An Empirical Analysis of How Inventory Levels and Prices Affect Online Retail Sales
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Several prominent Internet retailers provide real-time inventory-level information to online shoppers. This practice suggests that retailers may be leveraging inventory information to induce demand. In this study, we are interested in understanding how inventory levels observed by consumers online affect sales, as well as how this inventory-sales link influences the impact of price discounts on sales. Prior research in operations management and marketing has yielded conflicting views on how inventory-level information affects sales. Some researchers have advocated that high inventory levels stimulate sales by signaling popularity or availability, whereas others have suggested that low inventory levels trigger imminent sales due to scarcity effects. Managers in practice may be likewise split in their views regarding inventory-level data’s impact on consumers, as some firms share such information while others do not.

Estimating how inventory levels influence sales rates (see arrow 1 in Figure 1) is not a trivial exercise. For one, inventory levels may be endogenous with respect to product sales rates (as depicted by arrow 2 in Figure 1), since a retailer may maintain higher inventory quantities for products that sell faster, ceteris paribus. Therefore, even if inventory levels do not influence sales rates, fast-moving stock keeping units (SKUs) offered by that retailer may exhibit higher inventory levels relative to slow-moving ones. In addition, the sales rate for a SKU may be endogenous with respect to that SKU’s price. Specifically, price may have a negative effect on a SKU’s sales rate (as depicted by arrow 3 in Figure 1). An additional source of complexity is that a retailer can endogenously choose prices for SKUs with respect to the SKUs’ sales rates (see arrow 4 in Figure 1). For example, retailers that offer may price discounts for slow-moving SKUs to induce more sales.

Figure 1: Model framework.

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To address the aforementioned modeling challenges, we compiled a data set comprising products’ inventory levels, prices, and sales from Amazon.com. For generalizability, we tracked SKUs in Amazon’s “Home, Garden, and Tools” (HGT) department. The HGT department is one of the largest and most diverse at Amazon, containing products sold by both Amazon and a variety of third-party sellers. Using a web crawler application developed by Cartbound, we tracked price and inventory changes for SKUs in Amazon’s HGT department between July 1, 2014 and February 28, 2015. Tracking 3,468 SKUs, with at least 30 available observations each, yielded a total of 158,521 observations during the data-collection period. To establish links between inventory, prices, and sales, and address the inherent endogeneity among these variables in the framework depicted in Figure 1, we analyzed the data by estimating a simultaneous equation model.

Our panel data and choice of retailer provide a rich setting where we can investigate interrelated effects of inventory levels, pricing, and sales rates, across a large cross-section of SKUs and over a period during which demand conditions can vary significantly. Our focus on a single retailer provides uniformity across exogenous dimensions at the firm level that might bias sales rates, pricing, and inventory availability. Moreover, using a focal online retailer allows us to control for differences in the delivery of information through the consumer-retailer interface, retail brand, and service promises to consumers—including fulfillment options and return policies that could influence sales and price elasticity. As Amazon does not operate a B&M channel to sell the products in our analysis, we were able to circumvent the need to control for sales rate effects due to cannibalization between multiple channels (i.e., online versus B&M) as well as to account for effects caused by variations in inventory display and pricing strategies across these different channels.

Our results provide rigorous empirical support for the view that lower inventory levels can indeed induce scarcity perceptions, which consequently yield higher sales. Our empirical analysis using SKUs in the HGT department at Amazon suggests that, a reduction of 1 unit in the inventory level can increase the likelihood of a sale by 2.6% on average. The statistical significance of this effect is noteworthy in our study setting of Amazon.com, as we establish this inventory-sales link even in the presence of consumers’ ability to search alternative sellers for the same SKUs Amazon lists. Therefore, we expect the scarcity inducing effects of disclosed inventory to be even stronger for products for which the alternative supply options are limited.

Our results also highlight how inventory level effects complement the (intuitively anticipated) demand stimulating effects of price cuts. First, we quantify the average impact of a price cut on the likelihood of a SKU selling in the future. We also find that, even in the presence of the aforementioned
price effect on sales, disclosed (low) inventory levels still have statistically significant effects on sales. We summarize these findings in Table 1.

Table 1: Results regarding the proposed effects in our framework as depicted in Figure 1.

<table>
<thead>
<tr>
<th>Arrow in Figure 1</th>
<th>Effect</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Inventory Level → Sales Rate</td>
<td>A product’s inventory level has a negative effect on its sales rate.</td>
</tr>
<tr>
<td>2</td>
<td>Sales Rate → Inventory Level</td>
<td>An increase in a product’s sales rate increases its inventory levels.</td>
</tr>
<tr>
<td>3</td>
<td>Price → Sales Rate</td>
<td>The price that an online retailer charges for a product has a negative effect on its sales rate.</td>
</tr>
<tr>
<td>4</td>
<td>Sales Rate → Price</td>
<td>A product’s sales rate has a positive effect on the price an Internet retailer charges for the product.</td>
</tr>
</tbody>
</table>

Our findings regarding the impact of price discounts on sales are consistent with prior research highlighting how price-sensitive Internet sales are due to low search costs. It should, however, be noted that price discounts hurt retail profits unless they stimulate enough demand to negate reductions in gross margins. As such, online retailers should welcome non-price tactics to stimulate demand. Our findings not only support the use of disclosure of low stock levels as one such tactic that is effective on its own, but also highlight that selective disclosure, when used alongside price discounts, can provide an additional lift in sales. By accurately choosing the threshold stock level below which a retailer should disclose its exact stock levels to stimulate sales, the retailer can calibrate the complementing price discount. We show that online retailers should not only estimate the sales lift that can obtain from price discounts and disclosed stock levels, but also the sales lift they should anticipate when they use both tactics concurrently. Online retailers who fail to understand the link between the effects of these two demand-stimulating tactics may end up offering larger-than-needed price discounts. As the net margins in retail are already very thin, such gross margin reductions beyond requisite levels may dictate whether a retailer can remain profitable.