Menu costs and dynamic duopoly ☆

Kazuko Kano *

Graduate School of Economics, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan

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ABSTRACT

Examining a state-dependent pricing model in the presence of menu costs and dynamic duopolistic interactions, this paper claims that the assumption regarding market structure is crucial for identifying the menu costs for price changes. Prices in a dynamic duopolistic market can be more rigid than those in more competitive markets, such as a monopolistic-competition market. Therefore, the estimates of menu costs under monopolistic competition are potentially biased upward due to the price rigidity from strategic interactions between dynamic duopolistic firms. By developing and estimating a dynamic discrete-choice model with duopoly to correct for this potential bias, this paper provides empirical evidence that dynamic strategic interactions, as well as menu costs, play an important role in explaining the observed degree of price rigidity in weekly retail prices.

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1. Introduction

In this paper, I study a structural state-dependent pricing model with menu costs for price changes in which brands of retail products play a dynamic game of price competition. The model provides the claim of this paper: the estimates of menu costs identified under a maintained hypothesis of monopolistic competition could be biased upward due to the price rigidity generated from dynamic strategic interactions between two brands in a duopolistic market. Using scanner data collected from a large supermarket chain in the Chicago metropolitan area, I provide empirical evidence that not only menu costs but also dynamic strategic interactions play an important role in the high-frequency movements of weekly retail prices after correcting for potential bias. To the best of my knowledge, the bias in the estimates of menu costs due to dynamic strategic interactions in a duopolistic market has not been investigated thoroughly in the literature on state-dependent pricing.

Following past studies, this paper defines menu costs as any fixed adjustment costs a price setter has to pay when changing its price, regardless of the magnitude and direction of a price change. Several papers provide evidence that menu costs are empirically important in understanding retail price dynamics. Constructing direct measures of physical and labor costs in large supermarket chains in the United States, Lévy et al. (1997) claim that menu costs play an important role in the price setting behavior of retail supermarkets. Estimating menu costs as structural parameters of single-agent dynamic discrete-choice models in monopolistically competitive markets, Slade (1998) and Aguirregabiria (1999) find that their estimates of menu costs are positive and statistically significant. More recently, using a dynamic oligopoly competition model, Nakamura and Zerom (2010) observe that menu costs are crucial for explaining price rigidity in the short run.

As is frequently observed in macroeconomics literature, monopolistic competition is the most commonly adopted market structure in past studies on price rigidity.[1] This hypothesis of market structure, however, is problematic if the market under study is dominated by a small number of firms. In this case, duopolistic/oligopolistic competition may be a more appropriate market structure for studying firms' pricing behaviors. More importantly, if duopolistic/oligopolistic competition prevails in the market of investigation, the estimates of menu costs identified under the maintained assumption of monopolistic competition may be biased due to tighter strategic interactions among firms. For example, suppose that there are just two dominant firms in a market that compete in price. Although monopolistic-

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[1] The seminal paper that applies a monopolistic-competition model to aggregate price rigidity is Blanchard and Kiyotaki (1987).

competition models create a degree of strategic complementarity among firms' prices, each firm perceives its own market power to be so small that it recognizes the average price to be exogenous. In contrast, in a duopolistic market, firms explicitly take into account strategic interactions. Because this would lead to a stronger degree of strategic complementarity, firms may prefer less aggressive price competition. Due to their tighter strategic interactions, the equilibrium price of the market may be rigid to some extent *regardless of the existence of menu costs*. Within such markets with tighter strategic interactions among firms, the working hypothesis of monopolistic competition spuriously results in the overestimation of menu costs. This situation implies that in order to draw a precise inference on menu costs, it is essential to properly identify the market structure of a product under investigation and allow for dynamic duopolistic/oligopolistic interactions among the firms in the market.

Although a number of empirical papers study price rigidity using micro data, few investigate the relationship between the price rigidity of a product and its market structure, taking into account the effect of dynamic duopolistic/oligopolistic interactions.[2] Slade (1999) estimates the thresholds of price changes as functions of strategic variables using a reduced-form statistical model. Assuming that firms follow a variant of the (s, S) policy, Slade observes that firms' strategic interactions in a dynamic oligopolistic competition model exacerbate price rigidity. This observation suggests a potential upward bias of the estimates of menu costs, as previously discussed. In this paper, I go beyond the reduced-form model of Slade (1999) by developing a fully-structural dynamic discrete-choice model equipped with menu costs and dynamic duopolistic interactions. Because the effect of dynamic duopolistic interactions on equilibrium prices is captured by the strategies of the two firms in the model, the rigidity due to menu costs is separately inferred from that due to dynamic strategic interactions. Another important exception is Nakamura and Zerom (2010), who investigate the sources of the incompleteness of the pass-through of wholesale prices to retail prices observed within the coffee industry. They construct an empirical model under dynamic oligopolistic competition among manufacturers and identify the menu costs at the wholesale level. Their estimation indicates that though the menu costs are negligible, they are nevertheless important for explaining the price rigidity observed in the short run. Notice that the objective of this paper is different: I examine how an empirical inference about menu costs might be affected when the underlying market structure is misspecified.

By examining a small product market of graham crackers, I estimate menu costs under both monopolistic competition and dynamic duopoly. The former is the benchmark and the latter is the minimum extension of monopolistic competition with dynamic strategic interactions. It is worth noting that the main claim of this paper is not a theoretical consequence of dynamic-duopolistic competition; this is because in the estimation under dynamic duopoly, there is no restriction that would lead to price rigidity. Thus, the estimated menu costs can be either greater or smaller than that in the monopolistic-competition model. I find that the estimates of menu costs are statistically significant under the two market structures. The comparison between the estimation results from the two specifications supports the main claim of this paper: the dynamic strategic interactions between brands result in an upward bias of the estimates implied by the benchmark specification of monopolistic competition.

The next section describes the data used for analysis. Section 3 introduces the dynamic discrete-choice duopoly model. Section 4 describes the empirical strategy of this paper. Section 5 reports the empirical results, and Section 6 concludes.

2. Data

The data used in this paper are weekly scanner data collected across the branch stores of Dominick's Finer Food (DFF, hereafter), the second largest supermarket chain in the Chicago metropolitan area during the sample period from September 1989 to May 1997.[3] The data set contains information on actual transaction prices, quantities sold, indicators of promotions (simple price reductions and bonus-buys), and a variable called average acquisition cost (AAC, hereafter), which is a weighted average of the wholesale prices of inventory in each store, by stores and Universal Product Codes (barcodes).[4] The products in the data set are priced on a weekly basis, which matches the sampling frequency of the data. The fact that the prices are actual transaction ones is ideal for studying price rigidity as the frequency and timing of price changes are the most important statistics in this study.

I choose standard graham crackers as the product to be analyzed for three reasons. First, only a small number of firms dominate the market. Second, across firms, there is only one similarly-sized package (15 or 16 oz) for the product. Third, because a box of graham crackers is a minor product, I can avoid the possibility that pricing is affected by competition among retailers due to, for example, a loss-leader motivation. There are four brands in this market: two national brands (Keebler and Nabisco), one local brand (Salerno), and one private brand (Dominick's). The market share of the four brands is approximately 97% of the total sales of standard graham crackers. Note that DFF buys graham crackers directly from manufacturers.[5] Further, note that prices are fairly uniform across stores; in other words, DFF does not adopt zone pricing, wherein stores are assigned to one of three categories: high-, mid-, or low-priced stores. The zone pricing strategy is typically used for products that sell in large volumes. In contrast, zone pricing is not adopted for products with small sales volumes such as graham crackers, probably because it is too costly for a retailer to tailor-make the prices of such goods. These facts suggest that manufacturers' decisions are more likely to be reflected in retail prices, and the pass-through rate from the wholesale price to the retail store would be large.

Fig. 1 plots the shelf prices of the four brands in a representative store, displaying the following important aspects of the data. First, the shelf prices discretely jump both upward and downward. Second, the prices stay at the same level for a certain period of time although temporary price reductions or "sales" are observed quite frequently. Third, the price levels vary over time for each brand. These patterns suggest that the pricing decisions can be decomposed into a discrete decision—whether or not to change the price—and a continuous decision—what level of price to set. Thus, it is important to incorporate the discrete decision into a model.

Fig. 1 also reveals another important aspect of the data: the pricing patterns of the two national brands, Keebler and Nabisco, are similar to each other, but quite different from those of the other two brands. Observe that the prices of the two national brands move quite frequently around the higher levels for most of the sample period, while the prices of the other two brands move less frequently around the lower levels. Tables 1 and 2 provide further evidence to support this claim. Table 1 reports several summary statistics of the data across brands. The fourth column of the table shows the market

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[2] Carlton (1986), Cecchetti (1986), and Kashyap (1995) are among the empirical studies on price rigidity that use micro data. For more recent studies, see Nakamura and Steinsson (2008) and the references cited therein. For theoretical studies that deal with duopolistic/oligopolistic competitions in the presence of fixed adjustment costs, see Dutta and Rustichini (1995) and Lipman and Wang (2000). Unfortunately, it is not straightforward to construct econometric models from their theoretical implications.

[3] The data set is publicly available online at the website of James M. Kilts Center, Graduate School of Business, University of Chicago. The website also provides links to papers that describe the pricing practice of DFF.
[4] For details on AAC, see Peltzman (2000).
[5] The data set provides a code that indicates whether DFF buys a product directly from manufacturers or through wholesalers.