Fairness in the Beer Distribution Game

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Fairness concerns play an important role in our lives. Until recently, it was assumed this applied only to our personal lives and had no impact on people as economic beings. In the view of traditional economic models, people are seen as profit-seeking and self-regarding agents, which are exclusively concerned about their own material payoff. Evidence based on experimental research proved this to be false, which led to the development of a substantial number of fairness models, most notably the Fehr and Schmidt (1999) model which conceptualizes fairness as inequity aversion. This research continues their work by applying their conceptualization in the dynamic and multi-stage setting of the Beer Distribution Game.

Fairness concerns have been shown to be pervasive in organizations and markets (Kahneman et al. 1986; Xia et al. 2004; Nguyen & Klaus 2013). That also includes supply chains where decisions of the agents are influenced by fairness concerns (Anderson & Weitz 1992; Samaha et al. 2011), including competitive supply chains where agents exhibit fairness concerns even towards agents that are their direct competitors (Choi & Messinger 2016). Most of the studies of fairness focus on the so-called distributional fairness in simple settings (e.g., the newsvendor problem or wholesale price contracts; Nie and Du 2017). Ho and Su (2009) were the first to study peer-induced fairness alongside distributional fairness in a setting of two independent Ultimatum Games played by a leader and two followers in a supply chain context. The next logical step is to test the theoretical assumptions and current findings in more complex and dynamic settings. One such setting which, so far, has not been utilized in fairness research is the Beer Distribution Game.

Fairness concerns are surprisingly absent from both the Beer Distribution Game and the bullwhip effect literature. To the best of our knowledge, there is no research dealing with either distributional or peer-induced fairness concerns in the context of the Beer Distribution Game, and fairness is not considered as one of the possible causes of the bullwhip effect. One paper which mentions fairness in this context is Coppini et al. (2010) which studies how an actor's position in the supply chain influences its responsibility for generation of the bullwhip effect, as well as its predisposition to suffer from it. They conclude that supply chains are "unfair" systems because the stages that are more responsible for generating the bullwhip are those that suffer less from it, and vice versa, those that are less responsible for its generation are the ones that suffer more. Whether or not this has an impact on agents' decision making has not yet been investigated.

The Beer Distribution Game has become a popular experimental tool to study the bullwhip effect, primarily because of its simplicity and robustness of results. As the number of publications related to the Beer Distribution Game increased, a need for computerized versions of the game emerged. Some versions kept the human decision-makers and only replaced the original board with computers (e.g., Croson & Donohue 2003, 2005), while others partially (e.g., Martin et al. 2004) or completely (e.g., Coppini et al. 2010) removed human decision-makers and replaced them with mathematical models. One such model, in which decision-makers are completely replaced by a decision heuristic based on the order equation developed by Sterman (1989), was developed by Kirkwood (1998) in Vensim software.

Kirkwood's model provides a very good representation of the game and simulation results match the empirically observed behavior with reasonable accuracy. With that said, in order to use it to study fairness concerns it needs to be extended since it is missing some key features. Fehr and Schmidt (1999) propose modeling fairness concerns as inequity aversion, which means that players compare their own

payoff to other players' payoffs, and the discrepancies impact how fair they perceive the outcome to be. Players in the Beer Distribution Game are focused on managing their inventories and backlogs, and only in the end are provided with supply chain costs information to inform them about their individual and joint performance. The lack of individual real-time performance measures, as well as the focus on overall supply chain performance, make the standard Beer Distribution Game an unlikely setting in which players would experience fairness concerns. Although cost information can be provided during the gameplay, it does not exactly match the factors used by Fehr and Schmidt (1999) which employs payoffs and their differences to determine players' utilities. By measuring profit at each stage and making these values known to players throughout the game, it is possible to shift the focus of the game to individual performance and to profit as a payoff value which the players could use to compare their relative standings to other players.

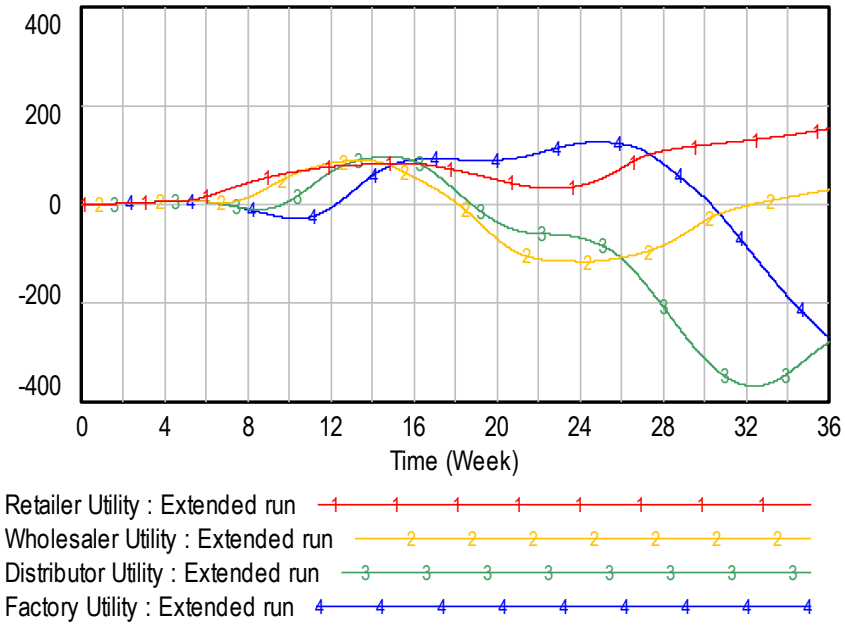

Figure 1. Utilities in the extended Beer Distribution Game

Our simulations (Figure 1) suggest that Coppini et al. (2010) were correct in stating that the upper tiers suffer most from the bullwhip effect, even though they are not the ones causing it. At the end of the simulation, distributor and factory are indeed the worst performers. Nevertheless, their conclusions might be misleading since they associate suffering with the amplification of orders. In fact, using its position at the end of the supply chain, the factory is able to take advantage of amplified orders throughout most of the game, running up the profits and maintaining high utility. It benefits from its empty inventories and high sales while everyone else suffers because of it. We suggest that the two middle tiers might be the ones to suffer the most, in particular the distributor. They possess neither of the two position advantages (being closest to the final customer like retailer or being closest to the manufacturing point like the factory) which they could use to their advantage and are instead left at the mercy of amplified orders and empty inventories coming from down- and upstream respectively. In this particular setting, the wholesaler is the one suffering more from increased lead times, and the distributor is the one suffering more from amplified orders.

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