

Chapter 1

Introduction

1.1 Motivation

Cost increases, for example, due to inflation, force retailers and sellers to renegotiate wholesale prices. Disagreements over prices have become frequent, causing empty shelves in retail environments (Repko and Lucas 2022). The list of current examples include Tesco's negotiations with Heinz and Unilever in the UK (Hooker and Meierhans 2022), or Edeka's and Rewe's dispute with Kellogg's in Germany (Fritsche 2023). These negotiations share a common cause: Sellers want to increase prices due to higher input costs, but retailers fear lower demand when they pass price increases on to end customers.

Empty shelves lead to lost profits and decrease customer goodwill, which negatively affects the entire supply chain. This exemplifies why supply chains should be coordinated effectively. Coordination occurs when all members of a supply chain take actions that optimize the chain's performance as a whole (Chopra and Meindl 2007). Coordination throughout the supply chain ensures that the maximum profit for the entire supply chain can be realized, which is often synonymous with coordination.

In theory, coordination can be achieved by selecting prices and contract types that align incentives for all members of the chain. Such coordination mechanisms have been discussed in the literature (see Cachon 2003 for an extensive review on coordinating contracts) and include contract types such as buyback, real option, or service level contracts. But even though such contracts, when parameterized correctly, can increase profits for all chain members, coordination is often not achieved (Katok and Wu 2009).

This is because individual members of the chain make suboptimal decisions that do not maximize their expected profits (Becker-Peth and Thonemann 2018). Non-profit-maximizing decisions are the starting point for the field of behavioral operations management, which serves as a foundation of this thesis. Behavioral operations management leverages principles from behavioral science to improve the understanding of operations management decisions. Such decisions have been shown to be prone to a number of biases, e.g., anchoring and insufficient

adjustment, loss aversion, or other-regarding preferences such as fairness or trust (Davis 2018, Bolton and Chen 2018).

In this thesis, we dive into the behavioral mechanisms behind incomplete coordination. Our main interest lies in identifying how wholesalers or manufacturers can design contracts to improve retailers' ordering behavior and thereby increase supply chain efficiency. We are motivated by examples of incomplete coordination in research and practice.

We are guided by three main questions. All three questions share the common goal to achieve better coordination: First, how should wholesalers split profits and risks in the supply chain through their contracts with retailers? This directly relates to the motivating example of price negotiations. Second, how can wholesalers select among contract types? Even though equivalent in profits some contract types could be superior to others in the way they lead to effective coordination. Third, how can wholesalers leverage individual information on retailers to select better wholesale prices? As big data and online channels become increasingly common, B2B wholesalers will need a method for tailoring individual prices to retailers.

1.2 Outline and Contribution

The thesis consists of three research projects that address different levers for improving wholesaler-retailer coordination in B2B supply chains. A separate research project is presented in each of the three main chapters (Chapters 2 - 4). In these research projects, we generate insights on retailers' behavior that can be incorporated into manufacturers' decision making concerning contracts and contract parameters. We use different methodological approaches: in laboratory experiments, we develop and test behavioral models, and in the field, we use machine learning to find individual demand models based on data collected from actual retailers. In Chapter 5, we summarize the results and give an outlook for future research.

Chapter 2 aims at understanding how risk aversion impacts order quantities under coordinating contracts in a newsvendor setting.¹ The purpose of this

¹Chapter 2 is based on the paper by Bonzelet (2022) that was published in the *International Journal of Production Economics*. This chapter is single-authored. Prof. Ulrich W. Thonemann participated in discussions about the experimental design and gave input for the modeling approach, the design and analysis of the experiments, and the positioning of the paper. The paper further benefited from participants of the Brownbag Seminar 2021 on January 27, 2021 and from the comments of three anonymous referees and an associate editor.

research is to study retailers' order quantities in the face of their varying risk preferences. Based on an analytical model, we derive hypotheses about how order quantities of risk averse retailers change under different shares of expected chain profit. We test our hypotheses using existing experimental data and a validation experiment that elicits subjects' certainty equivalents together with their order quantities and, hence, allows us to connect order quantities and risk preferences. Our main finding reveals that, consistent with increasing relative risk aversion, retailers tend to decrease orders as their expected profit share of the supply chain increases. A mediation analysis confirms that this effect is partly driven by risk preferences of the retailer. Additionally, we compare buyback and real option contracts, discovering that risk averse retailers tend to place higher orders under real option contracts. The contribution lies in linking risk aversion to ordering decisions under coordinating contracts and comparing the impact of different contract types. Suppliers can use our insights to tailor contracts based on retailers' risk preferences.

Chapter 3 explores another dimension of the relation between retailers' profits and order quantities. Here, we examine whether the steepness of the expected profit function of the retailer influences the order quantity.² Bolton and Katok (2008) suggest that the flat shape of the expected profit function of the retailer around the profit maximizing order quantity leads to suboptimal order decisions of the retailer under wholesale price contracts. As service level contracts can be parameterized to have steep expected profit functions, this research aims at exploring whether orders will be closer to optimality under service level contracts with steeper expected profit functions. The concept of salience formalizes this notion. We hypothesize that higher cost salience around the optimal order leads to closer to optimal order quantities of retailers. We conduct laboratory experiments, comparing supply chain efficiency under different service level contracts and

²Chapter 3 is based on a paper by Bolton, Bonzelet, Stangl, and Thonemann that was published in *Production and Operations Management* in 2023. An earlier version was published in Stangl (2017). It is joint work with Gary E. Bolton, Tobias Stangl, and Ulrich W. Thonemann. Tobias Stangl was mainly involved in the problem identification, development of the hypotheses as well as the experimental design and analysis of the main experiments and the robustness experiments in Section 3.7.1 and 3.7.2. Sabrina Bonzelet was mainly involved in the design and execution of the robustness experiments in Section 3.7.3 and 3.7.4 and in the analysis of the experimental results in terms of alternative explanations. Prof. Gary E. Bolton and Prof. Ulrich W. Thonemann participated in discussions about the experimental design and gave input for the modeling approach, the design and analysis of the experiments, and the positioning of the paper. The paper benefited from the comments of three anonymous referees and the editors of *Production Operations Management*. Additionally, it benefited from seminar participants at the University of Cologne and the University of Texas at Dallas, and participants at the 2014 INFORMS Annual Meeting, the POMS 26th Annual Conference, and the 2016 INFORMS Annual Meeting

wholesale price contracts. The results show that retailers indeed achieve higher supply chain efficiency when service level contracts have steeper expected profit functions. To attribute this effect to salience, we conduct robustness experiments and test various alternative explanations such as service level anchors, loss aversion or quantal choice.

While Chapters 2 and 3 can provide guidance on the selection of contract types and parameters when little information about a retailer is known, **Chapter 4** dives deeper into retailer heterogeneity and observes how individual price history and reference prices influence retailers' orders.³ The research is motivated by the case of a wholesaler who aims at determining individual prices for retailers to maximize profits. Since their business is set in a non-contractual environment, this application offers many observations on different prices and orders. We therefore aim to suggest algorithms and modeling approaches to estimate an individual retailer's price response functions that allow to derive individual prices. We receive data from the wholesaler to estimate retailers' ordering probability in a given week and use these estimates to optimize individual wholesale prices. We suggest a machine learning approach that leverages the heterogeneity of retailers along with features like reference prices. We compare this approach to other benchmark models on data for four different SKUs and find that it is superior in predictive performance and calibration. Prices generated by our approach can improve profits by up to 13.5%.

All in all, our research contributes to a better understanding of retailers' ordering decisions. It gives direct implications for wholesalers in their contracting and pricing decision by using experimental data as well as data from the field. The results of Chapter 2 extend the literature by demonstrating that risk aversion is a key factor influencing order patterns, particularly under different contract parameterization and types. Risk aversion has so far been sparsely studied in the behavioral operations management literature. Similarly, little attention has been paid to service level contracts in the literature, even though they are widely applied in practice. We contribute to the literature by connecting the salience of the profit function to order decisions under service level contracts in Chapter 3. Lastly, we extend the field-based research on retailers' ordering decisions in Chapter 4. We contribute by modeling real-world ordering decisions using price, purchasing history and reference prices as features. We demonstrate the value of integrating machine learning into the domain of B2B pricing. This extends the

³Chapter 4 is joint work with Prof. Ulrich W. Thonemann, who participated in discussions about the modeling approach and gave input for the design of the model comparison and analysis of the results.

understanding of how advanced data-driven models can be effectively applied in a practical wholesale context.

In summary, our findings contribute to the literature on behavioral operations management, especially in the realm of behavioral contracting and the newsvendor problem. They also extend to the literature on analytical business-to-business pricing and applied machine learning.