Heterogeneity of Reference Effects in the Competitive Newsvendor Problem

The newsvendor problem is centered on balancing the gain from satisfying demand with the loss from unsold inventory. Unsurprisingly, the concepts of gains and losses from prospect theory have been applied to explain the observed behaviors, such as the pull-to-center effect. Interestingly, initial attempts to incorporate prospect theory into the newsvendor utility structure did not provide a conclusive explanation for observed behaviors (Schweitzer and Cachon 2000, Nagarajan and Shechter 2014). Only recently, Long and Nasiry (2015) analytically proved that prospect theory can explain the pull-to-center effect by expressing the newsvendor’s reference point as a weighted average between the minimum and maximum payoffs, to which they refer as “optimism”. Ho et al. (2010) also presented a model of reference-dependence based on ex-post inventory error explaining the pull-to-center effect. However, their model only allows for losses (from shortages or leftovers) and never gains, hence it is not prospect-theoretic in a strict sense. Examining both models, we find that the models are equivalent: up to re-parametrization they produce identical order quantities. In addition, we show that the level of optimism in Long and Nasiry’s model really represents the relative preference between ex-post inventory errors (over vs under ordering).

Although newsvendor experiments initially focused only on monopolist behavior, several recent studies have examined newsvendor behavior under competition (Ovchinnikov et al. 2015, Feng and Zhang 2017, Zhao and Zhao 2016, Quiroga et al. 2016). Adopting the formulation by Long and Nasiry (2015), yet interpreting it as the ex-post inventory bias, we examine whether the reference effects can explain observed behaviors from the competitive newsvendor experiments. Our main result is that the heterogeneity in reference points leads to an equilibrium in which one newsvendor accounts for the behavior of its competitor, while the other newsvendor for the most part ignores its competitor and acts like a monopolist. The newsvendor with greater sensitivity to excess inventory has a higher reference point, perceiving more demand realizations as losses. Consequently, this newsvendor always orders less inventory compared to the competitor and never profitably captures spillover demand. Thus, the newsvendor with greater sensitivity to excess inventory is largely unconcerned with the magnitude of its competitor’s behavioral bias and decisions. Conversely, the newsvendor with less sensitivity (disutility) to having surplus inventory benefits more from spillover demand and determines the total market demand, adjusting their order based on the decision of the competitor. This matches the experimental observations from Ovchinnikov et al. (2015), Feng and Zhang (2017), and Zhao and Zhao (2016), that human newsvendors are insensitive to the competitor’s strategy.

We benchmark the derived behavioral equilibrium against the unbiased Nash equilibrium and find that the level of heterogeneity between the newsvendors dictates when each newsvendor (or both) over- or under-order. In the special case where a biased newsvendor is competing against an unbiased newsvendor, the unbiased newsvendor sets the total supply, while the biased competitor acts ignorantly and orders suboptimally. This creates large spillover demand from the biased competitor toward the unbiased one, and results in a significant profit increase for the latter. This matches the experimental evidence from Quiroga et al. (2016). Finally, we compare the total order quantity to a behavioral monopolist. We show that the behavioral duopoly can lead to a total market supply exceeding the market supply of a monopolist when demand is perfectly-correlated (when as per the standard theory they should be identical), explaining observations from Feng and Zhang (2017) and Zhao and Zhao (2016). Combining all findings, we show that heterogeneity in reference-dependence can explain several regularities observed in recent experimental studies of newsvendor competition.
References


