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Human Decision Making in Systems with Limited Capacity

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EXTENDED ABSTRACT

Humans are a crucial component of operational decision making and, thus, largely influence the performance of companies and supply chains. Although behavioral studies are a well established approach within some domains of operations research – e.g., the bullwhip effect (Sterman 1989; Croson and Donohue 2006; Nienhaus et al. 2006; Croson et al. 2014; Sterman and Dogan 2015; Cannella et al. 2018) – research on human decision making in operations management is still a young, but recently growing field of research (Croson et al. 2013).

In this paper we put a special focus on human decision making within capacitated systems and highlight the potential influence of human decision making. Behavioral decision making, including risk and loss averse behavior, limited cognitive abilities and behavioral biases can be expected to result in different outcomes compared to supply chains including only rational profit-maximizing agents. The aim of this paper is to shed some light on the human influence on supply chains with limited capacity – which prevail in industrial practice where people compete for resources.

A prominent example is the rationing game which is known to be one of the drivers of the bullwhip effect (Lee et al. 1997). Here, multiple retailers compete for limited capacity of the supplier which leads to strategic ordering behavior depending on the allocation policy of the supplier. State-of-the-art literature on the rationing game analyzes this phenomenon from a game-theoretical perspective in simple single–period models (Lee et al. 1997; Cachon and Lariviere 1999a; Bakal et al. 2011; Lee and Park 2016; Rong et al. 2017). To the best of the author's knowledge there is only one paper by Rong et al. (2009) that analyzes the rationing game using an experimental study. They analyze the impact of supply disruptions (stochastic capacity) on the ordering behavior.

Related to the bullwhip effect is the so–called "lead time syndrome" which is characterized by a positive feedback loop, defined by a self-reinforcing mechanism (see Wight 1970; Mather and Plossl 1978; Sterman 2000; Knollmann and Windt 2013). The limited capacity plays a crucial role for this phenomenon, since the lead times increase non–linearly with increasing resource utilization (e.g., Pahl et al. 2007). Figure 1 describes this vicious cycle which is

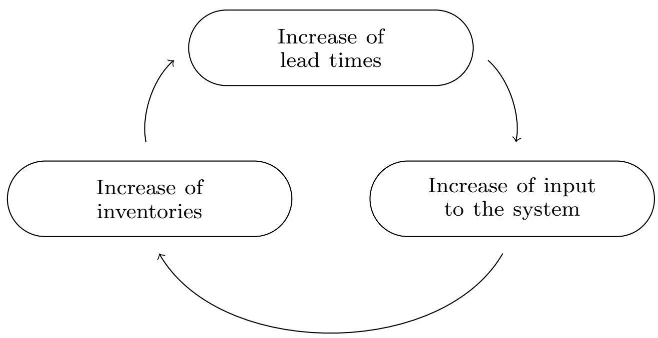

Fig. 1. The vicious cycle of the lead time syndrome

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frequently observed in production planning and was also described in recent supply chain literature (Disney and Lambrecht 2008; Fransoo and Lee 2013; Cannella et al. 2018): An increase in the lead times causes an increase in quantities ordered by the retailers, which, due to higher inventories, results in increasing lead times, thus aggravating the basic syndrome. Several studies in the production planning literature examine the lead time syndrome using analytic (Selcuk et al. 2006, 2009) and control theoretic models (Knollmann and Windt 2013; Windt and Knollmann 2014; Knollmann et al. 2014; Bendul and Knollmann 2016). However, although anecdotal evidence highlights the important role of human factors influencing the lead time syndrome (e.g., Moscoso et al. 2010; Windt and Knollmann 2014), there is no study that analyses the human influence on this phenomenon. To sum up, analyzing the lead time syndrome is not only relevant for a deeper understanding of the bullwhip effect, but also for other decision making processes such as lead time management and order release planning.

Based on earlier behavioral operation management studies (Mather and Plossl 1978; Sterman 1989; Nienhaus et al. 2006; Croson and Donohue 2006; Moscoso et al. 2010; Haemaelaeinen et al. 2013; Croson et al. 2014; Becker-Peth and Thonemann 2018), we conjecture that in the case of limited capacity the following environmental factors and behavioral causes influence human decision making:

(1) Supply chain design:
  (a) Demand uncertainty

(b) Supply uncertainty
(c) Coordination risk among entities

(2) Behavioral causes:
(a) limited cognitive abilities
(b) risk and loss aversion
(c) supply line underweighting

We argue that future studies should pursue two directions to analyze human decision making in systems with limited capacities:

(i) they should address the influence of environmental factors where studies can build on earlier results for scenarios with uncapacitated systems (e.g., Croson and Donohue 2006; Croson et al. 2014; Sterman and Dogan 2015) and analyze the role of competition on human ordering behavior. Furthermore, the role of information distortion between retailer and supplier should be analyzed in detail, for example the supplier could provide up-to-date estimations of ordering delays or load dependent lead times and thus reduce supply risk i.e. the lead time uncertainty. We conjecture that: First, similar to the uncapacitated case, human's behavior triggers the bullwhip effect in capacitated systems. Second, that human behavior initiates the lead time syndrome (Haeussler et al. 2020) similar to other positive feedback loops e.g., during financial bubbles (e.g., Heemeijer et al. 2009 and Bao et al. 2017).
    Another interesting analysis would be to investigate the influence of (capacity) allocation policies on human ordering behavior. Thus, to test whether the theory of "truth inducing" allocation policies by Cachon and Lariviere (1999a,b) hold within an experimental study.
(ii) based on the findings in (i), future research should develop decision support tools that use the above mentioned behavioral causes to increase decision quality. This can be done, for instance, by confronting human decision makers with their expected loss if they do not follow the suggested (optimal) policy or by providing effective visual support tools (e.g., Hutter et al. 2018).

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