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Reference points in revenue sharing contracts—How to design optimal supply chain contracts

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ABSTRACT

Coordinating supply chains is an important goal for contract designers because it enables the channel members to increase their profits. Recently, many experimental studies have shown that behavioral aspects have to be taken into account when choosing the type of contract and specifying the contract parameters. In this paper, we analyze behavioral aspects of revenue-sharing contracts. We extend the classical normative decision model by incorporating reference-dependent valuation into the decision model and show how this affects inventory decisions. We conduct different lab experiments to test our model. As a result, human inventory decisions deviate from classical normative predictions, and we find evidence for reference-dependent valuation of human decision makers. We also show how contract designers can use the insights we gained to design better contracts.

1. Introduction

Numerous recent studies have analyzed the inventory decisions of human decision makers in a newsvendor setting and shown that stocking quantities differ significantly from expected-profit-maximizing predictions (e.g., Schweitzer and Cachon, 2000; Bolton and Katok, 2008; Bostian, Holt, and Smith, 2008, and many more in the literature review). These studies primarily focus on wholesale price contracts, whereas few studies have analyzed contracts other than wholesale price contracts. Among these few studies, Katok and Wu (2009) study buyback and revenue-sharing contracts from a retailer perspective, and Zhang, Donohue, and Cui (2012) analyze these two types of contracts from a supplier perspective. Both of these studies find evidence for contract-specific behavior—i.e., different contracts that are theoretically equivalent induce different behavior. Further, Becker-Peth, Katok, and Thonemann (2013) show that source-dependent valuation of money influences human inventory decisions under buyback contracts. In this paper, we analyze revenue-sharing contracts in detail. Under such contracts we have only one cash-in stream, so source dependency cannot be relevant in our context. In contrast to wholesale price contracts, revenue-sharing contracts do not allow retailers to retain all the revenue; rather, it must be shared with the supplier, which might lead to behavioral effects. We model these possible effects by introducing reference values concerning the contract parameters. The underlying theory assumes that the valuation of a decision outcome is determined by not only the absolute value of the outcome but also its difference from a reference point. Contract-specific reference points are part of mental accounting, which is defined as a "set of cognitive operations […] to […] evaluate […] financial activities" (Thaler, 1999). Reference dependency has received little attention in the behavioral operations literature so far, and we are the first to model reference-dependent contract parameters in supply contracts.

The contribution of this paper is threefold. First, we incorporate reference-dependent valuation into the context of supply contract decisions and show how contract-specific reference points affect human inventory decisions. Second, we analyze how reference points are set in the context of revenue-sharing contracts. Third, we test our model analyzing actual decisions from laboratory experiments. We find evidence of reference prices, which significantly affect inventory decisions. The results of these analyses can serve as guidelines for contract designers to determine contracts and contract parameters.

The remainder of this paper is organized as follows. In Section 2, we present the relevant analytical and behavioral background regarding supply contracting with a focus on revenue-sharing contracts. In Section 3, we incorporate reference-dependent valuation into the traditional newsvendor model. We then analyze different kinds of reference points and derive hypotheses for human inventory decisions. In Section 4, we report the results of different experiments to test these hypotheses. On the basis of the obtained results, we then derive guidelines for the parameterization of supply contracts for

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different supply chain settings (Section 5). We summarize our findings in Section 6.

2. Analytical and behavioral background—literature review

In this section, we first explain the supply contract used in this study in Section 2.1, and we then summarize the results of earlier studies on behavioral operations concerning supply contracts in Section 2.2.

2.1. Analytical model of supply contracts in operations research

The typical setting analyzed in the literature considers a supply chain with a single manufacturer and a single retailer. In this setting, the retailer faces random demand with a cumulative distribution function $F(\cdot)$ and an exogenous retail price r, and a supply contract between the manufacturer and the retailer determines the transfer payments, e.g., the wholesale price for purchased products. Further, the retailer decides on the stocking quantity q and places the order with the manufacturer, and the manufacturer then produces the quantity and delivers the products to the retailer. This setting is also known as the newsvendor problem (Arrow, Harris, & Marschak, 1951; Edgeworth, 1888).

Wholesale price contracts lead to double marginalization (Spengler, 1950). To overcome this problem, different contracts can be used to coordinate the channel, i.e., to incentivize the retailer to stock the channel-profit-maximizing stocking quantity (for an overview see Cachon, 2003, chap. 6).

We focus on a commonly analyzed type of supply contract: the revenue-sharing contract (Cachon & Lariviere, 2005). Revenue-sharing contracts have received considerable attention in operations research but primarily from the normative perspective. The original single-period model (Giannoccaro & Pontrandolfo, 2004; Lariviere, 1998) has been extended in various directions, e.g., to cost sharing (Kunter, 2012), multiple periods (Li & Hua, 2008), asymmetric power distribution (Pan, Lai, Leung, & Xiao, 2010), and retail competition (Yao, Leung, & Lai, 2008). Chauhan and Proth (2005) analyze supply chain partnerships based on revenue-sharing, and Van der Veen and Venugopal (2005) show that implementation in practice yield in a win–win situation.

The operations research literature has focused on examining rational profit-maximizing decision makers and designing contracts for such decision makers in different settings. In a recent study, Hämäläinen, Luoma, and Saarinen (2013) note the importance of incorporating behavioral aspects in operations research models, and we follow this line of research. Specifically, in this paper, we focus on behavioral decision making under a revenue-sharing contract. By gaining insight into actual decision making, we can extend existing models to design optimal contracts for actual (non-expected-profit-maximizing) decision makers.

2.2. Behavioral aspects of supply contracts

Decision making in the *newsvendor* setting that we analyze has been the topic of various recent studies in the field of behavioral operations (e.g., Schweitzer and Cachon, 2000; Benzion, Cohen, Peled, and Shavit, 2008; Katok and Wu, 2009; Bolton, Ockenfels, and Thonemann, 2012; Ren and Croson, 2013).[1] These studies make one common observation, the so-called pull-to-center effect, which refers to the observation that subjects tend to stock below profit-maximizing quantities for high critical ratios and above for low critical ratios. Several theories have been ruled out as explanations for this effect, such as risk-averse or risk-seeking behavior, loss avoidance or underestimation of the opportunity costs (Schweitzer & Cachon, 2000).

Su (2008) uses random optimization errors to explain the pull-to-center effect; however, Kremer, Minner, and Van Wassenhove (2010) show that random errors cannot explain all effects, but that the decision bias is context dependent. A second explanation for the pull-to-center bias is the anchoring and adjustment heuristic (Kahneman & Tversky, 1979). By anchoring on mean demand subjects adjust insufficiently toward profit-maximizing stocking quantities. This explanation is supported by numerous studies, and it can be modeled by using an anchoring parameter on the mean demand (Bostian et al., 2008). A third explanation for the pull-to-center bias is demand chasing. Bolton and Katok (2008) show that subjects overreact to recent demand realizations and adjust their stocking quantity in the direction of previous demands. Further, Ho, Lim, and Cui (2010) show that the pull-to-center effect can also result from psychological costs of stock-outs and left-over inventory.

Behavioral supply contracting studies have primarily focused on wholesale price contracts, whereas few studies have analyzed other contract types. A notable exception is Katok and Wu (2009), who study inventory decisions under revenue-sharing and buyback contracts. They find evidence that human inventory decisions differ between contracts that theoretically lead to identical inventory decisions. However, their paper focuses on social preferences and does not analyze the rationales underlying the different stocking quantities under different contract types.

Regarding buyback contracts, Becker-Peth et al. (2013) show that mental accounting (Thaler, 1985) and source-dependent valuation (Loewenstein & Issacharoff, 1994) can explain human inventory decisions that are not in line with standard theory. Zhang et al. (2012) also use mental accounting to explain human decision making but consider the problem from the manufacturer's perspective. They analyze revenue-sharing and buyback contracts in a setting in which the manufacturer is the decision maker and is able to determine the contract parameters; the computerized retailer places expected-profit-maximizing stocking quantities. Zhang et al. (2012) find that the manufacturer uses different mental accounts for the different payment times. These payments differ between the two types of contracts, i.e., high upfront income but subsequent payback under buyback contracts and low upfront income but additional subsequent income under revenue-sharing contracts. Whereas Zhang et al. (2012) describe the contract choice and parameterization by the manufacturer using mental accounting, we analyze the actual ordering decisions of the retailer and will use reference prices to model actual decision making.

In many situations, reference-dependent valuation can explain decision makers' actual behavior that diverges from expected-profit-maximizing behavior. Kahneman (1992) uses negotiations on salary increases as an illustrative example. A salary increase offer can be evaluated as a gain relative to the status quo or a loss relative to certain reference points, e.g., the previous year's increase. Winer (1986) and Kalyanaram and Winer (1995) model the effect of reference prices on customer's brand choice. Further, Hardie, Johnson, and Fader (1993) show that reference points affect many decisions in the buyer behavior context. In a setting where two persons with identical tastes visit a high-quality restaurant, one person might be disappointed because he was previously accustomed to better quality in the restaurant, whereas the other one might be pleasantly surprised by the high-quality meal if he is accustomed to lower quality restaurants (Hardie et al., 1993).

To the best of our knowledge, reference-dependent valuation has not yet been analyzed in the supply contracting literature. One notable exception is Ho et al. (2010), who model a reference point on selling all purchased products and analyze how reference dependency engenders the pull-to-center effect if psychological costs of leftovers and stock-outs are present. In this paper, we address another aspect of mental accounting and reference-dependent valuation.

[1] Studies with deterministic demand settings include Loch and Wu (2008), Cui, Raju, and Zhang (2007), Ho and Zhang (2008), Lim and Ho (2007), and Katok and Pavlov (2013).

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