Chapter 1

Introduction

1.1 Research Topic and Motivation

"The theory of inventory control tells us how much safety stock is necessary for fulfilling 99% of the orders in time, but not how to select the 1%, maybe some tens of orders per day, which are postponed or cancelled." (Fleischmann and Meyr, 2004, p. 14)

Although not explicitly stated, the authors indicate that there is more to demand management than just achieving a high service level. Rejection or postponement of orders are decisions that should be properly considered, since they play a critical role for any enterprise. Hill (2000) concisely sums it up when stating that "the most important orders are the ones that you turn down".

A number of concepts and methods emerged in the past decades addressing this issue by trying to more actively manage demand. One prominent example for successful demand management is the emergence of revenue management, which was first applied in the pricing strategies of airline tickets.

In the late 1970s, deregulation of the American airline market allowed new airlines to enter the market. Specialized only on the most profitable routes, the new airlines were highly successful and gained substantial market shares, so that the established airlines had to react to the increased competition. As most of them operated a large network with manifold destinations, they could not compete in a conventional manner against the highly-specialized new-comers able to offer much lower prices: due to specialization, the new airlines had less infrastructure costs, less maintenance costs and by focusing on the most popular destinations they reached a high seat utilization. In contrast, on many flights of the established airlines, seats were not completely sold—especially on the less popular routes and on weekends.

American Airlines was the first player to react to the new market conditions by an innovative pricing strategy. Instead of a cost-covering pricing of seats, they set the prices for some tickets on the less-utilized flights on the basis of marginal costs. Since marginal costs of an additional passenger are close to zero, American Airlines realized that it is better to sell the seat for a very low price, instead of leaving it empty.

Looking back, the new ticket pricing strategy developed by American Airlines sounds intuitive, but at that time it was an innovative way of thinking.
It was a simple idea that enabled American Airlines to offer competitive and even lower prices than the competing low-cost airlines. The only problem was to identify which seats could be sold for normal prices and which seats to sell for low prices because they would stay empty otherwise. American Airlines tied the availability of low-price tickets to conditions which were fulfilled only by leisure customers usually not willing to pay the normal prices. For example, low-price tickets had to be bought 30 days in advance, preventing business travelers from buying these tickets. Thus, the introduction of specialized tickets designed for a specific customer class enabled American Airlines to skim much more revenues from the total possible market potential.

In the last decades, revenue management (RM) has become a very popular method of managing demand to increase profitability. This is not astonishing given the high revenue increasing potentials of RM. Boyd (1998, p. 29) for instance states that “revenue improvements from implementing a revenue management system can range from 2–8 percent (or more) depending on the carrier”. The German airline Lufthansa AG reported an increase in revenues of € 715 Mio. in 1997 (Klophaus, 1998, p. 150)—approximately equal to the result of normal operations in this year (Kimms and Klein, 2005, p. 2). As seen in the case of American Airlines, the success of RM essentially relies on identifying and exploiting differences in the customers’ willingness to pay.

However, RM is mainly deployed in service industries—as for example airlines, car rentals, or hotels. It has not (yet) proven to be as successful in other domains of application as, e.g., in manufacturing. In those industries, different demand management concepts evolved in the past (for an overview see Fleischmann and Meyr, 2004). Demand management in manufacturing is often handled by a demand fulfillment module of the so-called advanced planning systems (APS). This module takes into account production quantities determined by a mid-term master planning module and short-term production planning. Based on these quantities, the demand fulfillment module decides on the basis of simple rules which customer to fulfill at which time, e.g. rules such as the first-come-first-served (FCFS) principle. As these rules are rather simple and created with a focus on general applicability, the results of demand fulfillment in APS leave space for improvements. Therefore, demand management in manufacturing might learn from the experiences gained in the service industries during the last decades.

Accordingly, practitioners as well as researchers put more and more effort in exploring ways to adapt RM concepts to the specific needs of manufacturing (Harris and Pinder, 1995, Swann, 1999, Arslan et al., 2007, Gupta and Wang, 2007). The core idea is that customer differentiation is beneficial also in a manufacturing environment. Additionally, the building block of RM in the service industries—perishable assets—corresponds to perishable capacity in
manufacturing industries. For instance, an empty seat in an airplane can be compared to a machine standing still due to an insufficient number of orders.

However, the majority of scientific research focuses on adapting RM concepts to make-to-order environments because of the mentioned correspondence of perishable assets and perishable capacities in make-to-order manufacturing. In make-to-stock manufacturing environments, this correspondence does not apply as the machines schedules are based on forecasts instead of specific customer orders. The aim of this thesis is thus to analyze the current state-of-the-art in demand management (irrespective of a specific industry), and then relating the ideas found in the literature to make-to-stock manufacturing environments.

Our starting point is the current process of demand fulfillment in APS for make-to-stock manufacturing. In the case of make-to-stock, production planning is done on the basis of demand forecasts: when a customer order arrives, it can be either fulfilled from on-hand inventory or postponed to later arriving supply. The basic question to be answered in this thesis is to decide if it pays off to refuse a low margin customer order in expectancy of future more profitable orders.

The analysis relies on a number of assumptions as summarized in the following:

- Make-to-stock manufacturing environment with scarce capacities
- Deterministic future incoming supply
- Customers with different priorities
- Immediate order confirmation required
- Customers are willing to accept a late delivery under a price discount

In the short-term, it is assumed that the later arriving supply quantities are known and can be promised to arriving customers. Additionally, we assume a setting of scarce capacities, because the case of oversupply in make-to-stock manufacturing reduces to simply accepting and fulfilling all arriving customers orders. A further assumption in this work is that customers can be segmented according to their different willingness to pay, different costs of fulfillment, or different strategic importance. The first case typically applies to airlines when they charge different prices according to the remaining booking time and other factors like remaining capacity. In the second case, the costs of serving a customer order can be used as a differentiator. Note that only those costs which can still be influenced when accepting the order are relevant here. This includes, for example, transportation costs, taxes, and any variable costs of downstream production. The third case, the discrimination according to the strategic importance of customers may go beyond immediate costs and revenues. For example, loyal customers may be extremely important and should...
be given more favorable terms than occasional customers (see Quante et al. (2009b, Sect. 3.1.5) for a further discussion). In addition, customers are assumed to require an immediate response to their order, but are willing to accept a late delivery under a price discount. Note that these assumptions are equivalent to those in the work of Meyr (2009).

1.2 Organization, Objectives and Contributions

The idea of this thesis originates from the current state of the art of demand fulfillment in make-to-stock manufacturing, where in general APS are used as supporting tools. Therefore, this work starts in Chapter 2 with a description of the current state-of-the-art in demand fulfillment and introduces the required terms and definitions.

In order to search the literature for alternative approaches and concepts suitable for make-to-stock manufacturing, we decided to systematically classify the literature dealing with demand management. The focus was explicitly also beyond manufacturing when reviewing the literature, since we want to search in other disciplines for further ideas. We start introducing a framework for demand management (DM) in Chapter 3 and identify generic model types. In addition, a classification of commercial software solutions is presented in order to get an idea of how these solutions work.

Subsequently, based on the framework of Chapter 3, the general types are aligned to the specific requirements of make-to-stock manufacturing at the beginning of Chapter 4 and shortcomings of the respective model types are identified. A detailed analysis of specific models follows with a focus on manufacturing environments, but without concentrating on make-to-stock systems at this point.

Based on the literature review, Chapter 5 presents new models that reflect important characteristics of order fulfillment in make-to-stock production environments, namely customer heterogeneity, limited short-term supply flexibility, and short-term allocation flexibility. Previous literature has not addressed the interplay between these factors. The presented models are primarily based on the ideas of revenue management. We prove structural properties of the models and derive an optimal demand fulfillment policy. The result links order fulfillment in make-to-stock manufacturing to revenue management concepts. By this, we provide a way to unite the currently distinct concepts.

As these models of Chapter 5 explicitly take into account stochastic demand, we compare the developed models with existing deterministic ones described in Section 4.3. Before we conduct an extensive numerical study assessing the performance of various models in Chapter 7, we introduce the used simula-
tion environment in Chapter 6. We show the superiority of the developed approaches in stochastic environments over the simple FCFS policy and the deterministic models of Section 4.3. Additionally, we identify which key influence factors drive the potential benefits.

This work concludes in Chapter 8 with a discussion of the results and issues for future research.