DISCUSSION PAPER SERIES

DP13281
(v. 3)

MICRO-RESPONSES TO SHOCKS: PRICING, PROMOTION, AND ENTRY

Alexis Antoniades, Sofronis Clerides and Mingzhi Xu

INDUSTRIAL ORGANIZATION

ISSN 0265-8003

MICRO-RESPONSES TO SHOCKS: PRICING, PROMOTION, AND ENTRY

Alexis Antoniades, Sofronis Clerides and Mingzhi Xu

Discussion Paper DP13281
First Published 28 October 2018
This Revision 05 October 2019

Centre for Economic Policy Research
33 Great Sutton Street, London EC1V 0DX, UK
Tel: +44 (0)20 7183 8801
www.cepr.org

This Discussion Paper is issued under the auspices of the Centre's research programmes:

- Industrial Organization

MICRO-RESPONSES TO SHOCKS: PRICING, PROMOTION, AND ENTRY

Abstract

We study the market response to firm-specific shocks in a natural experiment setting. In 2006, a boycott of Danish products in several Arab countries was devastating for Danish cheese products firms. In Saudi Arabia their market share collapsed from 16.5% in January to below 1% in March and never fully recovered: by 2009 it was 6.3%. By analyzing micro-level (scanner) price and sales data, we find that (i) Danish firms lowered prices but kept the product mix the same; (ii) non-Danish firms kept prices constant but changed their product mix by introducing new products and new product bundles; and (iii) non-Danish firms chose to introduce products that were similar to the Danish in characteristic space in order to compete head-to-head. We complement the analysis with a theoretical framework that helps to account for our main findings.

JEL Classification: L10

Keywords: boycotts, multi-product firms, demand shock, Saudi Arabia

Alexis Antoniades - aa658@georgetown.edu
Georgetown University

Sofronis Clerides - s.clerides@ucy.ac.cy
University of Cyprus and CEPR

Mingzhi Xu - mzhxu@ucdavis.edu
Peking University

Micro-responses to Shocks: Pricing, Promotion, and Entry*

Alexis Antoniades
Georgetown University

Sofronis Clerides
University of Cyprus and CEPR

Mingzhi Xu
INSE at Peking University

August 4, 2019

Abstract

We study the market response to firm-specific shocks in a natural experiment setting. In 2006, a boycott of Danish products in several Arab countries was devastating for Danish cheese products firms. In Saudi Arabia their market share collapsed from 16.5% in January to below 1% in March and never fully recovered: by 2009 it was 6.3%. By analyzing micro-level (scanner) price and sales data, we find that (i) Danish firms lowered prices but kept the product mix the same; (ii) non-Danish firms kept prices constant but changed their product mix by introducing new products and new product bundles; and (iii) non-Danish firms chose to introduce products that were similar to the Danish in characteristic space in order to compete head-to-head. We complement the analysis with a theoretical framework that helps to account for our main findings.

Keywords: Boycotts, multi-product firms, demand shock, Saudi Arabia

JEL Code: F11, F16, L2, I24, J24

*We would like to thank Orley Ashenfelter, Cheng Chen, Daniel Westbrook, and seminar participants at various universities and conferences for helpful comments made, and Ganesh Seshan for bringing the boycott against Danish products to our attention. This research was made possible by support of an NPRP grant from the Qatar National Research Fund. The statements made herein are solely the responsibility of the authors. Contact author, Alexis Antoniades: Georgetown University in Qatar, School of Foreign Service, Education City, Doha, 23689; E-mail: aa658@georgetown.edu. Sofronis Clerides: Department of Economics, University of Cyprus, P.O. Box 20537, 1678 Nicosia, Cyprus; E-mail: s.clerides@ucy.ac.cy. Mingzhi (Jimmy) Xu: INSE at Peking University; Email: mingzhixu@nsd.pku.edu.cn.

1 Introduction

A fundamental question in economics is how firms respond to shocks. The answer is important because how firms respond has implications for firms themselves, for consumers, for policy makers, and for the economy in general.

Consider, for example, a positive demand shock, either aggregate or firm-specific. Firms can respond by adjusting prices, either directly through changes in regular prices or indirectly through changes in the frequency and the depth of promotions, including non-price promotions. Prices can increase during periods of peak demand as traditional competitive equilibrium models predict, or decrease as other competing models suggest.[1] Indeed, some evidence suggests that prices either may not rise or may even fall during such periods. Warner and Barsky (1995), MacDonald (2000), Chevalier et al. (2003), and Nevo and Hatzitaskos (2005) show that prices fall during periods of anticipated demand shocks for grocery products in the US. Perrone (2016) finds that ice cream prices do not rise during unanticipated positive demand shocks arising from high temperatures. Gagnon and Lopez-Salido (2019) find surprisingly small responses in the prices of retail products during periods of unanticipated demand shocks, such as labor conflicts and mass population displacement episodes.

The rigidity of prices with respect to both anticipated and unanticipated demand shocks may be due to the existence of other important channels by which market adjustments take place, such as changes in product mix (also referred to as product scope or product assortment). A large literature on multi-product firms documents that adjustments at the extensive margin (changes in sales attributed to the entry and exit of new products) can be at least as important as changes in the intensive margin (changes in sales attributed to goods that exist before and after shocks).[2]

When firms choose to alter their product mix in response to shocks, they have to decide on the type, number, and quality of new varieties to introduce. They must then decide whether to compete "head-to-head" with competitors by introducing identical products or to "fill in the blanks"by introducing differentiated products. They must also choose which products to drop, what the cannibalization effects may be between newly introduced varieties and existing ones, and what prices to set not only for new varieties but also for existing ones. Complicating things further, these decisions may potentially differ for single- versus multi-product firms, for premium-brand versus second-tier manufacturers, and for shocks that are temporary versus permanent,

[1]Models that predict countercyclical prices include those with cyclical demand elasticities that come from economies of scale in search costs (Bils (1989) and Warner and Barsky (1995)), countercyclical collusion models (Rotemberg and Saloner (1986); Borenstein and Shepard (1993); Bernheim and Whinston (1990)), and loss-leader advertising models (Lal and Matutes (1994); Hosken et al. (2000); Chevalier et al. (2003)). Chevalier et al. (2003) provide a nice overview of these three classes of models.

[2]Bernard et al. (2010) find that product adding and dropping is associated with changes in the firm size of multi-product firms. The same authors (Bernard et al. (2011)) also show that product switching within these firms explains a third of the total increase in real US manufacturing shipments between 1972 and 1997. Similarly, Copeland et al. (2011) study prices of new cars in the US and find that production decisions and promotions offer companies a more significant tool for adjusting to changes in demand than (regular) prices.

anticipated versus unanticipated, demand- versus supply-specific, and positive versus negative.[3]

Understanding the multiple ways in which firms respond to shocks is important but not easy. While a variety of studies have looked into each one of these potential responses in isolation and yielded very valuable insights, less work has been done to document the multi-dimensional response of firms to shocks, and even less on the response of their competitors.[4]

Our study aims to fill this void by exploiting a natural experiment setting where a large, unanticipated demand shock hits a subset of firms in a market. Our rich data covering a five-year period allow us to explore in detail the short- and medium-run responses of different market participants.

On January 26, 2006, imams in Saudi Arabia called for a boycott on Danish products during Friday prayers. The reason was the publication of 12 cartoons depicting the prophet Muhammad by *Jyllands-Posten*, Denmark's largest newspaper, which caused outrage among Muslims. Within a week, the call for a boycott had spread to more than 10 Arab countries. Dairy products became a focal point of the boycott campaign because they are Denmark's main export to the Gulf countries.[5] Most large retailers caved to public pressure and joined the boycott, removing Danish products from their shelves. Images of empty supermarket shelves appeared on TVs around the world. The boycott was called off after four months, in late May 2006.

Using scanner data on cheese sales in Saudi Arabia, we first show that the boycott had an immediate and dramatic effect on Danish brands in Saudi Arabia. Their market share collapsed from 16.5% in January to below 1% during the boycott. Lost Danish sales during the boycott were entirely picked up by non-Danish brands. Danish sales recovered somewhat after the boycott was officially called off in May 2006 but never returned to their previous levels. From the end of the boycott up until December 2009 when our data end, Danish brands accounted for only 6.3% of all cheese sales, just over a third of their 18.4% share in 2005. In response to the negative demand shock, we find that Danish firms lowered prices moderately by about 5% (for about a year) but kept the product mix the same.

The adverse, substantial shift in demand away from Danish products toward non-Danish prod-

[3]For more on the response of premium- versus second-tier manufacturers, see Pauwels et al. (2004) and references therein. The authors study the impact of store brand entry on competitors and find that it benefits premium-brand manufacturers, harms second-tier manufacturers, results in an enlarged product assortment (mix), and intensifies promotional activity. For cannibalization effects associated with new product entry, see Feenstra et al. (2009), Eckel and Neary (2010), and Dhingra (2013). For quality consideration of new product entry, see Johnson and Myatt (2003) and Eckel et al. (2015).

[4]Examples include event studies that look at the stock market response to negative news such as aircraft crashes (Borenstein and Zimmerman (1988), Bosch et al. (1998), and labor strikes (De Fusco and Fuess (1991)). Other work has looked at the demand effects of negative events: Crafton et al. (1981) and Reilly and Hoffer (1983) examined the effect of automobile recalls on automobile demand, and Freedman et al. (2012) studied the effects of toy recalls on demand for the affected firm's other products. Also related is work by Cawley and Rizzo (2008) that studies the spillover effects of prescription drug withdrawals.

[5]Cheese and curd accounted for almost half of the Danish exports to the Gulf Cooperation Council countries in 2005 (UN COMTRADE). The Gulf Cooperation Council (GCC) countries are Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates. Of these, Saudi Arabia is by far the biggest economy. It accounts for about 84%, 70%, and 50% of the total land, population, and GDP of the GCC.

ucts provides a perfect setting for studying how the non-Danish firms responded to the unanticipated positive demand shock brought about by the boycott. In particular, we are able to examine pricing responses, promotional activity, and changes in their product mix as they seek to capture market share.

To help motivate our analysis and interpret the results, we first build a micro-founded theory of multi-product firms. The model, based on Hottman et al. (2016) and Feenstra et al. (forthcoming), allows us to consider how heterogeneous firms adjust prices and product variety in response to changes in demand, while taking into account potential cannibalization effects on sales of existing products from lowering prices of other products, introducing new varieties, or doing both. Specifically, under some fairly standard assumptions, we show that a positive demand shock has a positive impact on prices and product variety in large firms but a negative impact in small firms. Most importantly, we show that when the cost of introducing new products is high, a demand shock is transmitted through prices. However, when this cost is low, price response is significantly muted as the adjustment can now take place though changes in the product mix (the extensive margin).

Indeed, our analysis confirms the predictions of the model. We find that in contrast to Danish firms, non-Danish firms kept regular prices constant but altered the product mix substantially both during and after the boycott by introducing new varieties (barcodes) and new promotional bundles. Changes in the extensive margin were more pronounced in the case of large firms. The finding that the increase in non-Danish sales came almost entirely from the extensive margin is important. As we highlighted earlier, a large literature consistently concludes that prices do not respond to demand shocks. We confirm this here as well and attribute the finding to the ability of (non-Danish) brands to expand their product scope.

Given the substantial product entry we document in the response of non-Danish firms, we proceed to examine in more detail the characteristics of these new varieties. Are these new varieties (barcodes) different products or a repackaging of existing products into new promotional bundles? For the barcodes that represent new products, did the non-Danish brands choose to introduce products identical to the Danish product line (same package type, weight, and description), or did they introduce similar but not identical products? Following the convention in the marketing literature, we refer to the former as head-to-head competition and the latter as fill-in-the-blanks competition.

We find that while a significant number of these new barcodes represented new promotional bundles of existing products, especially immediately after the end of the boycott, the vast majority represented genuinely new products. Moreover for these new products, we find that the non-Danish firms chose to directly compete with Danish brands by introducing predominately identical, rather than similar, products.

The remainder of the paper is organized as follows. In Section 2 we present some background information on the boycott against Danish products, and in Section 3 we describe the market for

cheese products in Saudi Arabia and the data we are using. Section 4 documents the impact of the boycott on sales and then proceeds to discuss the impact on prices, promotions, and product mix for both Danish and non-Danish firms. We rationalize the empirical findings by introducing a simple model of multi-product firms in Section 5. Section 6 offers an interpretation of our results and concludes.

2 The Boycott

On September 30, 2005, *Jyllands-Posten*, Denmark's largest newspaper, printed 12 drawings depicting the Prophet Muhammad. Danish Muslim groups called the depiction of the Prophet in cartoons blasphemous and protested against the *Jyllands-Posten* publications. The debate between those who supported freedom of speech and those who supported respect for religion went global when the cartoons were reprinted in various publications in more than 50 countries in early 2006.

On January 26, 2006, Saudi Arabia recalled its ambassador from Denmark and initiated a boycott of Danish products. The call for the boycott was spearheaded by the imams during the Friday prayers. Within a week, the boycott had spread to Iraq, Yemen, Syria, Palestine, Bahrain, Qatar, the United Arab Emirates, Jordan, Algeria, Morocco, Tunisia, and Oman. On January 28, the Denmark-based Arla Dairy Group placed advertisements in Middle Eastern newspapers in an effort to stop the boycott of its products. Two days later, the European Union trade commissioner threatened to take the issue to the World Trade Organization if the boycott persisted. The next day, Saudi hospitals refused to buy Danish insulin. In the days that followed, violence broke out in many regions, including Syria, Lebanon, Pakistan, Iran, and Gaza, where the Danish embassies were set on fire. It is believed that more than 140 people died during the violent protests. On April 24, an Al-Qaeda video of Osama Bin Laden emerged, urging Islamic nations to continue the boycott.

In response to the public outcry against Denmark, and after observing that consumers had stopped buying Danish goods, most retail outlets in Saudi Arabia joined the boycott in mid-March by removing all Danish products from their shelves. In May, Yusuf Al-Qaradawi, the most prominent Sunni religious cleric, called off the boycott. Despite the end of the boycott, a local supermarket chain decided to keep Danish products off its shelves indefinitely. This particular chain accounted for about 40% of all supermarkets in Saudi Arabia.

3 Market and Data

Our study of the impact of the boycott focuses on the market for processed cheese products in Saudi Arabia. We chose Saudi Arabia because it is a large country that was at the boycott's

epicenter. We chose processed cheese because it is the product by Danish firms with the strongest presence in Saudi grocery stores.

The data come from Nielsen and cover the years 2005-2009. The frequency is monthly, and each observation describes the total quantity of a product (barcode) sold at a retail outlet in a given month and its price on the day of the audit. Nielsen also provides information on the brand, the distributor or manufacturer, weight, package, and variant, and on whether or not the product is under a promotion. "Kraft White 240 Glass Jar Blue" and "Lavachequirit White 240 Glass Jar Blue" are descriptions of two such barcodes. We eliminated extreme price movements by dropping observations where the monthly price change is above +300% or below -75%.[6]

We also have information on outlets. Each outlet is classified as supermarket, large grocery, small grocery, or mini-market/self-service, based on size. We can identify outlets belonging to the same chain and the region where each operates. The majority of the chains are local, but international retailers such as Carrefour also operate in Saudi Arabia. There is substantial outlet churning, especially among the smaller outlets; only 352 out of 1,795 outlets are in the sample in all months between January of 2005 and December 2009.[7] Most of our analysis will utilize a balanced set of outlets (those present in the sample throughout) to ensure that our results are not driven by entry and exit of outlets. In cases where the entire sample is used, it is stated explicitly.

Table 1: Descriptive Statistics for the Market of Cheese Products in SA: 2005-2009

Year	Products	Brands	Suppliers	Outlets	Chains	Channels	Regions
2005	550	68	28	334	6	4	4
2006	539	60	27	334	6	4	4
2007	670	71	28	334	6	4	4
2008	718	73	28	334	6	4	4
2009	699	63	27	334	6	4	4

Table 1 presents descriptive statistics for the balanced data. In 2005,550 cheese products (EAN codes) were sold in Saudi Arabia. These products belonged to 68 brands and 28 distributors or manufacturers. Over time the number of products increased, the number of brands dropped slightly, and the number of distributors/manufacturers remained fairly constant.

[6]These thresholds are recommended by Statistics Netherlands on their work on inflation measures using monthly scanner data (De Haan and Van der Grient (2011)).

[7]A new outlet entry in the dataset does not imply that the outlet is newly established. While this may be one reason, another reason may be that Nielsen decided to include it as part of their sampling strategy or because the company just received permission to audit the outlet. Similarly, an exit could imply that the outlet went out of business, it dropped from the sample that Nielsen chooses to follow, or its management decided to stop sharing information with Nielsen. The dataset covers sales of cheese products across 1,795 retail outlets. The number of outlets is reduced to 334 when we restrict the sample to these outlets that existed in all periods. Most of the outlets dropped represent mini-markets and groceries, and account for a very small fraction of total sales.

Table 2: Market shares of product segments

Segments	2005	2006	2007	2008	2009
GLASS JAR	0.447	0.441	0.445	0.453	0.461
TRIANGLE	0.156	0.156	0.149	0.147	0.141
TIN	0.133	0.138	0.146	0.138	0.138
SQUARE	0.119	0.120	0.124	0.119	0.122
SLICES	0.103	0.108	0.106	0.108	0.111
TUB	0.021	0.017	0.016	0.015	0.014
PLASTIC JAR	0.020	0.020	0.014	0.020	0.013

Products can be divided into seven segments based on packaging: glass jar, plastic jar, slices, triangles, squares, tubes, and tin (cans). The glass jar segment is by far the largest, with about 45% of the product category (Table 2). Slices, triangles, tins, and squares have 10%-15% of the market each. Plastic jars and tubes have a market share on the order of 2% each.

Table 3: Share of Danish products within segments

Segments	2005	2006	2007	2008	2009
GLASS JAR	0.383	0.194	0.186	0.142	0.161
TUB	0.183	0.081	0.059	0.061	0.048
SQUARE	0.093	0.047	0.027	0.012	0.003
TRIANGLE	0.047	0.011	0.025	0.006	0.000
TIN	0.009	0.006	0.010	0.014	0.000
SLICES	-	0.000	0.000	0.000	0.000
PLASTIC JAR	-	-	-	-	-
Overall	0.282	0.136	0.123	0.095	0.121

Notes: A dash indicates that no Danish products are available in that segment. Segments are ordered by Danish market share in 2005.

Table 3 shows the market share of Danish firms within each segment. Danish firms are very strong in the glass jar segment, where they had 38.3% of the market in 2005. They also have a substantial presence in tubes (18.3%) and to a lesser extent in squares (9.3%) and triangles (4.7%). The existence of these segments is important because they can serve as a (quasi) control group in our analysis.

Within segment, products are standardized. There are some exceptions, such as different flavors, but the main products in each segment are observationally identical except in the brand name. For example, 19 brands offer a 500g glass jar blue cheese spread during our sample period; most of those products are not differentiated in our data except by the brand name attached to them.

Five brands belonging to four firms accounted for about 90% of sales in this market in 2005. The firms are Kraft (US), Almarai (Saudi), Arla (Denmark), and Bel (France). Kraft and Almarai market their products under their name; Arla uses the brand name Puck; and Bel has several brands, the two most important of which are La vache qui rit and Kiri. Another four firms had about 9% (1.3%-4.5% each), and the remaining 1.3% was split roughly among 50 fringe firms with under 0.2% each. Danish brands sold 68 different cheese products, accounting for 12% of all products sold and 17% of all revenue.[8] Half the brands were multi-product, in the sense that they sold multiple cheese varieties.

Finally, note that the retail market in Saudi Arabia does not seem particularly different from markets in more advanced economies. International brands, international retailers, and expat managers have a large presence. A few stores account for the majority of sales, and these stores carry more brands and more products within brands. Within product categories, a small portion of products accounts for the majority of sales, and these products for the most part tend to be foreign-branded goods.

4 The Boycott Impact on Danish Cheese Sales

We start the analysis by documenting the immediate and devastating impact that the call for a boycott had on Danish sales of cheese products in Saudi Arabia. Figure 1 plots the market share of Danish brands in the processed cheese category in all outlets included in the Nielsen survey from January 2005 to December 2009. The share of Danish products collapsed from an average of 18.4% in 2005 to 7.5% in February 2006 (the first full month of the boycott) and to less than 1% in March-April 2006 (by which point all major retailers had joined the boycott). Practically overnight, Danish brands went from dominating to vanishing.

When the boycott ended in May, there was a partial but short-lived recovery. Sales of Danish cheese products fluctuated wildly, first rebounding to nearly 15% of the market a couple of months after the boycott was called off and then falling sharply again. Evidence presented next suggests that the temporary rebound was caused by lower prices offered by Danish producers in the weeks following the end of the boycott, especially on a couple of big-volume items, perhaps in an effort to get rid of accumulated and expiring stock. From the end of 2007 until the end of our sample two years later, the market share of Danish brands stabilized at an average of 6.5%, roughly at one-third of its 2005 level.[9]

[8] Using a balanced panel of outlets, the Saudi market for cheese products in 2005 was about US $30 million. Based on data from all the outlets in our sample, as well as discussions we had with Nielsen, we estimate the total Saudi market for cheese products in 2005 to be closer to US $100 million and to have doubled in value by 2009.

[9] As far as we are aware, this is perhaps the most successful example of boycott ever documented in the literature. Most studies that analyze boycotts, including those cited earlier in the paper, find either no effects of the boycott on sales or only modest, short-term effects that dissipate with time. An exception is Hendel et al. (2017). The authors study the impact of a call for boycott against a sudden increase in cottage cheese prices in Israel and find that retailers lowered prices by 25% overnight in response to the pressure from consumers and the backlash that

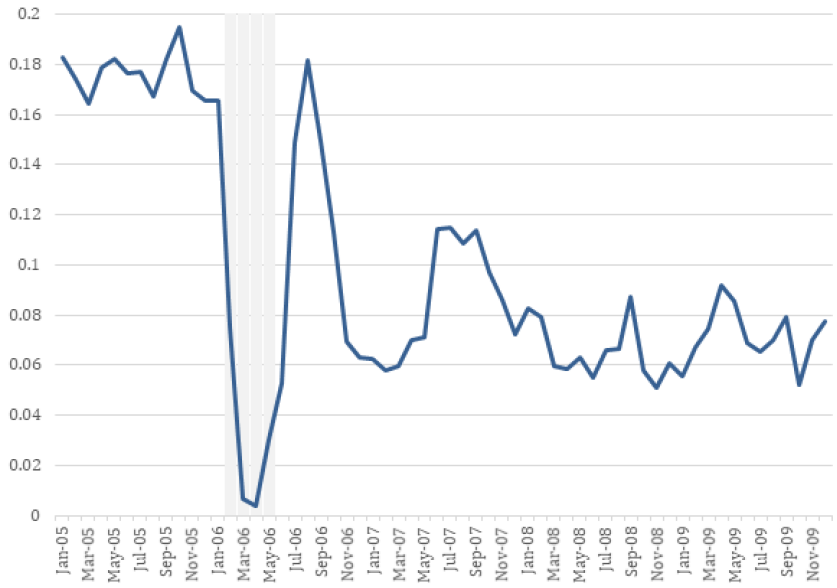


Figure 1: Market Share of Danish Cheese Products in Saudi Arabia (Jan. 2005 - Dec. 2009)

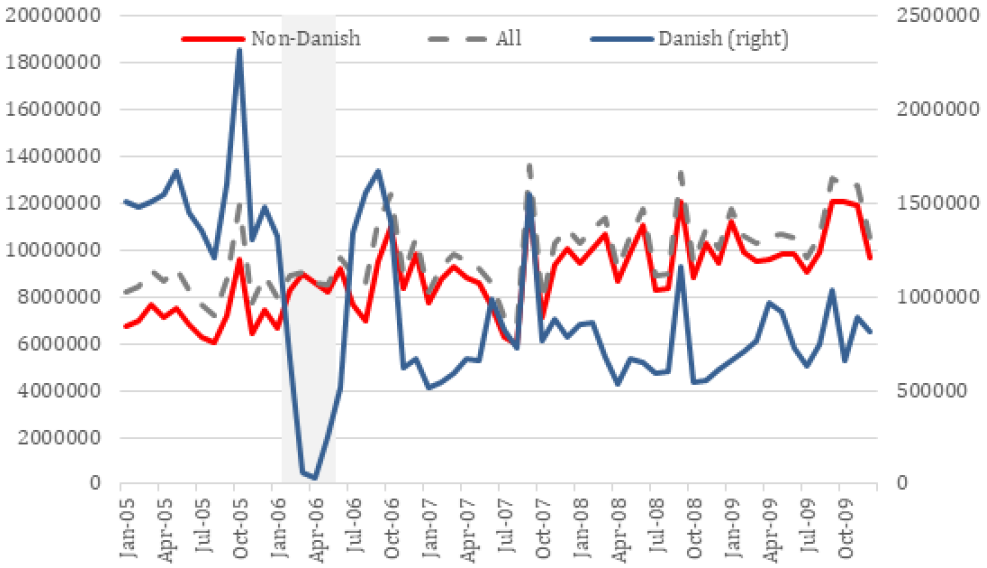


Figure 2: Category revenue by Danish/non-Danish brands

The drop in Danish market share was entirely picked up by non-Danish brands, while overall sales of cheese products in Saudi Arabia remained constant. This is shown in Figure 2 where total revenue in the processed cheese category is broken down by Danish and non-Danish brands. Annual spikes in sales correspond to the holy month of Ramadan, a period with increased demand

followed the price hike.

for groceries. Danish revenue collapsed from about 18% to almost zero during the boycott, while non-Danish revenue rose by the same magnitude. Overall, total category revenue did not deviate from its trend levels, which strongly suggests that the drop in Danish sales was picked up entirely by the non-Danish brands. Therefore, we deduce that the boycott was a zero sum game: losses for Danish firms were recouped by non-Danish firms. This is a key observation that allows us to simultaneously study the response of firms to both a negative demand shock and a positive shock by comparing and contrasting the reaction of Danish and non-Danish producers.

5 A Model of Multi-product Firms

5.1 Prices and Product Scope

To better understand the response of multi-product firms to economic shocks and to guide our subsequent analysis, we present a conceptual framework of producers and retailers where adjustments can come through prices, product scope, or both. The main ingredients of our model are similar to Feenstra et al. (forthcoming), but we differ in two important ways. First, to capture firms' response to the boycott in the short run, we assume that the measure of firms is exogenously given and fixed. Second, we extend the model by allowing for a variable fixed cost of introducing varieties to study the heterogeneous effects of demand shocks on firms' price and scope decisions.

Specifically, let $i \in I_f$ and $f \in \Omega^F$ denote the set of all firms and all varieties sold by firm f, respectively. The representative consumer has nested CES preferences over all firm products and all varieties, described by the utility function

$$U = \left[\sum_{f \in \Omega^F} \sum_{i \in I_f} (q_{fi})^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}, \tag{1}$$

where $\sigma > 1$ denotes the elasticity of substitution across varieties. For simplicity, we assume the elasticity of substitution across firms is the same as elasticity of substitution across varieties.[10]

Now consider firm f producing variety i. The firm chooses the range of goods (varieties) to produce and their prices. The profit maximization problem for this firm is

$$\max_{p_{fi}, i \in I_f} \sum_{i \in I_f} \left[(p_{fi} - c_{fi}) q_{fi} - k_{fi} \right], \tag{2}$$

where k_{fi} denotes the fixed cost of selling each variety i, and c_{fi} denotes the marginal cost (including trade cost) of selling variety i. As captured by equation (2), in addition to allowing for heterogeneous marginal costs, we also allow the fixed cost associated with introducing new prod-

[10] Our theoretical predictions remain unchanged if the elasticity of substitution across firms differs from that for varieties.

ucts to differ by variety. Finally, firms treat the prices of other firms as given under Bertrand competition.

When the firm sells multiple products, it must take into account how lowering the price of one good decreases demand for all of its other products: we call this the cannibalization effect. Denoting p^*_{fi} and N^*_f as the optimal price of product i and the number of products supplied by firm f, the first-order condition for prices suggests that[11]

$$p^*_{fi} = \left[1 + \frac{1}{(\sigma - 1)(1 - S_f)}\right] c_{fi}, \tag{3}$$

where S_f denotes the market share of firm f. When firm f jointly maximizes over all product prices, the markup p^*_{fi}/c_{fi} is positively related to firm f's market share S_f. A similar relationship is found in standard oligopoly models.

To introduce a new variety firms have to pay a fixed cost that depends on the number of existing products, that is, $\sum_{i \in I_f} k_{fi} = k_f N_f^{\delta}$. The parameter $\delta \in (0, \infty)$ captures how easy or difficult it is for a firm to introduce new products. For instance, if $\delta \in (0, 1)$, then there are increasing returns to scale technology, so it costs less for wide-scope firms to introduce an additional product.

To simplify the subsequent analysis, suppose there are symmetric marginal costs within each firm, so that the firm sells N_f varieties.[12] The profit maximization problem in (2) is simplified as[13]

$$\max_{p_f,\, N_f} N_f(p_f - c_f)q_f - k_f N_f^{\delta}. \tag{4}$$

As the firm expands the number of varieties sold, it draws demand away from existing varieties. Taking this cannibalization effect into account, we show in Appendix A1 that the optimal product scope (N^*_f) of firm f should satisfy[14]

$$(N^*_f)^{\delta} = \frac{1}{\delta}\left[\frac{S_f(1 - S_f)}{\sigma - (\sigma - 1)S_f}\right]\frac{Y}{k_f}, \tag{5}$$

where Y denotes the total expenditure. The cannibalization effect is captured by the non-linear relationship between product scope and market share (i.e., $\frac{S_f(1-S_f)}{\sigma-(\sigma-1)S_f}$).

To summarize, in equilibrium, firm f's optimal price positively depends on its market power, whereas product scope is a non-linear function of market share because of the cannibalization effect. The market share of firm f is jointly determined by the prices and product scope across all firms,

[11] Detailed derivations refer to Feenstra et al. (forthcoming) and are also provided in Appendix A1.

[12] In other words, we are assuming that $c_{fi} = c_f$ does not depend on i. Feenstra et al. (forthcoming) show that, with iceberg trade costs, the generalized model allowing a rising marginal cost of products that are further from the core-competency of the firm (i.e., c_{fi} increases in i) will generate a similar expression for the optimal scope.

[13] For simplicity, we omit subscript i since products are the same within a firm.

[14] We assume that δ is sufficiently large so that the firm's profit is concave in N_f because of cannibalization; that is, the marginal profit of an additional product decreases in N_f.

$$S_f = \frac{N_f^*(p_f^*)^{1-\sigma}}{P^{1-\sigma}}, \quad P^{1-\sigma} \equiv N_f^*(p_f^*)^{1-\sigma} + \sum_{h \neq f} N_h^*(p_h^*)^{1-\sigma}. \tag{6}$$

5.2 Pass-through of Demand Shocks

We now consider how changes in demand, captured here through the change in market size (Y), affect the equilibrium.[15] We assume that firms perceive such shocks to affect their market share only through changes in their own prices and scope, without taking into consideration the actions of other firms. We formalize this assumption below.[16]

Assumption 1: *In solving its optimization problem, the firm assumes that changes in other firms' product offerings (i.e., price and product scope) will affect its market share, but the firm will not take that into account; that is, firm f will treat N_h and p_h ($\forall h \neq f$) as exogenously given.*

Assumption 1 specifies how a firm perceives the demand shock and changes its price and scope correspondingly. However, the ultimate change in a firm's market share will certainly depend on the reaction of other firms to the shock. To exercise its market power and influence the market share, a firm can alter its product offerings (i.e., price and product scope); that is, $dP/dN_f \neq 0$ and $dP/dp_f \neq 0$, where P is the aggregate price index in (6).

To see how demand shocks affect a firm's optimal decisions, we rewrite $d\ln p_f^*$ and $d\ln N_f^*$ in terms of log changes in demand shocks under Assumption 1, which are displayed in (7) and (8) (see Appendix A2 for details):

$$d\ln p_f^* = \frac{S_f d\ln Y}{S_f \times [2\sigma - (\sigma-1)S_f] - \sigma(1-\delta)} = -\frac{S_f d\ln k_f}{S_f \times [2\sigma - (\sigma-1)S_f] - \sigma(1-\delta)} \tag{7}$$

$$d\ln N_f^* = \frac{\sigma d\ln Y}{S_f \times [2\sigma - (\sigma-1)S_f] - \sigma(1-\delta)} = -\frac{\sigma d\ln k_f}{S_f \times [2\sigma - (\sigma-1)S_f] - \sigma(1-\delta)} \tag{8}$$

As implied by the above two equations, in our model an increase in Y is equivalent to a decrease in k_f.

Proposition 1. *The impact of demand shocks on firms' product offerings depends on the technology of introducing new goods:*

Case (i): when the technology exhibits non-increasing returns to scale (i.e., $\delta \in [1, \infty)$), positive demand shocks lead firms to increase both product prices and the number of products.

[15] We note that in the model, an increase in market size is equivalent to a decrease in the fixed cost of introducing new products (k_f).

[16] The assumption is quite feasible in our analysis, as firms may not have enough time or information to carefully react to the unexpected demand shock (e.g., the boycott incident).

Case (ii): when the technology exhibits increasing returns to scale (i.e., $\delta \in (0,1)$), positive demand shocks raise both prices and the product scope for large firms but decrease both of these measures for small firms, where the cutoff market share ($\tilde{S}$) to distinguish small from large firms is defined by

$$\tilde{S} \times [2\sigma - (\sigma - 1)\tilde{S}] = \sigma(1 - \delta).$$

As implied by Proposition 1, when the marginal fixed cost decreases with respect to firm scope, an expansion in market size benefits large firms more because of increasing returns to scale. That is, the cost advantage from scope expansion will partially cancel out the loss associated with losing (cannibalizing) revenue. Such an advantage will particularly benefit firms of wide scope.[17]

A positive demand shock, either an increase in Y or a decrease in k_f, will raise prices and the number of varieties for large firms. However, the relative adjustment of price (to product scope) will depend on how easy a firm is able to expand its scope. Hereafter, we discuss the pass-through of demand shocks to various firm variables in case of $\delta \in (0,1)$ (i.e., an increasing returns to scale (IRS) technology for firms to introduce new products).

Proposition 2. *Assuming that firms selling more products also have higher sales, a change in demand raises prices more when the cost of introducing new products (the placement fee) is high. That is, $\left(d\ln p_f^*/d\ln Y\right) / \left(d\ln N_f^*/d\ln Y\right)$ increases with k_f.*

The proof of Proposition 2 is in Appendix A4. The condition in Proposition 2 that firms selling more products also have bigger total sales is not trivial because of the cannibalization effect, though it is the case on average in the data. Proposition 2 implies that the price response becomes more muted when it becomes easier to expand scope, regardless of the type of technology used in introducing new goods.

As we have discussed in Proposition 1, the increasing returns to scale (i.e., $\delta \in (0,1)$) drives the heterogeneous response to demand shocks across firms, which also reconciles with our findings empirically. In Proposition 3, we summarize in detail how the increasing returns to scale technology affects firms' adjustments in prices, scope, and market share.

Proposition 3. *When the technology is IRS (i.e., $\delta \in (0,1)$), large firms raise their price and scope in response to positive demand shocks, whereas small firms lower both (for a definition of large and small firms, see Proposition 1). Particularly, among large firms:*

(a) product scope adjustment decreases in firm size (i.e., $\left|d\ln N_f^*/d\ln Y\right|$ decreases with S_f).

(b) the relationship between price adjustment (i.e.,$\left|d\ln p_f^*/d\ln Y\right|$) and firm size depends on the degree of IRS: bigger-sized firms raise prices less in case of strong IRS (i.e., small value of δ), whereas they would increase prices more if IRS is weak (i.e., big value of δ).

[17] The proof of Proposition 1 is provided in Appendix A3.

(c) in the case that the least impacted group consists of small firms (i.e., the market share barely changes before and after the shock),[18] *the market share of large firms increases and the rise in market share diminishes with firm size; that is, a smaller-sized large firm grows more than a bigger-sized large firm after the positive shock.*

The proof of part (a) in Proposition 3 follows (7) in that $d\ln N_f^*/d\ln Y > 0$ for large firms (i.e., Proposition 1) and $d\ln N_f^*/d\ln Y$ decreases with S_f. The proofs of (b) and (c) are in Appendix A5. Proposition 3 shows that there is heterogeneous pass-through of demand shocks to prices, the product scope, and the market share across small and big firms. The positive demand shock will lead big firms to introduce more varieties and increase their market share if small firms barely change after the shock.

6 Analysis

We now proceed to examine in more detail the impact of the boycott on Danish and non-Danish firms by utilizing the richness of the scanner data. First, we study the impact of the boycott on prices, then on promotional activity, and finally on entry and exit of products and firms. Next, focusing only on non-Danish firms, we consider whether the response of small versus large firms was any different, as the model would have predicted. Finally, we examine the newly introduced products in order to shed more light on their characteristics.

6.1 Prices

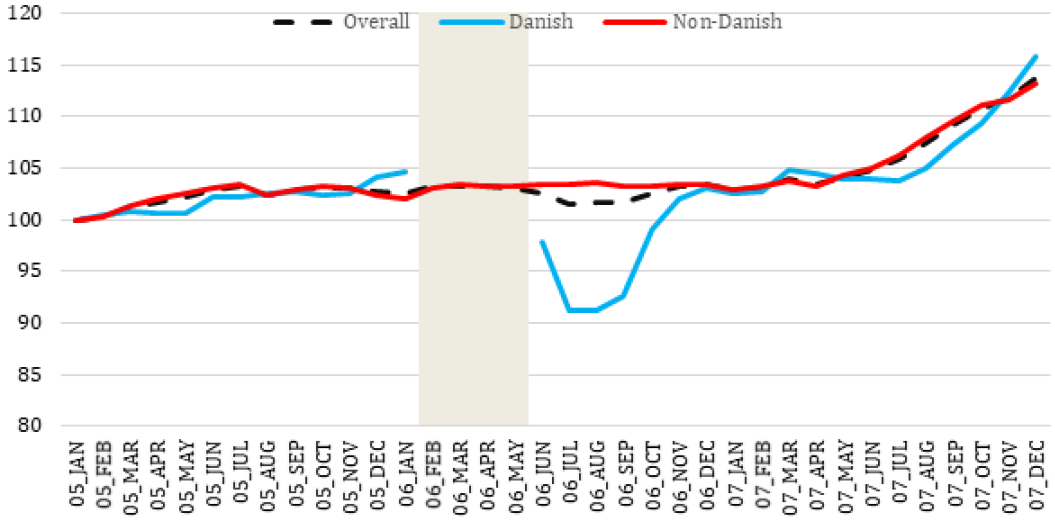


Figure 3: Price index for cheese products: varying weights as per sales in each month

[18]The cutoff market share ($\tilde{S}$) to distinguish small from large firms refers to Proposition 1.

As in the case of any shock, changes in the overall price level can come from multiple sources: changes in reference prices, changes in the composition of the basket, substitution away from some goods, and promotions.

To understand what happened to prices and investigate the impact of these sources, we first compute a simple price index of cheese products in Saudi Arabia that fixes the expenditure shares based on pre-boycott, 2005 sales. Let p_{ist} be the price per kilogram of cheese product i sold in store s at time t. The price index at time t is

$$P_t = \sum_{i,s} w_{is,2005} * p_{ist}$$

where $w_{is,2005}$ are expenditure weights, computed based on 2005 sales.[19]

Figure 3 depicts the price index (i) for all cheese products, (ii) for Danish, and (iii) for non-Danish each month between January 2005 and December 2007. Prices are normalized to 100 in the beginning of the period and omitted for Danish goods during the boycott.

As the figure shows, the overall price level of cheese products did not change much during the boycott, and was similar to that of the preceding months. In the months following the lifting of the boycott, however, a clear pattern emerges: Danish firms lowered prices by as much as 8%, while non-Danish firms kept prices constant. As a result, there was a decline of about 2% in the overall price index following the end of the boycott.

By keeping weights constant, the price index calculated above accurately captures changes in prices of goods that existed in 2005 but does not account for changes in the true cost of cheese products. This is because a price index using fixed weights does not account for changes that may have resulted from anticipated entry and exit of new products and promotional bundles (the extensive margin) or from substitution away from Danish goods as the economy adjusted to the shock.

To account for these discrepancies, we recalculate the price index, but this time we let the weights vary in each period t based on the expenditure share of each product during that period. The results, which are plotted in Figure 4, show an even larger drop in Danish prices (exceeding 10% in one month). Non-Danish prices during the boycott seem to have somewhat declined during the boycott.

The fact that the indexes are very similar whether fixed or varying weights are used suggests that (1) consumers were switching from Danish cheese products to other premium-brand cheese products of similar prices and not to cheaper substitutes from second-tier brands, and (2) new entrants that resulted from market adjustments to the boycott were priced similarly to current products or the products they replaced.

[19]The results are identical if expenditure shares are computed based on sales averaged across 2005, 2006, and 2007, instead of just 2005.

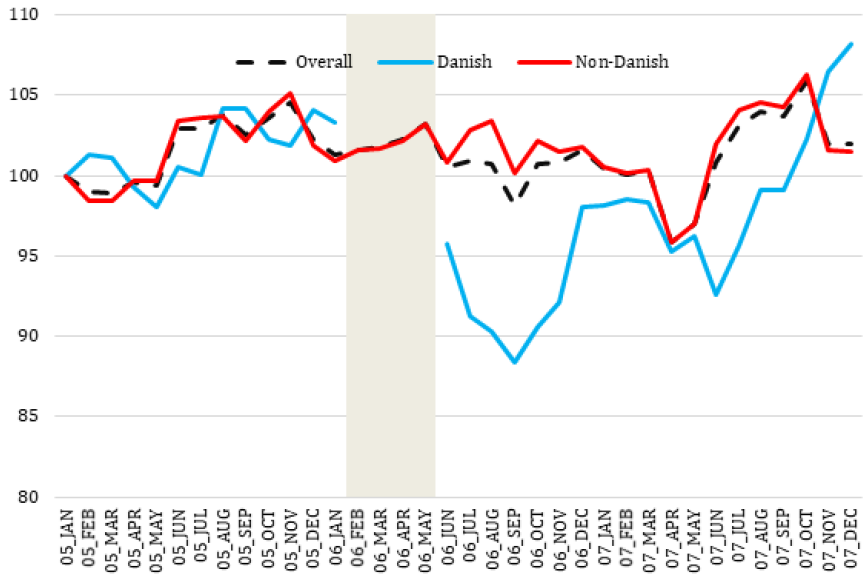


Figure 4: Price index for cheese products: fixed weights as per 2005 sales

Overall, and consistent with a large body of work, we fail to find evidence of price increases in response to an increase in demand (as in the case of non-Danish producers).[20] But we do find evidence of non-trivial price decreases in response to a drop in demand (as in the case of Danish producers), at least in the short run.

6.2 Promotions

Promotions are an important component of supermarket pricing behavior that has received great attention over the years.[21] Firms are often reluctant to decrease the regular price of their products as it might signal to consumers a drop in quality and may cause consumers to perceive a subsequent price increase as unfair. Therefore, firms rely more on promotions as a means of price discrimination and to draw more consumers into their stores.

[20] In their seminal paper, Chevalier et al. (2003) use scanner data from a large supermarket chain in the Chicago area to study the response of prices to periods of (anticipated) peak demand. Using an index with varying weights in each period, they find that "in general, prices tend to be lower rather than higher during periods of peak demand." The authors argue that their results are consistent with loss-leader models in which positive shifts in demand trigger price reductions as the reach and impact of promotions and sales are higher during those times. Using the same data but an index with fixed weights, Nevo and Hatzitaskos (2005) confirm that prices tend to be lower during periods of peak demand. However, the authors argue that the observed drop in prices is not driven by actual price reductions but rather by the substitution effect: a relative increase in the demand for cheaper products during those times (e.g., a spike in the demand for cheaper tuna used during Lent to make traditional casserole dishes or tuna salads). They conclude that the loss-leader model is not supported by their results.

[21] The marketing literature has been interested in promotions for a long time. Industrial organization economists started paying attention in the 2000s (Hendel and Nevo (2006a) and Hendel and Nevo (2006b)), and macroeconomists followed thereafter.

Promotions take the form of temporary price cuts (price promotions) or other special offers that are typically initiated by the manufacturer (non-price promotions) and must have a different barcode. Examples of non-price promotions include the following:

(1) promotion bundle: for example, Kraft cheddar glass jar gold 500mg x 2+ Kraft cheddar glass jar blue 140mg,

(2) promotion free: for example, Kraft cheddar glass jar gold 500mg + Kraft 113mg tin free,

(3) promotion price: for example, Kraft cheddar glass jar gold 500mg 10% off special price,

(4) promotion same: for example, Kraft cheddar glass jar gold 500mg + 100mg free,

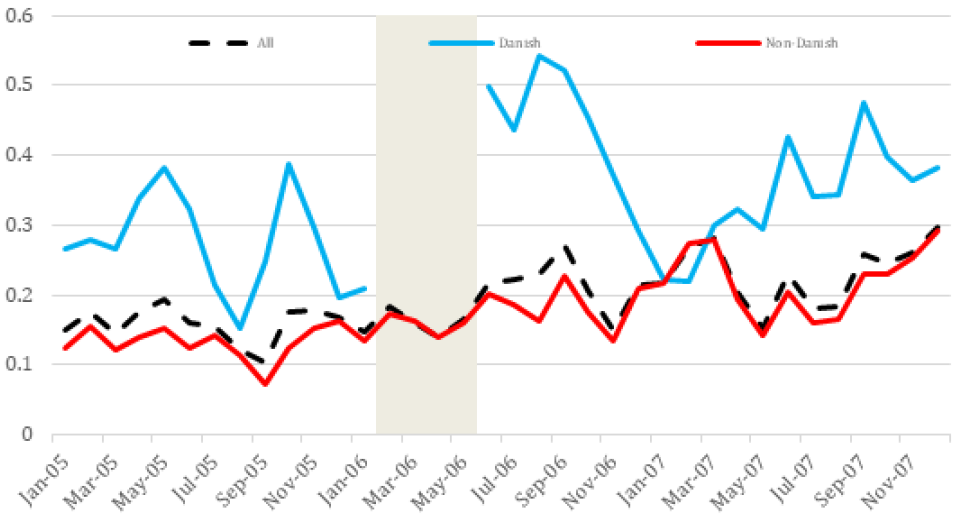
(5) promotion unit: for example, Kraft cheddar glass jar gold 500mg x 2,

(6) promotion volume: for example, Kraft cheddar glass jar gold 500mg + 20% extra.

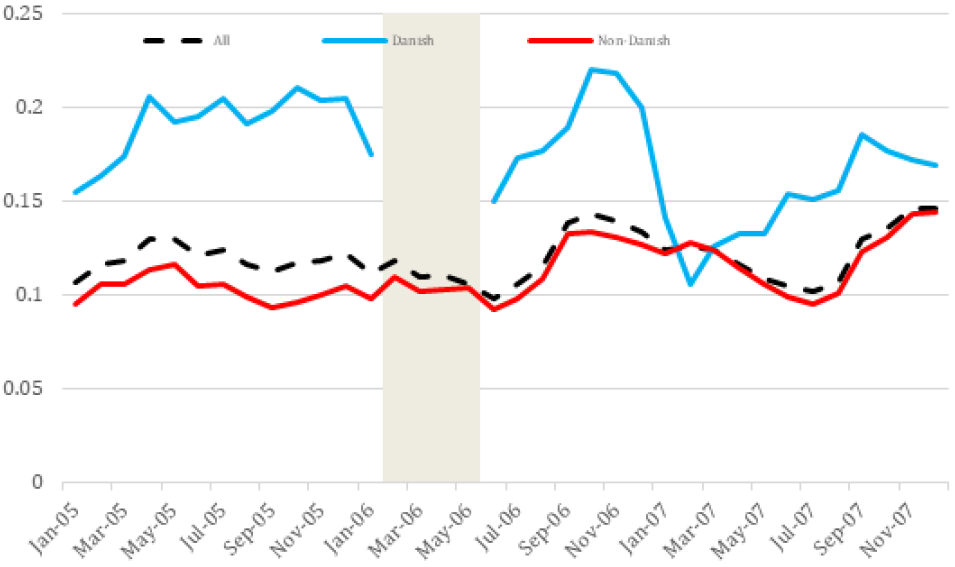
In Figure 5, panel (a), we compute the share of sales that came from promoted products, and in panel (b) the percentage of products (barcodes) that are promoted each month. Information on promotions in the dataset is provided by Nielsen through a variable that flags non-price promotions. Information on price promotions is obtained through an algorithm that flags a V-shaped price pattern in the price series.[22]

According to Figure 5, panels (a) and (b), promotions (dotted black line) accounted for about 18%-20% of total cheese sales, with about 12% of all items on the shelves being promotions. When the boycott ended, promotional activity for non-Danish firms (red line) and Danish firms (blue line) increased, although the increase in sales coming from promotions was substantially larger for Danish relative to non-Danish firms. Following the end of the boycott, sales from promoted products more than doubled for Danish brands. Surprisingly, the number of promotions offered by these brands as a share of total products available did not increase. For example, in June 2006, about 15% of all Danish barcodes represented promoted goods (Figure 5(b)), while sales from these promotions accounted for 53% of total Danish sales (Figure 5(a)). A year prior to that, promoted goods accounted for 20% of all Danish products but accounted for only 30% in sales. We investigated further and found that the Danish cheese producers did not increase the number of promotions, but rather they strategically offered non-price promotions on their best sellers. These items were not frequently promoted before. So while the number of promotions did not increase substantially, sales from promotions contributed to more than half of overall sales.

[22]For more information on the price sale filter, see Klenow and Kryvtsov (2008) and Nakamura and Steinsson (2008).



(a) As percentage of total sales



(b) As percentage of total products

Figure 5: Promotions

6.3 Intra-firm Adjustments

In our sample, the vast majority of cheese sales come from multi-product firms (MPFs). The top five brands, all multi-product, account for about 90% of sales. The prevalence of MPFs is consistent with broader evidence in the literature that also finds that product switching within firms is a far more important channel for adjustments than entry and exit of firms.[23]

[23] Bernard et al. (2011) use US data from 1972 to 1997 to show that multi-product firms (MPFs) are very common and important: they comprise 41% of all firms in the manufacturing sector, and they account for 91% of output. They also show that intra-firm product switching explains a third of the total increase in real US manufacturing

Given the muted response of prices we observed so far and the evidence in the literature on the importance of intra-firm adjustments, we proceed next to examine the impact of the boycott on the product mix of firms. Following Broda and Weinstein (2010), we break down total sales growth between two periods into sales of products that survive and products that are new or disappear. Specifically,

$$\underbrace{\frac{V_t - V_s}{V_s}}_{\text{Total growth}} \equiv \underbrace{\frac{C_t - C_s}{V_s}}_{\text{Common products growth}} - \underbrace{\frac{D_s}{V_s}}_{\text{Destruction}} + \underbrace{\frac{N_t}{V_s}}_{\text{Creation}}$$

where V_t and V_s measure total sales in periods t and s, respectively. The variables C_t and C_s measure total sales in periods t and s of products that are common in both periods.The variable D_s measures total sales of products that existed in period s but disappeared in period t, and N_t measures sales of new products that appear in period t but not in period s. We also define the intensive and extensive margins of growth as

$$\text{Intensive} = \text{Common Products Growth}$$

$$\text{Extensive} = \text{Creation} - \text{Destruction}$$

The intensive margin accounts for the share of growth that is driven by growth in sales of products that existed in both periods. The extensive margin accounts for the share of growth that is driven by the creation of new products, after taking into account losses in sales of products that exit the market.

We first compute the growth in total sales of Danish and non-Danish brands between 2005 and 2006. Then we decompose the growth into intensive and extensive margins based on the formulas above. We also extend the analysis by looking at two-, three-, and four-year horizons. The results are shown in Table 4, panel (i).

When we look at the table, we see that intra-brand adjustments for the brands that experienced a negative (Danish) and a positive (non-Danish) demand shock took place at opposite margins. The drop in sales of Danish brands in 2006 (43%) is explained mainly by the intensive margin (35%), whereas gains by non-Danish brands (21%) are explained by the extensive margin (15%). The decomposition suggests that Danish brands continued to sell the same products, but revenue

shipments during that period. Similarly, Goldberg et al. (2010), using detailed firm-level Indian data, find that MPFs tend to be larger, more productive, and more likely to export. Broda and Weinstein (2010), using scanner data similar to ours, find that 46% of the products in their sample in 1999 disappeared by 2003, while 50% of the products in 2003 did not exist in 1999. For theoretical models on MPFs, see Allanson and Montagna (2005); Eckel and Neary (2010); Bernard et al. (2010, 2011); Nocke and Yeaple (2014); Macedoni and Xu (2018); Feenstra et al. (forthcoming); and references within. Many of these authors study the response of MPFs to globalization, where both market size effects and competition effects are combined, and it is difficult to separate or distinguish them. Our work complements this literature by considering the response of MPFs to a pure demand shock.

per product dropped as a result of the boycott. In contrast, non-Danish brands expanded their product mix in order to fill the void left by the change in preferences against Danish products and to attract new customers. In other words, the positive demand shock affected the product mix of firms (intra-firm adjustments) and not prices. The conclusions remain the same whether we look at two or three years ahead.

Table 4: Sales Growth Decomposed into Intensive and Extensive Margins by Brand Type

	Danish			Non-Danish		
Year	Total	Intensive	Extensive	Total	Intensive	Extensive
(i) Product definition = barcode						
2005-2006	-0.43	-0.35	-0.08	0.21	0.05	0.15
2005-2007	-0.47	-0.48	0.02	0.19	-0.06	0.25
2005-2008	-0.54	-0.47	-0.06	0.37	-0.08	0.45
2005-2009	-0.47	-0.41	-0.06	0.46	-0.06	0.52
(ii) Product definition = brand + weight + package type						
2005-2006	-0.44	-0.39	-0.04	0.20	0.16	0.05
2005-2007	-0.48	-0.45	-0.03	0.19	0.05	0.14
2005-2008	-0.54	-0.44	-0.10	0.37	0.09	0.28
2005-2009	-0.48	-0.33	-0.14	0.45	0.08	0.37

It is also worth noticing that we find strong evidence of cannibalization generated by the entry of new products by firms. This is shown by the -6%, -8%, and -6% growth on the intensive margin for non-Danish firms between 2005 and 2007, 2008, 2009, respectively.

6.4 Firm Size, Prices, and Product Entry

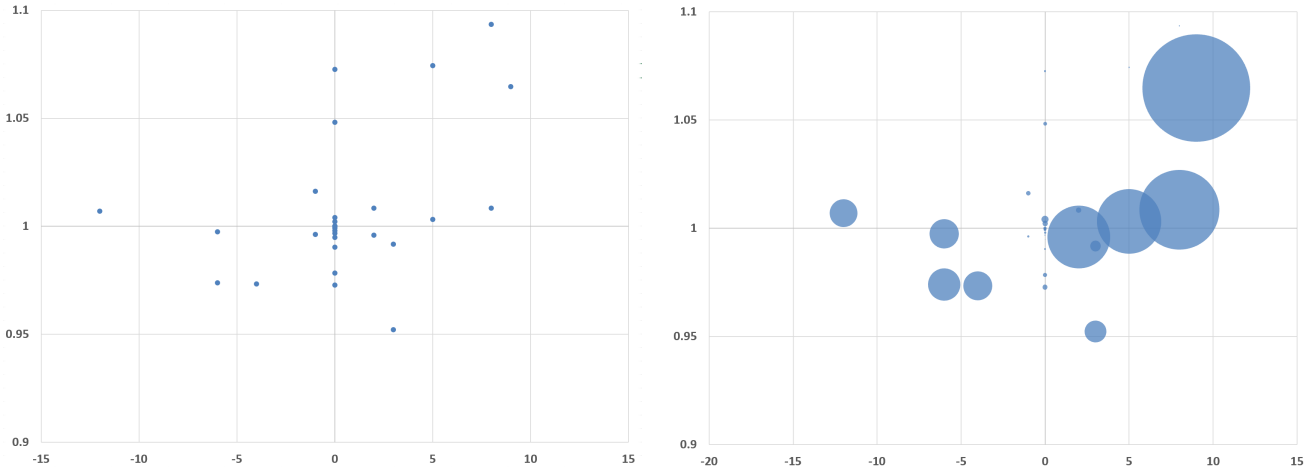
So far we have dealt with all non-Danish firms as a homogeneous group and studied the response of the group in terms of prices, promotions, and changes in the product mix. Here, we delve deeper into this group by documenting heterogeneity in the response and success of these firms, and especially between premium-brand versus second-tier manufacturers.

A key observation from analyzing the growth in sales before and after the boycott by firm size is that while non-Danish firms as a group gained from the boycott, not all firms benefited.[24] We believe that differences in performance observed can be explained by the fact that consumers switched away from Danish brands - considered premium brands – primarily toward the other four or five premium brands but not toward second-tier brands. However, few second-tier brands responded by adding more varieties, hence creating a tougher operating environment for them

[24]The evidence is displayed in Figure A.1.

post-boycott. That is, the boycott resulted in fewer varieties, less competition, and more demand at the premium-brand level, but more varieties, more competition, and the same demand at the second-tier brand level. We study product entry and competition in the next section.

The diversity of responses to the boycott, especially for second-tier brands, can be seen in Figure 6. Each point on the figure identifies a brand. On the horizontal axis we measure the percentage change in the number of products offered by each brand between January 2006 and January 2007. On the vertical axis we measure the percentage price change in the basket of products that each brand sold in both periods. In the right panel, we repeat the analysis, but this time we use the size of the circle to proxy for the size of each brand based on January 2006 sales. Consistent with the theory presented above, we find that small firms lowered prices, but large firms both raised prices and increased the number of varieties. We consider this a key empirical finding of this paper.



(a) Number of products

(b) Prices

Figure 6: Brand strategies: changes in products and price

The findings seem to corroborate the theoretical implications of the conceptual framework presented above: positive demand shocks raise prices and product scope (variety) for large firms but lower these measures for small firms. Furthermore, as we have seen in the subsection above, most of the reaction came through the extensive margin and not through prices, which is consistent with the model predictions if we assume that the cost of introducing new products by cheese brands diminishes as the number of existing products increases.

6.5 Product Entry Characteristics

We have documented that the boycott against Danish cheese products in Saudi Arabia resulted in higher sales for non-Danish brands and that the majority of these added sales came from the introduction of new products, the so-called extensive margin.[25]

[25]While we consider non-Danish firms as a homogeneous group, within the group there were winners and losers, especially among small brands. In the online appendix, we explain the reasons behind this. We find that consumers

Of interest, then, is to examine the characteristics of these new products. In particular, we want to know (i) whether these new products (barcodes) are genuinely new products or reintroductions of existing ones but in new promotional bundles, and (ii) whether competitors chose to introduce products to compete directly with Danish firms or chose products that were similar but not identical. Following the convention in the marketing literature, we refer to the former case as head-to-head competition and the latter as fill-in-the-blanks. For example, a Danish product with high sales before the boycott contained the following product description "240 gram GLS (glass jar) Blue."As the boycott takes place and non-Danish firms considered what new products to introduce, our data allow us to examine whether these firms chose to offer consumers the exact same product (240 gram GLS Blue) or something similar (e.g., 240 gram GLS Gold or 150 gram GLS Blue).

(i) Promotional bundles

So far, and consistent with existing work on scanner data, we considered each barcode to be a unique product. But not all new barcodes represent a new product variety. For example, Kraft may offer a 500mg blue cheese and a 200mg gold cheese in period 1, and then again offer these two products in period 2 but also with a promotional bundle combining these two products (e.g., 500mg blue + 200mg gold free). This new bundle will carry a unique barcode and will appear as a new product entry in our analysis above.

Because an important aspect of our investigation is to better understand growth at the extensive margin, we proceed to distinguish between growth that comes from new barcodes and growth from genuinely new products. Therefore, here we use a more restrictive definition of what a new product is. Specifically, to count as a new product, a barcode must have a brand-weight-package triplet that did not exist before. For example, "Kraft 500mg blue + 200mg gold free" or any other promotional bundle combinations of Kraft 500 will not count as new products as long as Kraft 500mg existed before. Note that this strict definition of product variety will understate new products as it will not flag various new flavors as new products (e.g., Kraft 500 light cheese).

The results from the strict definition of what a new product is are reported in Table 4, panel (ii). Even with the stricter definition of what counts as a new product, we still conclude that for non-Danish firms, growth in sales after the boycott happened at the extensive margin. Hence, our results are not driven by the way we define a new product.

switched away from Danish cheese products and toward other premium-branded cheese products. This benefited the premium-brands competitors. But small brands also tried to benefit by introducing new products and, some, by raising prices. However, overall cheese sales among fringe brands did not increase much, while competition was now tougher because of the substantial product entry in that segment. Fringe brands that raised prices were therefore punished by the market, and all suffered from fragmented sales.

(ii) "Head-to-head" versus "fill-in-the-blank" competition

We can investigate competition in a couple of ways, and both ways lead to the conclusion that firms chose to compete head-to-head. First, we counted the number of cheese brands and products in 2005 and then again in 2007 for each of the six cheese subcategories. This is shown in Table 5. According to the table, the JAR subcategory (which combines both glass and plastic jars), where the Danish brands had the highest market share pre-boycott, attracted the highest entry of both brands and products. Therefore, we conclude that entry was not randomly placed within the cheese category but specifically targeted the subcategory of cheeses where the Danish had significant presence.

Another way to illustrate the same finding is to allocate cheese products between two categories: those varieties that are identical to Danish cheese products sold in 2005 and those that are not. First, we create a triplet of weight, package type, and variant such as blue, gold, and low. For example, "Glass Jar .24 gold," "Glass Jar .24 blue," and "Glass Jar 0.24 low" are three such product triplets. In total, all of the 328 cheese products sold in Saudi Arabia in 2005 belonged to 105 such distinct triplets.

Table 5: Brands and items by segment, 2005-2007

Segment	Category share	Danish share	Brands		Items	
	2005	2005	2005	2007	2005	2007
JAR	0.466	0.348	16	28	186	294
TUBE	0.020	0.175	9	8	27	22
SQUARE	0.122	0.095	5	6	33	46
TRIANGLE	0.151	0.043	47	51	113	138
TIN	0.142	0.007	9	12	60	80
SLICES	0.099	0.000	16	20	106	137

Next, we flag the product triplets sold by Danish firms in 2005 and call this the Danish product space pre-boycott. Out of the 105 product triplets, Danish firms in 2005 sold cheese products in only 24 of these triplets.

Finally, we count the total varieties in the Danish product space in 2005 and 2007 and compare that number with the number of varieties outside the Danish product space. The results are shown in Table 6. As the table shows, the number of varieties in the Danish product space jumped from 152 in 2005 to 202 in 2007, while the number of varieties outside the Danish product space fell from 176 to 169. Note that our definition of head-to-head competition is very strict: we consider the same items of different weights as different triplets and do not count them as head-to-head competition. Yet, even with such a strict definition of what an identical product is, there is clear

evidence that non-Danish firms chose to compete head-to-head with the Danish firms and not to fill in the blanks.

Table 6: Orientation of New Products

Danish Product Space	No. of triplets in 2005	No. of varieties	
		2005	2007
Yes	24	152	202
No	81	176	169
Total	105	328	371

7 Conclusion

Firms have several ways of responding to changes in economic conditions or shocks: they can adjust the prices of existing products; they can adjust the frequency, depth, and type of promotional activity; and they can adjust the variety of products offered.

In this paper we have used a successful boycott against Danish cheese products in Saudi Arabia to study how both Danish and non-Danish firms responded during and after the boycott. Our analysis, which benefited from micro- (scanner-) level data, revealed some interesting findings. First, and perhaps as expected, Danish firms lowered prices and increased the depth of promotions (but not the share of goods promoted). Interestingly, they did not change their product mix (the number of products that were available for sale).

The response of non-Danish firms was more surprising. These firms, who benefited from the boycott, did not increase or decrease their prices, and they did not change their promotional activity. Instead, they responded to the boycott by adding new products and changing their product mix. They chose to introduce new cheese products with attributes identical to those sold by Danish firms, hence competing head-to-head. To put the two together, the response of the Danish firms to the negative shock came at the intensive margin, and the response of the non-Danish firms to the positive shock came at the extensive margin.

Our results on the behavior of the non-Danish firms who experienced a positive, significant, and unanticipated demand shock seem to be consistent with other studies that fail to find meaningful price responses to anticipated and unanticipated demand shocks by the affected firms. As our theoretical framework predicts and our results suggest, when introducing new products is not expensive, then these changes in demand may be captured through the extensive margin (product scope) and not through the intensive margin (prices). Of interest is also the fact that we find premium brands to raise both prices and scope in response to the boycott, but fringe brands to do the opposite, a finding that we also capture in the theoretical part of the paper.

We believe that the pattern of market dynamics on display here makes a significant contribution to our understanding of the market adjustment process in response to a major shock and can provide key insights to enhance our understanding and our theories on pricing behavior and multi-product firms.

References

Allanson, Paul and Catia Montagna, "Multiproduct firms and market structure: An explorative application to the product life cycle," *International Journal of Industrial Organization*, 2005, *23* (7-8), 587–597.

Bernard, Andrew B, Stephen J Redding, and Peter K Schott, "Multiple-product firms and product switching," *American Economic Review*, 2010, *100* (1), 70–97.

_ , _ , and _ , "Multiproduct firms and trade liberalization," *The Quarterly Journal of Economics*, 2011, *126* (3), 1271–1318.

Bernheim, B Douglas and Michael D Whinston, "Multimarket contact and collusive behavior," *The RAND Journal of Economics*, 1990, pp. 1–26.

Bils, Mark, "Pricing in a customer market," *The Quarterly Journal of Economics*, 1989, *104* (4), 699–718.

Borenstein, Severin and Andrea Shepard, "Dynamic pricing in retail gasoline markets," Technical Report, National Bureau of Economic Research 1993.

_ and Martin B Zimmerman, "Market incentives for safe commercial airline operation," *The American Economic Review*, 1988, pp. 913–935.

Bosch, Jean-Claude, E Woodrow Eckard, and Vijay Singal, "The competitive impact of air crashes: Stock market evidence," *The Journal of Law and Economics*, 1998, *41* (2), 503–519.

Broda, Christian and David E Weinstein, "Product creation and destruction: Evidence and price implications," *American Economic Review*, 2010, *100* (3), 691–723.

Cawley, John and John A Rizzo, "Spillover effects of prescription drug withdrawals," in "Beyond Health Insurance: Public Policy to Improve Health," Emerald Group Publishing Limited, 2008, pp. 119–143.

Chevalier, Judith A, Anil K Kashyap, and Peter E Rossi, "Why don't prices rise during periods of peak demand? Evidence from scanner data," *American Economic Review*, 2003, *93* (1), 15–37.

Copeland, Adam, Wendy Dunn, and George Hall, "Inventories and the automobile market," *The RAND Journal of Economics*, 2011, *42* (1), 121–149.

Crafton, Steven M, George E Hoffer, and Robert J Reilly, "Testing the Impact of Recalls on the Demand for Automobiles," *Economic Inquiry*, 1981, *19* (4), 694.

Dhingra, Swati, "Trading away wide brands for cheap brands," *American Economic Review*, 2013, *103* (6), 2554–84.

Eckel, Carsten and J Peter Neary, "Multi-product firms and flexible manufacturing in the global economy," *The Review of Economic Studies*, 2010, *77* (1), 188–217.

_ , Leonardo Iacovone, Beata Javorcik, and J Peter Neary, "Multi-product firms at home and away: Cost-versus quality-based competence," *Journal of International Economics*, 2015, *95* (2), 216–232.

Feenstra, Robert C, *Advanced international trade: theory and evidence*, Princeton university press, 2015.

_ , Hong Ma, and DS Prasada Rao, "Consistent comparisons of real incomes across time and space," *Macroeconomic Dynamics*, 2009, *13* (S2), 169–193.

_ , Mingzhi Xu, and Alexis Antoniades, "What is the Price of Tea in China? Towards the Relative Cost of Living in Chinese and US Cities," *The Economic Journal*, forthcoming.

Freedman, Seth, Melissa Kearney, and Mara Lederman, "Product recalls, imperfect information, and spillover effects: Lessons from the consumer response to the 2007 toy recalls," *Review of Economics and Statistics*, 2012, *94* (2), 499–516.

Fusco, Richard A De and Scott M Fuess, "The effects of airline strikes on struck and nonstruck carriers," *ILR Review*, 1991, *44* (2), 324–333.

Gagnon, Etienne and David Lopez-Salido, "Small price responses to large demand shocks," *Journal of the European Economic Association*, 2019.

Goldberg, Pinelopi Koujianou, Amit Kumar Khandelwal, Nina Pavcnik, and Petia Topalova, "Imported intermediate inputs and domestic product growth: Evidence from India," *The Quarterly Journal of Economics*, 2010, *125* (4), 1727–1767.

Haan, Jan De and Heymerik A Van der Grient, "Eliminating chain drift in price indexes based on scanner data," *Journal of Econometrics*, 2011, *161* (1), 36–46.

Hendel, Igal and Aviv Nevo, "Measuring the Implications of Sales and Consumer Inventory Behavior," *Econometrica*, 2006, *74* (6), 1637–1673.

_ and _ , "Sales and Consumer Inventory," *RAND Journal of Economics*, 2006, *37* (3), 543–561.

_ , Saul Lach, and Yossi Spiegel, "Consumers' activism: the cottage cheese boycott," *The RAND Journal of Economics*, 2017, *48* (4), 972–1003.

Hosken, Daniel, David Matsa, and David A Reiffen, *How do retailers adjust prices?: Evidence from store-level data*, Federal Trade Commission, 2000.

Hottman, Colin J, Stephen J Redding, and David E Weinstein, "Quantifying the sources of firm heterogeneity," *The Quarterly Journal of Economics*, 2016, *131* (3), 1291–1364.

Johnson, Justin P and David P Myatt, "Multiproduct quality competition: Fighting brands and product line pruning," *American Economic Review*, 2003, *93* (3), 748–774.

Klenow, Peter J and Oleksiy Kryvtsov, "State-dependent or time-dependent pricing: Does it matter for recent US inflation?," *The Quarterly Journal of Economics*, 2008, *123* (3), 863–904.

Lal, Rajiv and Carmen Matutes, "Retail pricing and advertising strategies," *Journal of Business*, 1994, pp. 345–370.

MacDonald, James M, "Demand, information, and competition: why do food prices fall at seasonal demand peaks?," *The Journal of Industrial Economics*, 2000, *48* (1), 27–45.

Macedoni, Luca and Mingzhi Jimmy Xu, "Flexibility and Productivity: Towards the Understanding of Firm Heterogeneity for Multi-product Exporters," Technical Report, Working Paper 2018.

Nakamura, Emi and Jón Steinsson, "Five facts about prices: A reevaluation of menu cost models," *The Quarterly Journal of Economics*, 2008, *123* (4), 1415–1464.

Nevo, Aviv and Konstantinos Hatzitaskos, "Why does the average price of tuna fall during Lent?," Technical Report, National Bureau of Economic Research 2005.

Nocke, Volker and Stephen Yeaple, "Globalization and multiproduct firms," *International Economic Review*, 2014, *55* (4), 993–1018.

Pauwels, Koen, Jorge Silva-Risso, Shuba Srinivasan, and Dominique M Hanssens, "New products, sales promotions, and firm value: The case of the automobile industry," *Journal of Marketing*, 2004, *68* (4), 142–156.

Perrone, Helena, "Consumers' quality choices during demand peaks," *International Journal of Industrial Organization*, 2016, *44*, 154–162.

Reilly, Robert J and George E Hoffer, "Will retarding the information flow on automobile recalls affect consumer demand?," *Economic Inquiry*, 1983, *21* (3), 444–447.

Rotemberg, Julio and Garth Saloner, "A supergame-theoretic model of price wars during booms," *New Keynesian Economics*, 1986, *2*, 387–415.

Warner, Elizabeth J and Robert B Barsky, "The timing and magnitude of retail store markdowns: evidence from weekends and holidays," *The Quarterly Journal of Economics*, 1995, *110* (2), 321–352.

Appendix

A1. Solution to the Firm's Problem

Optimal Price

Denote Y as total expenditure, P_f as the CES price index (i.e., $P_f = \left(\sum_{i \in I_f} p_{fi}^{1-\sigma} \right)^{1/(1-\sigma)}$), and P as the overall CES price index $P = \left(\sum_{f \in \Omega^F} P_f^{1-\sigma} \right)^{1/(1-\sigma)}$. The total demand (expenditure) for firm f's product i is

$$p_{fi} q_{fi} = \left(\frac{p_{fi}}{P_f} \right)^{1-\sigma} \left(\frac{P_f}{P} \right)^{1-\sigma} Y = \left(\frac{p_{fi}}{P} \right)^{1-\sigma} Y.$$

The elasticity of demand for an individual variety is

$$\begin{aligned} \varepsilon_{fi} &= -\frac{d \ln q_{fi}}{d \ln p_{fi}} = 1 - \frac{d \ln(p_{fi} q_{fi})}{d \ln p_{fi}} \\ &= \sigma - (\sigma - 1) S_f s_{fi}, \end{aligned} \tag{9}$$

where $s_{fi} = d \ln P_f / d \ln p_{fi}$ is the share of expenditure on product i *within* the sales of firm f, and $S_f = d \ln P / d \ln P_f$ is the total share of sales of firm f.

The solution to problem (2) with respect to the price p_{fi} is

$$q_{fi} + \sum_{j \in I_f} [p_{fj} - c_{fj}] \frac{dq_{fj}}{dp_{fi}} = 0, \quad \forall j \in I_f. \tag{10}$$

To simplify this expression, it can be confirmed that the CES demand derivatives are symmetric, $dq_{fj}/dp_{fi} = dx_{fi}/dp_{fj}$.[26]

Using (10) and dividing by demand q_{fi}, we can re-express the first-order condition as

$$1 + \sum_{j \in I_f} \left[1 - \frac{c_{fj}}{p_{fj}} \right] \frac{d \ln q_{fi}}{d \ln p_{fj}} = 0, \quad \forall i \in I_f. \tag{11}$$

Denote the ratio of price to marginal cost (inclusive of transport costs) by $\mu_{fj} = p_{fj}/c_{fj} \geq 1$. Then let us conjecture a solution where the price-cost ratios are constant across all products sold by the firm in question, $\mu_{fj} = \mu_f$. Then it is immediately clear that the solution to (11) is

$$\left(\frac{\mu_f - 1}{\mu_f} \right) = - \left(\sum_{j \in I_f} \frac{d \ln q_{fi}}{d \ln p_{fj}} \right)^{-1}. \tag{12}$$

[26] See Feenstra (2015), page 266.

In order for this solution to be valid, however, we need to have that the sum of elasticities on the right side of (12) be independent of good i because we have assumed that the markup is common across goods. This independence is satisfied for CES demands, in which case the sum of elasticities is[27]

$$-\sum_{j\in I_f}\frac{d\ln q_{fi}}{d\ln p_{fj}}=\sigma-(\sigma-1)S_f>1. \tag{13}$$

Notice that the expression on the right-hand side of (13) is precisely what we get from (9). Then the optimal price (p^*_{fi}) of product i sold by firm f is obtained as

$$p^*_{fi}=\left[1+\frac{1}{(\sigma-1)(1-S_f)}\right]c_{fi}.$$

Optimal Scope

The first-order condition for maximizing (4) with respect to N_f yields

$$[p_f-c_f]q_f+N_f[p_f-c_f]\frac{dq_f}{dN_f}=\delta k_f N_f^{\delta-1}. \tag{14}$$

Using the demand function, the elasticity of demand with respect to product scope N_f is given by

$$\frac{d\ln q_f}{d\ln N_f}=(\sigma-1)\frac{d\ln P}{d\ln P_f}\frac{d\ln P_f}{d\ln N_f}=-S_f.$$

The second equality uses $\frac{d\ln P_f}{d\ln N_f}=\frac{1}{1-\sigma}$. Making use of the fact that the revenue earned per product by firm f is $p_f q_f=S_f Y/N_f$ and using equation (3) in the main text, the equilibrium condition for the optimal scope (N^*_f), characterized by (14), can be derived as

$$(N^*_f)^\delta=\frac{1}{\delta}\left[\frac{S_f(1-S_f)}{\sigma-(\sigma-1)S_f}\right]\frac{Y}{k_f}$$

A2. Derivation of Log Changes

We first derive the log change for the optimal price. Taking the derivative of (3), we have

$$\frac{dp^*_f}{dS_f}=\frac{1}{\sigma-1}\times\frac{1}{(1-S_f)^2}\times c_f$$

We multiply S_f/p^*_f on both sides and move $d\ln S_f$ to the right side of the equation to obtain

$$d\ln p^*_f=\frac{S_f}{1-S_f}\times\frac{1}{\sigma-(\sigma-1)S_f}\times d\ln S_f. \tag{15}$$

[27]The cross-elasticity is $d\ln x_{ifd}/d\ln p_{jfd}=-[(\sigma-\eta)+(\eta-1)S_{fc}]s_{jfc}$ for $i\neq j$, and using (9) then (13) is obtained.

Next, we move on to product scope. We log both sides of (5) and take a partial derivative with respect to S_f to obtain

$$\frac{\delta d \ln N_f^*}{dS_f} = \frac{1}{S_f} - \frac{1}{1-S_f} + \frac{\sigma - 1}{\sigma - (\sigma-1)S_f}.$$

Multiplying S_f on both sides and moving $d \ln S_f$to the right side provides the log change of scope with respect to the log change of market share:

$$\delta d \ln N_f^* = \left[1 - \frac{S_f}{1-S_f} + \frac{(\sigma-1)S_f}{\sigma-(\sigma-1)S_f}\right] \times d \ln S_f.$$

Combining the log changes due to demand $d \ln Y$, we obtain

$$\delta d \ln N_f^* = \left[1 - \frac{S_f}{1-S_f} + \frac{(\sigma-1)S_f}{\sigma-(\sigma-1)S_f}\right] \times d \ln S_f + d \ln Y. \tag{16}$$

Lastly, taking the partial derivation of equation (6) with respect to p_f^* and writing in the form of the log change, we obtain

$$d \ln S_f = (1-\sigma) \times (1-S_f) \times d \ln p_f^*.$$

Similarly, the log change in S_f with respect to N_f^* yields

$$d \ln S_f = (1-S_f) \times d \ln N_f^*.$$

So all together, we obtain

$$d \ln S_f = (1-\sigma) \times (1-S_f) \times d \ln p_f^* + (1-S_f) \times d \ln N_f^*. \tag{17}$$

We substitute $d \ln p_f$ in (15) with that in (17), which solves $d \ln S_f$ as a function of $d \ln N_f$:

$$d \ln S_f = \frac{(1-S_f)\left[\sigma - (\sigma-1)S_f\right]}{\sigma} \times d \ln N_f^*.$$

Next, we substitute the above expression of $d \ln S_f$ with (16), which solves $d \ln N_f^*$ as a function of $d \ln Y$:

$$d \ln N_f^* = \frac{\sigma}{S_f \times \left[2\sigma - (\sigma-1)\, S_f\right] - \sigma\,(1-\delta)} \times d \ln Y.$$

Lastly, we solve for $d \ln p_f$. Specifically, we divide both sides of (17) by $(1-S_f)$ and write $d \ln N_f^*$ as a function of $d \ln S_f$ and $d \ln p_f^*$:

$$d \ln N_f^* = \frac{1}{1-S_f} d \ln S_f + (\sigma-1)\, d \ln p_f^*.$$

Combining the above equation and (16), we obtain

$$\left[\frac{2S_f+\delta-1}{1-S_f}-\frac{(\sigma-1)S_f}{\sigma-(\sigma-1)S_f}\right]d\ln S_f+\delta(\sigma-1)d\ln p_f^*=d\ln Y.$$

We substitute $d\ln S_f$ in the above expression using (15) to obtain

$$d\ln p_f^*=\frac{S_f}{S_f\times[2\sigma-(\sigma-1)S_f]-\sigma(1-\delta)}\times d\ln Y.$$

Therefore, we obtain $d\ln p_f^*$ and $d\ln N_f^*$ as the function of $d\ln Y$:

$$\begin{aligned}d\ln p_f^*&=\frac{S_f}{S_f\times[2\sigma-(\sigma-1)S_f]-\sigma(1-\delta)}d\ln Y\\ d\ln N_f^*&=\frac{\sigma}{S_f\times[2\sigma-(\sigma-1)S_f]-\sigma(1-\delta)}d\ln Y.\end{aligned}$$

Similarly, we can solve $d\ln p_f^*$ and $d\ln N_f^*$ as the function of $d\ln k_f$:

$$\begin{aligned}d\ln p_f^*&=-\frac{S_f}{S_f\times[2\sigma-(\sigma-1)S_f]-\sigma(1-\delta)}d\ln k_f\\ d\ln N_f^*&=-\frac{\sigma}{S_f\times[2\sigma-(\sigma-1)S_f]-\sigma(1-\delta)}d\ln k_f.\end{aligned}$$

A3. Proof of Proposition 1

According to (7) and (8), $d\ln p_f^*/d\ln Y$ and $d\ln N_f^*/d\ln Y$ are positive if and only if

$$S_f\times[2\sigma-(\sigma-1)S_f]>\sigma(1-\delta).$$

The left-hand side of the inequality (i.e., $S_f\times[2\sigma-(\sigma-1)S_f]$) increases in S_f and reaches the minimum value of zero at $S_f=0$ and the maximum value of $\sigma+1$ at $S_f=1$.

When $\delta\in[1,\infty)$, it is immediate that $\sigma(1-\delta)\leq 0$ and the above inequality always holds; that is, positive demand shocks always lead firms to expand product scope and increase prices. In contrast, when $\delta\in(0,1)$, there exists a unique market share $\tilde{S}$ such that firms with market share greater than $\tilde{S}$ (i.e., $S_f>\tilde{S}$) will increase product price and scope in response to the positive demand shocks.

A4. Proof of Proposition 2

Taking the ratio of equations (7) and (8), we obtain

$$\frac{d\ln p_f^*/d\ln Y}{d\ln N_f^*/d\ln Y}=S_f\left(N_f^*,Y,k_f\right)/\sigma,$$

where firm share S_f is a implicit function of N_f^*, Y, and k_f in the initial equilibrium (see (5)). For firms selling the same number of products,

$$\partial \frac{d\ln p_f^*/d\ln Y}{d\ln N_f^*/d\ln Y}\Big/\partial k_f = \frac{1}{\sigma}\frac{\partial S_f\left(N_f^*, Y, k_f\right)}{\partial k_f} > 0,$$

where the inequality comes from that $sign\left(\frac{\partial S_f\left(N_f^*,Y,k_f\right)}{\partial k_f}\right) = sign\left(\frac{\partial S_f\left(N_f^*,Y,k_f\right)}{\partial N_f^*}\right)$ and the equilibrium condition that $\frac{\partial S_f\left(N_f^*,Y,k_f\right)}{\partial N_f^*} > 0$.

A5. Proof of Proposition 3

The proof of (a) is immediate. To prove (b), we focus on large firms, that is, $d\ln p_f^*/\ln Y > 0$ (Proposition 1). The elasticity of price change with respect to market size is $\frac{S_f}{S_f\times\left[2\sigma-(\sigma-1)S_f\right]-\sigma(1-\delta)}$, and we take the derivative with respect to S_f:

$$\frac{\partial\left(d\ln p_f^*/\ln Y\right)}{\partial S_f}\frac{(\sigma-1)S_f^2-\sigma(1-\delta)}{\left[S_f\times\left[2\sigma-(\sigma-1)S_f\right]-\sigma(1-\delta)\right]^2}.$$

The above expression is positive for large value of δ (weak IRS) and negative if δ is large enough (strong IRS).

To prove (c), we first use $\tilde{m}$ to index the unimpacted firm whose market share remains (or is close to being) unchanged after the positive demand shock. Then we write firm f's market share relative to that of firm $\tilde{m}$, that is, $\ln\left(S_f/S_{\tilde{m}}\right) = \ln\left(N_f^* p_f^{1-\sigma}\right) - \ln\left(N_{\tilde{m}}^* p_{\tilde{m}}^{1-\sigma}\right)$, and further derive its log change expression:

$$d\ln\left(S_f\right) = d\ln\left(S_f/S_{\tilde{m}}\right) = \left[g\left(S_f\right) - g\left(S_{\tilde{m}}\right)\right]d\ln Y,\ g(S) \equiv \frac{\sigma-(\sigma-1)S}{S\left[2\sigma-(\sigma-1)S\right]-\sigma(1-\delta)}. \quad (18)$$

To obtain (18), we combine using (6), (7) and (8). The first equality comes from the fact that firm $\tilde{m}$'s market share barely changes after the shock. In the case in which the market share of the least impacted firm is small (e.g., $S_{\tilde{m}} < \tilde{S}$), we have $g(S_{\tilde{m}}) < 0$. Since $g(S_f) > 0$ for large firms (i.e., $S_f > \tilde{S}$ where $\tilde{S}$ is implicitly defined by $\tilde{S}\left[2\sigma-(\sigma-1)\tilde{S}\right] = \sigma(1-\delta)$), the change in market share, therefore, is

$$d\ln\left(S_f\right) = g\left(S_f\right) - g\left(S_{\tilde{m}}\right) > 0$$

Next, let S_1 and S_2 be two big firms with $\tilde{S} < S_1 < S_2$ so that their market shares both increase after the shock. The relative share change is then

$$d\ln\left(S_2/S_1\right) = \left[g\left(S_2\right) - g\left(S_1\right)\right] d\ln Y,$$

where both $g\left(S_1\right)$ and $g\left(S_2\right)$ are positive. As $g'(S) < 0$ for $S \in \left(\tilde{S}, 1\right)$, it is immediate to show that

$$sign\left\{d\ln\left(S_2/S_1\right)/d\ln Y\right\} < 0,$$

which implies that, among large firms, the market share of a smaller-sized firm grows more than that of a bigger-sized firm.

A6. Appendix Figure

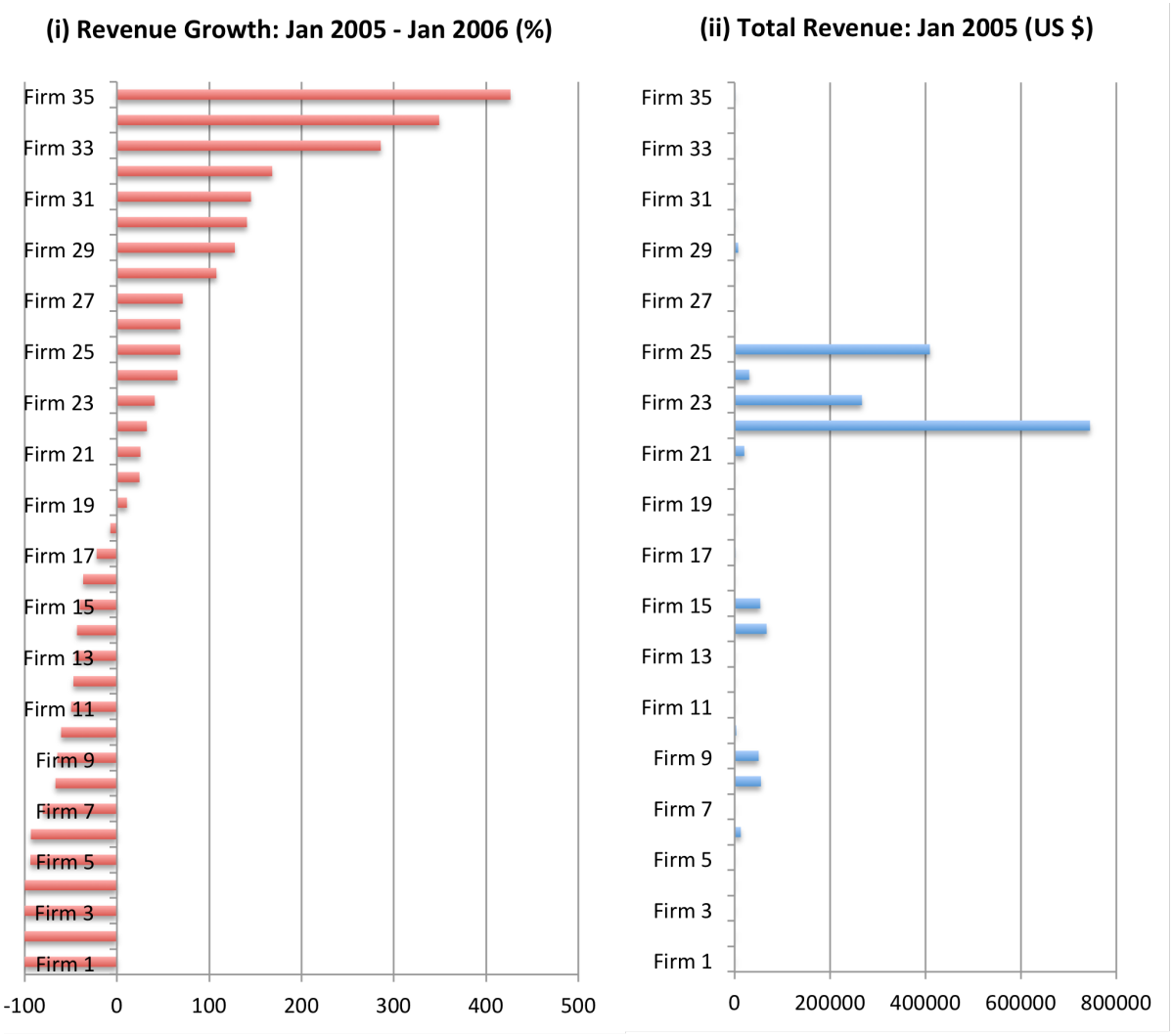


Figure A.1: Changes in Firm Revenues