The Effects of Menu Costs on Retail Performance: Evidence from Adoption of the Electronic Shelf Label Technology

1. Research Problem

Adjusting prices is costly. It involves managerial attention and effort for determining prices, physical labor to implement price adjustments, and communication of price changes to consumers. These costs, called menu costs in the literature, have several important implications. From an operations management perspective, menu costs are frictions that prevent firms from optimally matching supply and demand on a day-to-day basis, directly affecting retail performance. Specifically, pricing interacts with ordering and inventory management (Elmaghraby and Keskinocak 2003, Stamatopoulouso et al. 2017), assortment planning (Dong et al. 2009), demand learning (Araman and Caldentey 2009), and quality offerings (Akccay et al. 2010, Stamatopoulouso and Tzamos 2016). In addition, menu costs restrict the ability of firms to engage in yield management to maximize profits (Netessine 2006, Chen et al. 2010).

In this paper, we use the adoption of the electronic shelf label (ESL) technology by an international retailer to investigate the following questions: Would the alleviation of menu costs benefit retailers? If so, by how much? Moreover, would it benefit or hurt consumers? When it comes to retailers, it is reasonable to think that the adoption of ESLs or other similar technologies would have a positive effect (by eliminating physical menu costs), as long as the installation and maintenance costs are not very high. At the same time, whether or not such technologies can lead to benefits in terms of sales and gross margins is an empirical question that is far less obvious; it could be that in most cases retailers are already capturing the first order effects of demand and cost changes on gross margins with their current pricing. When it comes to consumer surplus and total welfare, theory (Varian 1985, Aguirre et al. 2010, Chen and Schwartz 2015) has reached the conclusion that just imposing profit-maximizing and rational expectation assumptions does not pinpoint the direction of the impact of dynamic pricing on welfare. It is thus an empiricist’s task to explore and understand these effects, informing theory about the situations in which one direction is more plausible than another.
2. Methodology

To address our research questions, we obtained a unique dataset from an international grocery store chain with stores in the United Kingdom that installed ESLs in 2015. ESLs are digital price tags typically attached to the front edge of retail shelving, which can be updated remotely whenever needed. ESLs reduce the cost of price adjustment by eliminating its manual labor component. We have transaction-level data (store ID, data/time, product ID, price, quantity) from four stores of this retailer; the first two stores that installed the ESL technology (chronologically), and two stores that were each chosen by our data vendor to be similar to one of the two stores that installed the ESLs.

We measure retailer performance using gross margin, defined as the sum of the differences of retail and wholesale price for all products sold at a given store in a given period of time. Gross margin does not perfectly capture profit, as it does not reflect operational costs (labor costs, ordering costs etc.). However, gross margin allows us to pick up the benefits for the firm in terms of additional earnings. When it comes to consumer surplus and total welfare, measurement is a much trickier issue. The reason is that we only observe point-of-sales data (retail price, wholesale prices, and quantities) and not the willingness to pay of the different agents. To perform our analysis, we turn to theory (Varian 1985, Aguirre et al. 2010, Chen and Schwartz 2015). Specifically, one can show that, under very general conditions, a sufficient condition for consumer surplus to decrease when moving from static to dynamic pricing is that the average price per unit sold (quantity-weighted average price) increases. In other words, the price per unit sold metric captures the most direct channel through which consumers might be hurt from dynamic pricing: products becoming more expensive on average. Similarly, under very general conditions, a sufficient condition for total welfare to decrease when moving from static to dynamic pricing is that the total quantity sold decreases. That is, the quantity sold metric captures the most direct channel through which the supply chain might be hurt from dynamic pricing: the supply chain delivering fewer products on average. Hence, theory suggests a very straightforward way of providing evidence that consumer surplus or total welfare is hurt from dynamic pricing using POS data alone: detect an increase in the average price per unit sold or a decrease in the total quantity sold. We test both hypothesis in our primary analysis.

To causally identify the effect of ESLs on our outcomes of interest we use a difference in differences (DiD) estimator with two different treatment dates. In our primary regression specification we log outcomes (gross margin, average price per unit sold, sales quantity, etc.). We include store and date fixed effects, and also control for product availability. Finally, we include a dummy variable that equals zero before the date ESLs were installed in a store, and turns to one after ESL installation. Hence, the estimated coefficient of this variable picks up any incremental changes in the outcome
variable after the technology is installed in a store, on top of any day-specific shocks (captured by the date-fixed effects) and store-specific differences (captured by the store fixed effects). We allow errors to be correlated at the store-month level, to control for serial correlation in our inference procedure.

3. Results
We find that gross margin is higher compared to the counterfactual in which the ESLs were not installed, the average price per unit sold is lower, and daily sales volumes are higher. The increase in gross margin suggests the retailer benefitted from ESLs beyond saving on labor costs. The decrease in average price per unit sold and increase in quantity sold suggest that the two most direct channels through which consumer surplus could be hurt (more expensive products or less products sold to consumers) are not supported by the data. All estimates maintain their significance when errors are clustered at the store-quarter level, and the analysis produces similar magnitudes and significance levels for the effects when performed at the weekly level.

Moreover, we demonstrate that pricing was a part of the mechanism that generated the observed changes in outcomes. In particular, we show that the volume of price-adjustments increased as a result of ESLs, the average size of a price adjustment decreased, and the degree of batching of price changes across different products decreased. These findings are reflective of prices responding to a reduction in menu costs. Differentiating between upward price changes and downward price changes, we also find that while the volume of upward price changes is not higher by a statistically significant level as a result of the ESLs, the volume of downward price changes increased. These results point to how the retailer increased its revenue using the ESL technology: with ESLs, stores gradually reduce price levels instead of abruptly slashing prices to respond to low sales velocity. As a result, more products are sold and at lower prices on average, increasing retail performance. This finding is corroborated by anecdotal evidence we retrieved from one of the largest producers of ESLs on how different retailers have been using the ESLs.

References


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