Examples of such factors are humans’ tendency to underestimate task-completion times (the so-called ‘planning fallacy’ (Ford and Sterman 2003; Kruger and Evans 2004)) and humans’ tendency to misperceive feedback and changing information (Blount and Janicik 2001; Croson and Donohue 2006). However, BOM-studies scarcely discuss or investigate possible organizational causes for this human behavior. A better understanding of the organizational variables that influence human behavior will provide an even fuller understanding of operations systems performance.

In this thesis, behavioral and organizational aspects are studied within a specific sub-field of OM: planning and scheduling, with a specific focus on the problem of coordination between employees involved in planning and scheduling. In Section 1.2, two examples from
practice are described that illustrate several reasons to investigate coordination in planning. The cases are followed with a discussion on shortcomings in current theoretical perspectives on planning (Section 1.3). An alternative, organizational perspective on planning is proposed in Section 1.4. In Section 1.5., related literature on coordination in planning is discussed. Research objectives and a thesis outline are presented in Section 1.6. Finally, an overview of the research methods employed within this thesis is provided in Section 1.7.

1.2 Two illustrations

In this section, two illustrations of behavioral and organizational factors in planning are provided. The illustrations are used in the remainder of this chapter to outline the practical relevance of the research issues being addressed in the thesis.

1.2.1 Coordination in route planning

The first example concerns route planning within a Dutch transportation firm. The firm is involved in road transport of frozen products having domestic as well as foreign destinations. Each week, around 3000 orders are processed, but the number of pallets per order and the locations of pick-up and delivery are diverse. Between 100 and 140 vehicles are used to transport all orders. Cross docking, that is the process of unloading and reloading to enable more efficient routes, takes place in three central warehouses. Nine planners are involved in the daily development, adaptation and monitoring of the route plans. Their main planning activity consists of the grouping and sequencing of orders into efficient routes for a specific region. Main planning objectives are to minimize driving distances, to use available capacity efficiently, and to minimize renting of vehicles and personnel from other firms. Important constraints are the number of available trucks, fixed time windows for deliveries, limitations for cross docking, and road transport regulations. A recent implementation of a computerized transport management system including an optimization algorithm had failed because not all relevant planning constraints could be included in the model. Therefore, planning has remained a manual task with some computer support for representation purposes. Twice per week, a list with the actual location of all trucks is provided to the planners, who subsequently claim a number of trucks to serve their region. In case of a truck shortage, planners negotiate with each other about alternatives routes and solutions. However, to avoid this, planners

---

1 This example comes from a paper presented during the 15th EurOMA conference in Groningen, The Netherlands (De Snoo et al. 2008).
sometimes overestimate the number of required trucks; then, there is a risk that too many vehicles and drivers are used.

Alongside being responsible for creation of efficient routes, the planners are involved in adaptation of the plans. For instance, the planners have to make decisions whether late orders can be included in the existing plans. These late orders come from clients, other transport companies and from colleagues who are optimizing their plans. Truck drivers and planners frequently interact with each other, for example about damaged goods, highway accidents, and changed orders. The planners also communicate with each other almost constantly. An important reason for this is related to the cross docking activities: transports from several domestic origins are unloaded in three central warehouses to be loaded into the trucks with foreign destinations. A delay of one truck could easily cause a delay in the departure of another truck. In other words, the decoupling between the route planning of shipments to and from the central warehouses causes a need for coordination.

Considering the organization of the route planning process in this firm, it can be argued that both the level of planning uncertainty (the lack of information about orders to be (re)planned) and the level of planning complexity (the high number of possible routes and the high number of constraints) make decomposition of the overall problem necessary. The total problem cannot be handled by a single planner; the allocation of planning tasks per region seems to be appropriate to deal with this. However, this task allocation causes high requirements on coordination between the interdependent planners to ensure the realization of well-aligned and efficient plans. During plan creation, planners need to coordinate, for instance because of the limited number of available trucks. When plans are adapted, more complex interdependencies have to be managed, for instance in case of truck delays. Consequently, to understand and improve planning performance within this firm, there is a need to understand how different interdependencies between planners can be managed efficiently. A further question is related to the process of event handling, i.e., the process of individual and joint responding to problems due to delays, material shortages, fixed window times, et cetera. The current method of truck allocation causes some planners to overestimate the number of required trucks for their region, showing a behavioral consequence that may be prevented by considering alternative capacity planning methods. Obviously, the planners rely on up-to-date information from their colleagues as well as the truck drivers (i.e., the people providing feedback about plan execution). Therefore, there is also a need to understand how alternative forms of information sharing and information technology might be helpful to improve planning performance.
1.2.2 Coordination in personnel planning

The second example involves planning within a public transport company transporting over one million passengers daily: Dutch Railways (in Dutch: Nederlandse Spoorwegen (NS)). In total, over 300 planners are involved in making and adjusting all kinds of plans. Two departments are involved in planning rolling staff: long-term staff planning (year plan (YP)) and short-term staff planning (day plan (DP)). Staff is planned in an abstract sense: circumscribed tasks are scheduled, and these tasks are allocated to shifts. An example is the shift of a train guard starting at station A, going to station B, back to A, and from there to C, taking nine hours and obeying various constraints, such as variety between trajectories, sufficient time for changing trains and for breaks, et cetera. The scheduled shifts are the input for local scheduling of ‘real’ staff, i.e., the individual guards and drivers; this scheduling is done locally at several regional stations in the country. For YP and DP, the planning puzzle is the same with regard to the objects to be allocated, the level of granularity and detail, and the main objectives and constraints to be considered. The planners do not create the plans, but only adapt them, because of lines under repair, new stations, increased service intensity on certain lines for a certain period, et cetera. The difference between YP and DP is related to the planning horizon: YP studies plans until eight weeks before realization, whereas DP adapts plans that are between eight weeks and one week before execution.

The research project started on invitation: the management of NS wanted to get insight in the working behavior of the planners to assess the possible consequences of merging both departments. The management expected that a merger could have positive effects for task rotation, information sharing, and planning quality. Differences in domain knowledge, methods of reasoning, and task and coordination performance were investigated by the research team. Regarding the latter topic, two research instruments were developed. First, the planners responded to a questionnaire about their planning tasks and communication behavior. Second, the planners were asked to record all their work-related interactions during one working week. The collected data provided several insights into the practice of coordination in personnel planning.

Figure 1.1 shows the average percentage of working time spent on a number of planning-related tasks for both departments. Clearly, puzzle solving is the most important task, but less than 50% of the working time is spent on this task: planning is more than puzzle solving.

---

2 This case study has been reported in Jorna et al. (2007).
3 A more extensive description of the planning situation at NS is provided in Kiewiet et al. (2005).
4 Similar instruments have been used in a study within a manufacturing firm (see Chapters 3 and 4).
The planners were also asked to respond to a number of statements (with 1 = totally disagree and 7 = totally agree). Table 1.1 shows some results. All planners are strongly dependent on information from others to perform their jobs. Regarding the other statements, significant differences were discovered between both departments. Within YP, planners frequently deliberate and collaborate with each other, whereas the planners within DP perform their jobs more individually. Probably, this difference can be explained by the work methods used in the departments: in YP, teamwork was encouraged. Another explanation could be the fact that planners within YP more enjoy interaction and coordination compared to their colleagues at DP, as shown in Table 1.1. At least, these findings suggest that perceptual variables about task interdependence, communication, and coordination could be potential determinants for planning behavior and performance.

**Table 1.1** Significant differences in responses to statements between YP and DP

<table>
<thead>
<tr>
<th>Statement</th>
<th>YP (N=7)</th>
<th>DP (N=8)</th>
<th>Mann Whitney U test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M  SD</td>
<td>M  SD</td>
<td>MWU</td>
</tr>
<tr>
<td>To perform my job, I am dependent on information from others.</td>
<td>5.4 1.3</td>
<td>6.6 .7</td>
<td>10.5</td>
</tr>
<tr>
<td>I frequently deliberate with my colleagues about possible planning solutions.</td>
<td>5.9  .9</td>
<td>2.9 1.6</td>
<td>2.0</td>
</tr>
<tr>
<td>I like interaction and coordination during my work.</td>
<td>5.4 .5</td>
<td>3.2 1.4</td>
<td>4.0</td>
</tr>
<tr>
<td>I frequently collaborate with a colleague on the same order.</td>
<td>5.4 1.0</td>
<td>2.0 .9</td>
<td>0</td>
</tr>
</tbody>
</table>

M = mean; SD = standard deviation.
The measurement of interactions in one week provided interesting results also. In total, 142 interactions were reported. First, frequent internal communication was only found within YP, but not within DP or between the departments, whereas the planning decisions of individual planners seemed to be clearly related. Second, the dominant reason (62%) for an interaction was information sharing (providing or asking for information); negotiation followed in 20 percent of the interactions. Thus, coordination was mainly used for information sharing to solve individual problems; opportunities for coordination to develop overall better plans were barely used. Finally, interactions between two reporting planners were sometimes experienced rather different. While one planner described the interaction as ‘throwing over the wall’, the other described it as ‘providing an opportunity’. In two cases, one planner chose the description ‘commanding’, but its partner chose ‘collaboration’. It can be imagined that these perceptions will have had consequences for the planning behavior of the planners.

In sum, the findings indicate that planners involved in comparable planning situations demonstrate quite different coordination behavior. Similar with the first example, this example puts forward a variety of questions regarding coordination in planning, including: In what ways does planning task design and planning performance measurement influence the need for coordination between planners? How do human perceptions of (task) interdependence influence coordination needs and behavior? How do physical location and proximity between planners influence their coordination behavior? These and other questions are elaborated upon in the subsequent sections.

### 1.3 The narrow perspective within the mainstream of planning theory

The examples clearly highlight a diversity of research questions on coordination in planning. Unfortunately, planning literature has taken little notice of the problem of coordination in planning, because of the lack of theory on organizational aspects of planning. Before discussing the reasons for this, planning itself should be described first.

Within OM, planning is viewed as the activity allocating a firm’s resources to customer’s demands (Heizer and Render 2008). Resources concern materials, machines, people, tools, vehicles, and tasks or processes. Within a firm, a variety of plans is developed, including sales plans, production plans, and staff plans. In the sales plan, customer orders are allocated to available time periods (that are dependent on machine and staff availability for instance); in the production plan, production orders and machines (and machine time periods) are assigned to each other. Generally, planning can be described as assigning entities from different groups
to each other; the assignments are subjects to constraints and alternative assignments can be compared on their level of goal realization (Van Wezel and Jorna 2006). Constraints and goals specify rules for the assignments and for the overall solution, e.g., ‘the route plan should start with the destination that is the most far away’, or ‘staff schedules should obey labor agreements about task diversity’. Further, one assignment, i.e., a single planning decision, has often consequences for subsequent planning decisions. This is valid for higher-level planning decisions that hierarchically impose constraints for lower level planning decisions as well as for planning decisions at the same level (Van Wezel 2001). For example, in the transport company, the plans containing the routes to foreign destinations constrain the route plans for domestic destinations, at least with regard to the availability of trucks.

During the past decades, two streams of research have been dominant in planning research: research focusing on techniques for plan generation and research focusing on planning frameworks that relate different (types of) plans. Regarding the former, many optimization algorithms, heuristics, and many other techniques have been developed to efficiently solve all kinds of planning problems (Leung 2004; Pinedo 2008). In this approach, the planning problem needs to be represented in a quantitative model, requiring a number of simplifications and assumptions. Within the route-planning example, one important limitation of this was already mentioned: the difficulty (or impossibility) to model all relevant (non-static) constraints in the model. Moreover, several authors have indicated the scarce use of these techniques in practice, mainly because of the weak link between the model assumptions used in the technique and actual planning reality (McKay et al. 2002; Aytug et al. 2005; Herrmann 2006; Van Wezel 2006). For instance, the planners at Dutch Railways spend less than 50% of their working time on puzzle solving tasks (tasks in which computer support was used).

The second stream of research has focused on approaches to connect different planning methods and systems within and between firms. For instance, within production firms, Manufacturing Resource Planning (Plossl and Wight 1967) is a leading planning framework, describing the links between and methods of sales, production, inventory, and purchasing plans on different hierarchical planning levels (Bertrand et al. 1990; Vollmann et al. 2005). Enterprise Resource Planning (ERP) frameworks have been developed to support and integrate both intra- and interorganizational planning activities (Stadler and Kilger 2002; 6

---

Both the term ‘planning’ and ‘scheduling’ refer to the activity concerned with the reconciliation of supply and demand (Slack et al. 2007). Often, a distinction in term use is made based on the time horizon considered; then, scheduling has the shorter horizon. However, scheduling is also called ‘short-term planning’ or ‘operational planning’. Therefore, both terms are used interchangeable in the thesis. In this chapter, the term planning is used.
Sumner 2005). However, these frameworks serve mainly as functional architectures of ICT systems rather than as process design tools assigning tasks and responsibilities to humans and prescribing the coordination mechanisms between them.

Both streams have been highly influenced by the rapid technological developments in IT, for instance because very complex planning problems could be solved taking only a small fraction of time in comparison with manual calculation techniques. Computer systems could support the processing of large amounts of information (Stratman and Roth 2002; Stadler and Kilger 2002; Gattiker and Goodhue 2005; Van Wezel 2006; Jacobs and Weston 2007). However, it has been mentioned that the “fundamental benefits of ERP systems do not in fact come from their inherent “planning” capabilities but rather from their abilities to process transactions efficiently and to provide organized record keeping structures for such transactions” (Bendoly and Jacobs 2004: 233). Further, in describing the history of ERP, Jacobs and Weston (2007) observe that although “current ERP technology provides an information rich environment that is ripe for very intelligent planning and execution logic, yet little has changed since the late 1970s in the logic associated with such applications as forecasting, reorder point logic, MRP, production scheduling, etc. The current systems are now just executing the old logic much faster and in real-time” (p. 363).

In sum, there seems to be a need for planning theory that extends the dominant paradigms. Current planning theory suffers from similar drawbacks as other OM theory: the problems addressed are too strongly simplified and focused, and (optimal) solutions are developed that do not match with planning reality, for instance because human and organizational factors are barely addressed (MacCarthy 2006; Fransoo et al. 2011). Consequently, there is also a need for a broad ‘BOM-perspective’ within the domain of planning and scheduling (Bendoly et al. 2006a; Loch and Wu 2007; Gino and Pisano 2008). Indeed, “lack of a theory to explain the relation between planning complexity, planning organization, task performance, and planning support makes it difficult to pinpoint the cause of planners’ dissatisfaction, to attribute the causes of poor organizational performance to planning, or to analyze and design planning practices” (Jorna et al. 2006: 507). Several authors have advocated that such new theory should be grounded into problems derived from planning practice (McKay et al. 2002; MacCarthy 2006). For instance, according to McKay et. al. (2002), “the most significant opportunities [for scheduling research] lie in more explicit recognition of a highly dynamic environment and in work that promotes field testing of research results” (p. 256). Therefore, in this thesis, an alternative perspective on planning is adopted.
1.4 An organizational perspective on planning

Planning can be considered as a transformation process with inputs and outputs (Fig. 1.2). In this view, information about the objects to be planned (e.g., orders, staff, machines), the planning goals, and planning constraints are the inputs of the planning process. This information is ‘manipulated’ during the planning process that consists of a variety of tasks and activities. The outputs of the process are information about the allocation of the objects and about the level of goal realization and constraint violations. The planning process requires resources to function, including planners, an organizational structure, and computer support.

The planning process starts when a new planning period is considered, either with an existing plan from the previous period to be changed and extended (i.e., planning with a rolling time horizon), or with a new, empty plan sheet that has to be developed from scratch. Considering the examples from Section 1.2, within the transportation firm, plans are developed from scratch, twice a week, given the fact that the trucks were going to the (foreign) destinations twice a week. Within NS, YP worked with a rolling planning horizon of 8 weeks, whereas DP-planners adapted existing plans one for one without considering other plans. The planning ends when the plan has been executed. Indeed, because of a rolling planning horizon and many plan adaptations, the planning process could sometimes be better viewed as a continuous process without a clear start and end.

The planning transformation process consists of a variety of activities and tasks, such as information collection, counting, attuning (including selecting, ranking, assigning and manipulation of constraints and goals), adaptation and negotiation (Mietus 1994; Van Wezel...
2001; Akkerman and Van Donk 2009). Figure 1.1 has shown how the planners at Dutch Railways spend their working time on these activities.

The main result of the planning process is the plan that is provided (‘released’) to the plan users. This plan consists of a number of related planning decisions, each partially defining the constraints for other planning decisions, as discussed above. Plans are released to lower levels for further detail planning or for execution. However, after its release, adaptation of the plan is often needed because of changing circumstances (Koh et al. 2002; Vieira et al. 2003; Aytug et al. 2005). Then, new information is used as input, the transformation process is aimed at adapting the plan to restore its feasibility and quality, and the output of this process consists of plan adaptations that are again released.

1.5 Coordination in planning

In this thesis, the focus is on situations involving multiple planners. In their review of studies on human factors of planning and scheduling, Crawford and Wiers (2001) pointed out that in many organizations several employees are involved in planning and scheduling tasks, while planning is often only a part of their job. Jackson et al. (2004) discerned different roles of the planners: the interpersonal role in which interaction with other personnel is expressed, the informational role in which the planner is the “information hub”, and the decisional role, where the planner makes the actual plan. Further, Van Wezel et al. (2006b) showed how the organization of the planning process, including rules about coordination between planners, can limit the level of production flexibility within a firm. Their findings indicate the need for flexibility in the planning process to enhance production flexibility. However, although these studies emphasize that coordination is an important part of planning, they do not thoroughly investigate possible causes of it or methods to ‘organize’ coordination efficiently. The need for such investigation was illustrated in the route planning example: the route planners were communicating so much that they started developing plans after normal working hours, because then they were able to concentrate without being disturbed. Thus, coordination came at the expense of puzzle solving (i.e., the order-route-truck allocation activity). Coordination in planning does not automatically result in better plans or higher performance; on the contrary, the transport company was suggested to build physical walls to prevent communication between the employees.

In the mainstream of planning theory, coordination between different planning layers is assumed to happen via regular information sharing and feedback loops (Bertrand et al. 1990;
Vollmann et al. 2005). In a sense, it is assumed that information is shared accurately, and that mutual alignment is reached in an efficient way (De Snoo et al. 2007a; Günter et al. 2011). A few frameworks pay explicit attention to human coordination.

First, to support the coordination process between different departmental planners within a firm, the framework of Sales & Operations Planning (S&OP) has been developed (Wallace 2004; Grimson and Pyke 2007). S&OP is a set of decision-making processes to balance demand and supply on the medium-term, to integrate financial planning and operational planning, and to link high-level strategic plans with day-to-day operations (Wallace 2004). Planners and managers from various departments are involved, including sales, marketing, operations, and finance. Within the S&OP approach, coordination between planners is organized by means of regular meetings in which decisions are made jointly. However, methods for alignment or adjustment of plans during or after the team meetings are not included. Therefore, although the S&OP approach includes prescriptions for meetings, the actual process of coordination is not addressed. Accordingly, information systems supporting S&OP tend to focus on decision support and not on process support or interaction support.

Second, concerning coordination between planners of different firms, the concept of collaborative planning has emerged (Barratt 2003; Akkermans et al. 2004; Windischer et al. 2009; Stadtler 2009). However, the concept is used in multiple ways, ranging from information visibility between companies to integrated and joint decision making (Kilger and Reuter 2002; Barratt 2004; Petersen et al. 2005). One approach of collaborative planning between firms has been formalized in the so-called Collaborative Planning, Forecasting, and Replenishment (CPFR) model (Seifert 2003). The CPFR model details four collaborative activities to be carried out in a sequential manner: strategy & planning, demand & supply management, execution, and analysis. It includes activities on the strategic level (establishment of the ground rules for the relationship, determination of product mix), tactical level (projection of consumer point-of-sale demand as well as order and shipment requirements), and operational level (order plans and operational control of planning and execution activities). Several empirical studies have shown a positive link between the use of CPFR and supply chain performance (Skjoett-Larsen et al. 2003; Danese 2006; Danese 2007). Like S&OP, CPFR is a framework clearly emphasizing the need for careful coordination between planners. However, it is also limited to prescribing joint activities and prerequisites for collaborative planning, without providing (organizational) guidelines for unplanned coordination. Further, the causal relationships of the proposed prerequisites for high collaborative planning performance, including goal sharing and information sharing, are not
addressed. Therefore, the extent to which such variables influence planning performance remains open for further research.

A different perspective on coordination in planning has recently been provided by Windischer et al. (2009) who developed a so-called ‘collaborative planning model’ that is based on theories from psychology. The model shows the behavioral activities that are at the core of collaborative planning, such as exchange of preliminary knowledge, communication of plan modifications, and lateral agreement on common goals. No sequential order of these activities is assumed; plan development and execution are seen as two intertwined bundles of sub-processes. The model has been useful to describe the state of collaborative planning between departments and firms (Günter 2007; Grote 2009). The model provides a starting point of the study of influencing behavioral and organizational factors within planning.

In short, given the importance of coordination in planning and given the paucity of studies empirically investigating behavioral and organizational aspects of this coordination, this thesis provides a collection of empirical studies focused on the problem of coordination in planning. Research objectives and an outline of the thesis chapters are presented in the next section.

1.6 Research objectives and thesis outline

As the previous sections have shown, research on coordination in planning has been limited to either descriptive case studies or prescriptive models for interdepartmental and supply chain planning. Behavioral and organizational aspects of coordination in planning have been studied barely. The main research objective for this thesis is to investigate the influence of several behavioral and organizational variables on the practice and performance of planning.

Alongside the initial theoretical reason to investigate the process of planning instead of elaborating on problem-solving techniques and algorithms (Sections 1.3 and 1.4), this thesis is motivated by a second reason that emerged during the research reported in Chapter 2. When investigating measures for planning performance used by a variety of firms, it was found that these firms not only use plan-related measures (such as delivery reliability and costs), but also planning-process related measures (such as responsiveness of planners and planning flexibility). To assess the performance of the planners in an organization, the common metrics proposed in planning literature appear to be insufficient. Managers need a broader spectrum of performance metrics, but, as a consequence, they also need a better understanding of the organizational and behavioral factors that determine planning performance (and how these
can be influenced). Thus, Chapter 2 starts with providing arguments for a research focus on behavioral and organizational factors of planning by investigating the use of planning performance criteria in practice.

Obviously, many factors could be investigated, and a choice had to be made for this thesis project. This choice is inspired by the findings reported in the second part of Chapter 2, showing that the performance of the planning process is especially important in situations characterized by high uncertainty. Such uncertainty causes a need for plan adaptation or rescheduling. Therefore, after Chapter 2, a further focus is made towards the plan adaptation sub-process as part of the overall planning process. Within this process, communication and coordination appear to be important planning tasks, as the case study in Chapter 3 shows.

Coordination between planners (during plan adaptation) is influenced by a large variety of factors. Chapter 4 focuses on physical vicinity as influencing factor, chapter 5 on coordination mode and task interdependence, and chapter 6 on goal and information sharing. Whereas Chapter 4 is based on a longitudinal case study, Chapter 5 and 6 are based on findings from behavioral laboratory experiments in which a job shop-rescheduling situation has been simulated. Finally, as an organizational guideline to structure coordination during plan adaptation, the second part of Chapter 3 presents an event-handling procedure. Within each of the chapters, the motives to select these specific variables and their role in planning theory are explained in detail. Figure 1.3 shows the main structure of the thesis. In Chapter 7, the main findings from the various chapters are summarized and discussed. Further, an overview of theoretical and practical implications and a few avenues for future research are provided.

1.7 Research methods

From the research outline, it becomes clear that a variety of research approaches has been applied. Each chapter includes empirical data collected with different research methods.

First, in Chapter 2, several types of surveys are employed (Malhotra and Grover 1998; Forza 2002): an exploratory survey to understand the meaning of planning performance in practice, a descriptive survey to investigate the use of planning performance criteria, and an explanatory survey to study the possible coherence between the contingency variable ‘uncertainty’ and planning performance focus. The survey method enabled the collection of data from a variety of firms, providing the opportunity to build an overall picture of the research phenomenon.
Second, a single-case study approach is used in Chapters 3 and 4 allowing an in-depth investigation of coordination in planning. This approach is especially appropriate to investigate phenomena that are barely studied and that require an open, exploratory design (Voss et al. 2002; Yin 2003; Eisenhardt and Graebner 2007; Siggelkow 2007). Further, the approach is useful if repeated measurements are performed (as in Chapter 4); then, a longitudinal approach is followed (Pettigrew 1990). The case has appeared to be useful as motivation, inspiration, and illustration (Siggelkow 2007): as illustration for the multitude and variety of coordination activities of planners (Chapters 3 and 4) and as motivation and inspiration for the development of an event-handling procedure (Chapter 4).

Third, experiments were chosen to investigate the influence of specific variables on coordination behavior and performance during job shop rescheduling (Chapters 5 and 6). The main reason for adopting a laboratory experiment is that the setting and environment could be controlled much better than in a field study (Bendoly et al. 2006a). Therefore, regularities can be determined more appropriately. Recently, controlled experiments have been used and
promoted for examining the complex interactions between behavioral and organizational variables and operations management questions (Schmidt et al. 2001; Speier et al. 2003; Croson and Donohue 2006; Bendoly et al. 2006a; Bendoly and Swink 2007; Cantor and Macdonald 2009). To the best of our knowledge, these chapters are the first in describing and analyzing laboratory experiments about coordination in planning.

Within each of the chapters, further arguments for the research methods are given. By using a variety of research methods, the thesis shows the opportunities to investigate behavioral and organizational factors in OM that results into a variety of challenging findings for planning theory and practice.