Extended Abstract, Managerial Insight and “Optimal” Algorithms

After nearly two decades and dozens of studies of behavior in the newsvendor setting, a worrisome consensus has emerged—humans almost universally deviate from optimal order quantities, thereby reducing firm profits. Given the centrality of the newsvendor problem to inventory management, this result suggests that firms could improve their performance by replacing human inventory managers with optimally programmed ordering systems. Is this true? And if so, why do firms rely so heavily on the judgment of human managers?

Human managers may be able to improve decision making by incorporating knowledge derived from idiosyncratic events that affect real-world performance but are omitted from standard analytical models. My primary research question is: How can a firm maximize profits in a newsvendor setting in which human managers have privileged access to valuable demand information but are also subject to cognitive limitations, biases, and heuristics?

In their seminal paper, Schweitzer and Cachon (2000) acknowledge the need for both human managers and algorithms. They note that “the forecasting task typically requires managerial judgment” while “the task of converting a forecast into an order quantity can be automated” (p. 419). Automation, they say, should be used alongside human decision making, not to its exclusion. Yet, to the best of my knowledge, no accepted model of the newsvendor problem captures the need for managerial judgment. I aim to fill this critical void with a descriptive theoretical model and a prescriptive empirical method.

At the heart of this paper are three assumptions: (1) the typical newsvendor model is misspecified relative to some practical settings in that it fails to include important real-world features that affect profits, (2) human managers can observe a subset of these unmodeled features and therefore have the potential to improve decision making, and (3) doing so requires the use of tacit knowledge and unstructured data (e.g., conversations, news reports, etc.) that cannot be admitted by standard models.
I add the concept of “managerial insight” (i.e., knowledge derived from unmodeled features of the world that can improve decision making) to the typical newsvendor setting by endowing human managers with a private signal of future demand that is inaccessible to automated algorithms. In theory, managers should be able to compute the optimal insight-informed order quantity to extract maximal benefit from this signal, and thus they should outperform the standard ordering policy. However, in a series of laboratory experiments, human newsvendors consistently deviate from the optimal insight-informed policy, sacrificing potential profits. In some cases, suboptimal orders lead to an erosion of profits (relative to the standard policy) despite participants’ superior demand information.

So how can managerial insight be leveraged without having to suffer the shortcomings endemic to human decision making? The solution, presaged by Schweitzer and Cachon (2000), is “to separate the forecasting task from the inventory decision task” by having “managers generate forecasts that are then automatically converted into order[s]” (p. 419). I introduce the Forecast to Individualized Normative Demand (FIND) algorithm, a procedure to empirically assess the informational content of managers’ forecasts (based on historical accuracy) and update the anticipated distribution of demand (according to Bayes’ rule). Finally, I apply optimal policy derived from normative analysis to this “posterior” distribution to compute an insight-informed automated order quantity. FIND outperforms the fully automated standard “optimal” (critical fractile) policy, standard “optimal” recommendations subject to managerial adjustments, and a common heuristic for combining human decisions with model prescriptions—simple averaging (Blattberg and Hoch 1990).

The primary contributions of this paper are as follows: (1) I establish a flexible (i.e., admits general demand) normative model of managerial insight, apply it to the newsvendor problem (allowing humans to gainfully contribute to decision making in this context
for the first time), and solve it for the special cases of normal and uniform demand to benchmark empirical performance; (2) I demonstrate that laboratory participants endowed with managerial insight and asked to make newsvendor ordering decisions fail to follow the optimal insight-informed policy (resulting in a substantial loss of potential profits); (3) I recast the newsvendor problem as a forecasting task and propose the novel FIND algorithm (which involves both econometric analysis and analytical modeling) to convert forecasts to orders—the algorithm is parsimonious (i.e., has no free parameters) and implementable (i.e., uses only historical and observable data); (4) I show outstanding performance of the FIND algorithm in a controlled laboratory experiment that is validated in three follow-on studies designed to test the robustness of changes in the subject pool, demand distribution, and signal format; and (5) I introduce the novel “dot flicker” method to convey noisy signals visually via complex images (with noise resulting from the limitations of human perceptual acuity); this technique provides evidence for the validity of the more common method (i.e., numerically with the explicit addition of a random error term).

The primary managerial takeaway from my work is this: Both models and humans have shortcomings. Models ignore important features of the world. Human decision making is error-prone and biased. My approach integrates the two to form a human-computer hybrid algorithm that helps to mitigate the weaknesses of each and outperforms either one alone.

References
