Two-sided hub-and-spoke collusion: Evidence from the grocery supply chain

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Abstract

We study a cartel that operated in Canada’s bread market. Allegations suggest that this was a two-sided hub-and-spoke (2SHS) cartel, in which suppliers helped to coordinate retail prices and retailers helped to coordinate supplier prices. This arrangement is hard to rationalize: manufacturers should have incentive to limit retailer market power, and vice versa, to avoid double marginalization problems. Our analysis contains three elements. First, we use court documents and aggregate pricing data to provide evidence that this form of cartel was effective: empirical evidence suggests that the impact of the cartel was to increase price inflation by about 30%. Second, while the court documents provide compelling evidence that suppliers were colluding, retailer involvement is less clear. To investigate, we study whether the effect of the collapse of the cartel in 2016 varies with market structure and find that it is more pronounced in more concentrated markets, implicating retailers. Finally, we develop a model to examine why the arrangement was one of 2SHS. Our explanation focuses on an asymmetry that arises in many b2b markets, with one supplier providing certain uncompensated services to retailers in exchange for greater market share. This asymmetry makes 2SHS collusion easier to sustain than either supplier-only or retailer-only collusion. Supplier-only collusion is difficult because the secondary supplier has incentive to undercut. Retailer-only collusion is hard because high retail prices incite the main supplier to lower its prices to induce the retailer to undercut rivals. We show that retailers can facilitate upstream collusion by redistributing profits towards the secondary supplier, which in turn allows for higher retail prices.

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1 Introduction

On January 31st 2018 documents were released containing Canadian Competition Bureau allegations that grocery retailers and suppliers had conspired to fix the wholesale and retail prices of fresh commercial bread. The Bureau became aware of the alleged price fixing in March 2015 when a grocery retailer informed it of a collusive arrangement in the industry through the Bureau’s immunity program. The allegations suggest that collusion began in late 2001 and continued for about a decade and a half. The documents describe a collusive arrangement in which suppliers helped to coordinate retail prices and retailers helped to coordinate supplier prices, and they provide evidence that price increases were coordinated on at least fifteen different occasions between 2001 and 2016.

Economists have only recently begun studying cartels linking both ends of the vertical supply chain – so called hub-and-spoke cartels. These arrangements, in which retailers help manufacturers coordinate and/or manufacturers help retailers, are not well understood because we typically assume that manufacturers have incentive to limit market power in the retail sector, and vice versa, in order to avoid problems of double marginalization. Existing explanations include those provided by Sahuguet and Walckiers (2017), Van Cayseele and Miegielsen (2013), Giardino-Karlinger (2014), and Gilo and Yehezkel (2020). In Sahuguet and Walckiers, if retailers are left to their own devices, their interactions generate inefficiencies for the entire market. In their setup, demand is assumed to be volatile (à la Rotemberg and Saloner (1986)) and the monopoly supplier does not know the state. In this case, information exchange between the supplier and retailers can increase profits of the vertical chain. In Van Cayseele and Miegielsen, Giardino-Karlinger, and in Gilo and Yehezkel, rewards or the threat of exclusion imposed by the supplier provide incentives to maintain the hub-and-spoke arrangement. In Van Cayseele and Miegielsen, and in Gilo and Yehyzkel the wholesale price is determined through a bilateral bargaining procedure and the supplier can charge higher price under retail collusion. In Giardino-Karlinger, the supplier earns zero along the collusive path, but absorbs all profits under punishment by exercising an exclusive dealing option.2

These explanation mostly involve settings featuring a monopoly wholesaler and competing retailers. Where competing wholesalers are considered, the assumption is usually homogeneous goods and retailers, and the proposed solution involves exclusion of one supplier. These papers also focus on cases where one end of the vertical chain is the hub helping to coordinate the behavior of the spokes at the other end. These features do not accurately characterize the settings of many of the

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1Legal disclaimer: This paper analyses the alleged cartel case strictly from an economic point of view. The investigation into, and prosecution of, firms involved in the alleged conspiracy is ongoing. The allegations have not been proven in a court of justice. However, for the purpose of this paper, we take these facts as established. The analysis is preliminary and incomplete, and the findings are still subject to change. We base our understanding of the facts mostly on documents prepared by the Competition Bureau. The appendix provides a description of their content.

2See also Sahuguet and Walckiers (2014), Van Cayseele and Miegielsen (2014), and Harrington (2018) for discussion.
hub-and-spoke cases that have been uncovered by antitrust authorities. Two of the most famous are Toys R Us v. FTC and Argos & Littlewoods v OFT. In the former, Toys R Us, acting as the hub, organized and enforced a horizontal agreement among its various suppliers (for example Hasbro, Mattel, Fisher Price). In the latter, a manufacturer, Hasbro coordinated pricing by retailers Argos and Littlewoods. Clearly, there is competition at both ends of the supply chain. Moreover, we do not always observe exclusion. Rather, many business-to-business settings feature multi-sourcing, with the downstream firm sourcing from multiple upstream suppliers. Lastly, at least in our setting, suppliers are the hub coordinating retailer behavior, but retailers in turn act as hubs to coordinate supplier pricing. In other words, the hub-and-spoke structure that we observe is two-sided.

In his analysis of different hub-and-spoke cartels Harrington (2018) proposes two main questions: why did this sort of arrangement arise and was this arrangement effective for raising prices. The objective of this paper is to provide answers to these questions by studying the cartel that arose in the Canadian commercial bread industry. Moreover, since unlike in traditional hub-and-spoke arrangements, this one is two-sided, we also test whether collusive behavior occurred at both ends of the supply chain. To do so we make use of three sources: (i) information obtained through conversations with industry insiders about how this market functioned before the cartel became operational, (ii) documents submitted by the Bureau to the courts that describe the collusive arrangement, and (iii) data on prices and market structure from Statistics Canada and Infogroup Canada.

To confirm that the two-sided hub-and-spoke arrangement was successful and to quantify the impact of the cartel we use consumer price index data from Statistics Canada and a difference-in-differences approach in which we compare inflation rates of bread and control products around the start and end of the cartel. This approach has been used to study the impact of alleged price fixing in other markets (see for instance Clark and Houde (2014), Miller and Weinberg (2017), and Clark, Coviello, Gauthier, and Shneyerov (2018)). Based on allegations by the Competition Bureau, we assume that the cartel started at the beginning of 2002. Our results suggest that relative to other foods, price inflation for bread increased following the start of the cartel. We find evidence that the increase in the rate of inflation was gradual for the first five or six years, and then levelled off, suggesting that it took a number of years for the cartel to learn how to properly coordinate. Overall, we find that price inflation was roughly 40% higher for bread as a result of the cartel.

These results imply that the two-sided hub-and-spoke arrangement was successful at increasing prices, but do not provide clear confirmation that the cartel was operating at both ends of the supply chain. The court documents and subsequent commentary offer compelling evidence that the suppliers were colluding and so one possibility is that the cartel operated only at the wholesale level. The objective of the second part of our empirical analysis is to test the hypothesis that retailers were also involved such that both ends of the supply chain were implicated in the collusive arrangement. We use store-level data from Statistics Canada and market structure information from Infogroup
Canada to compare pricing in different cities that feature heterogeneous retail-market structures. We look at the effect of the collapse of the cartel on city-level prices and price dispersion. Our results suggest that the impact of the collapse is a function of retail-market structure. If retailers were not involved in the cartel arrangement and only wholesalers were colluding, then price decreases following the collapse should be uniform across cities, while our findings show that the decline is more pronounced in more concentrated markets. Price dispersion decreased overall, but actually increased in markets with more discount chain competition. Markets with multiple discount chains broke from uniform prices after the announcement. This provides evidence that wholesalers were not the only participants in the cartel but that retailers also took part in price fixing, such that the arrangement was two-sided hub-and-spoke.

What remains to be shown is why they settled on the particular arrangement we observe. More specifically, we are interested in understanding the incentives to collude and why the form that the cartel took was two-sided hub-and-spoke, rather than retailer-only or supplier-only, or a more traditional form of hub-and-spoke collusion. To investigate these questions, we turn to theory and develop a model that addresses the shortcomings of the existing proposed explanations for this arrangement by allowing for (i) competition at both ends of the supply chain, (ii) multi-sourcing, and (iii) two-sided hub-and-spoke collusion.

Our explanation is based on certain key features of the bread market, that have come to our attention through conversations with industry insiders and through our study of the documents released by the Competition Bureau. Notwithstanding our sources, we believe that these features are more broadly applicable and characterize many business-to-business settings. In addition to supplying their product, wholesalers are expected to provide important services to retailers (including shelving, removal of unsold products, etc.). These services are costly to provide but have a public good aspect, so that a single wholesaler’s services benefit a retailer carrying the products of multiple wholesalers. As a result, each retailer wants a single wholesaler to be its main supplier. Moreover, since shelf space is scarce and the service costly, the retailer affords better shelf space at all of a retailer’s outlets nationwide to its main supplier. One or more “secondary” suppliers obtain the remaining shelf space share. The resulting asymmetry between wholesalers plays an important role in explaining the collusive arrangement. A second important factor is that wholesale prices are the outcome of negotiations between wholesalers and retailers, with wholesalers competing to be the main supplier. The service relationship that is formed between retailer and main supplier is such that the former views it as costly to switch away from the latter towards rival suppliers. The resulting switching cost determines the relative leverage that the main supplier has in the wholesale price negotiations. At the same time, consumers incur costs if they move across retailers to make purchases. The more consumers who are shoppers and the more sensitive these consumers are to differences in bread prices across retailers, the greater is competition in the retail market for bread. A greater fraction of price sensitive consumers induces lower retail prices. A combination of
low costs for the retailers of switching suppliers and low costs for consumers of switching retailers induces a situation in which neither the bread makers nor the retailers are making any significant profits.

Together, the asymmetric supply relationship and endogenous wholesale price setting imply that two-sided hub-and-spoke collusion is easier to sustain than either supplier-only or retailer-only collusion. Supplier-only collusion is difficult to sustain since the secondary supplier has an incentive to undercut in an attempt to become the main supplier: the asymmetry problem. Retailer-only collusion is hard to sustain because of the incentive that a main supplier has to offer the retailer a lower wholesale price—the endogeneity problem—to induce retail price cutting. Doing so shifts customers from rival retailers at which the wholesaler is not the main supplier to the one at which it is, thereby increasing the wholesaler’s profits. Among other things, joint collusion allows i) retailers to coordinate their shelf share allocations between main and secondary suppliers and ii) wholesalers to coordinate their price offers in ways that resolve both the asymmetry and endogeneity problems, thereby facilitating coordination.

Related literature

In addition to the articles on hub-and-spoke cartels mentioned above, our paper is also related to a number of other literatures. First, we are related to the empirical literature on the organization of cartels. Some of these papers have focused on describing the inner workings of cartels, for instance Pesendorfer (2000), Genesove and Mullin (2001), Roller and Steen (2006), Asker (2010), Clark and Houde (2013), and Igami and Sugaya (2018). Other papers have focused on distinguishing collusion from competition, for instance Porter and Zona (1999), Bajari and Ye (2003), Conley and Decarolis (2016), Aryal and Gabrielli (2013), Schurter (2017), and Kawai and Nakabayashi (2018). Block, Nold, and Sidak (1981) examine collusion in the US bread market in the 1960s and 1970s. Finally, Ross (2004) reviews cartels in Canada.

We are also related to an extensive literature on facilitating practices. The notion that an outside (or third) party can help to organize the cartel has been considered. The literature has mostly focused on the role of trade associations. Early models studying the role of trade associations for collusion were developed by Vives (1984) and Kirby (1988). More recently Alé-Chilet and Atal (2019) empirically examine the role of a trade association for facilitating collusion amongst physicians in Chile. See Marshall and Marx (2012) for a number of other examples. Greif, Milgrom, and Weingast (1994) characterize a repeated interaction between a city and merchants and describe how the city might help the merchants organize themselves into a guild. There is a long literature on the ability of vertical relations (i.e. resale price maintenance, integration, advertising restrictions) for facilitating collusion. See for instance Nocke and White (2007), Normann (2009), Rey and Vergé (2010), Jullien and Rey (2007), Matthewson and Winter (1998), Slade (2020) and Asker and Bar-Isaac (2020). Piccolo and Miklos-Thal (2012) show that firms can collude more easily in the output
market if they also collude on their input supply contracts. A number of papers have pointed out the anticompetitive effects of slotting allowance (see Shaffer (1991); Sudhir and Rao (2006); Marx and Shaffer (2010)). Lastly, there is a small but growing literature on so-called category captains. This term is given to suppliers who provide extensive advice to retailers. Some papers have alluded to the possibility that this could facilitate collusion (see for instance Gabrielson, Johansen, and Shaffer (2018) and Kurtulus and Toktay (2011)).

Finally, we are related to a number of papers studying on the grocery sector. This includes the literature on slotting contracts (for a discussion, see Wright (2007) or Wright and Klein (2007)), and the literature on competition in the grocery sector (see for instance Smith (2004), Ellickson (2007), and Ellickson and Misra (2008)). It also includes literatures on the grocery supply chain (see Sudhir (2001), Villas-Boas (2007), Bonnet and Dubois (2010), Draganska, Klapper, and Villas-Boas (2010), Noton and Elberg (2018), and Ellickson, Kong, and Lovett (2018)).

Outline

The rest of the paper proceeds as follows. In the next section we describe the market, including the vertical arrangements that characterize it. In Sections 3 and 4 we present the data, the evidence that hub-and-spoke collusion took place, and the empirical analysis of the impact of the cartel on prices. Section 5 contains the model which explains why two-sided hub-and-spoke arose. Finally, Section 6 concludes.

2 Institutional Details and Market Structure

Retail sector

In 2016, food and beverage sales in Canada accounted for 17 percent of the retail landscape, with sales valued at US$86 billion (C$115 billion). Approximately 58% of food sales were through grocery stores, which are currently dominated by three big players: Loblaws, Sobeys, and Metro. According to the court documents these three retailers accounted for 33.5%, 18.9% and 15.5% of the grocery market respectively. Other important players are Walmart with 8.8%, Giant Tiger with 1.4%, and Overwaitea, which is geographically focused on Western Canada, at 2.2%. There are also thousands of smaller outlets that range from tiny independent convenience stores all the way to high-end specialty food providers. The Big three each have a number of discount banners. Loblaws and its supermarket banners had 1501 stores in 2009. Sobeys had 1351 and Metro had 1483.

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3See also Shaffer (1991), Sudhir and Rao (2006), Marx and Shaffer (2010), FTC (2001), and www.ftc.gov/os/2001/02/slottingallowancesreportfinal.pdf
Wholesale sector

The commercial bread industry in Canada had $US2.2 billion in sales in 2017. Commercial bread is baked and shipped daily by suppliers. Two main suppliers, George Weston Ltd. and Canada Bread Co., dominate the market with 21.5% and 16.7% market share respectively in 2016 (EU (2017)). These are the only suppliers active in markets all across the country, with the remaining 2,386 bread producers operating at a more regional level. According to the court documents (paragraph 4.121, Competition Bureau ITO November 1st 2017) Weston and Canada Bread issue prices for their products on a national basis.4,5

Horizontal mergers

Interestingly, in the years leading up to the start of the cartel there were a number of major acquisitions that increased concentration at both ends of the supply chain. In 1998, Sobeys acquired the Oshawa Group, which owned the IGA franchise. It also acquired a number of regional chains in Ontario, and various food service and wholesale companies. In so doing it became the second-largest grocery chain in Canada. In November 1998 Loblaws acquired Agora Foods and its 80 outlets. Then one month later, it acquired Provigo Inc., the leading grocery chain in Quebec, pushing its market share to close to 40%. This acquisition led Metro to acquire Loeb in June 1999, which had been owned by Provigo who was forced to sell it for competitive reasons. On the supplier-side, Canada Bread made a major purchase in 2001, acquiring Quebec-based Multi-Marques, including its main brand POM. While we do not provide any causal analysis of the impact of these acquisitions, the fact that the cartel started so quickly after them, suggests that they may have had coordinated effects (see for instance Miller and Weinberg (2017), Igami and Sugaya (2018), Vasconcelos (2005) and Loertscher and Marx (2020)).


Vertical arrangements

Our understanding of the functioning of commercial bread industry is based in part on conversations with a former high-level executive in the industry. Importantly, to explain the incentives firms had to begin colluding, the insider provided us with a description of operation of this industry in the period leading up to the start of the cartel.

4Unless otherwise noted all paragraph references are to the Information to Obtain search warrants filed on Nov 1st 2017 by the Competition Bureau.

5Similar pricing has been documented for a number of grocery products in the US by Gentzkow and DellaVigna (2019).
The most common type of vertical arrangement is characterized by asymmetric long-term contracts between each downstream chain and the two bread suppliers. According to the industry insider, six key features explain the incentives of firms at both ends of the supply chain to collude and why the particular structure of the cartel was chosen. First, retailers compete in prices for heterogeneous consumers. Second, retailers sell products of both suppliers (i.e., multi-sourcing). Third, retailers require important, uncompensated services (shelving and display consulting, actual shelving of bread, removal of “stale” bread from stores, timely delivery of new product). Fourth, the nature of these services and scarce shelf space imply retailers want one producer to be their main supplier. Fifth, there is an asymmetry in shelf space allocation, with more allocated to main than to the secondary supplier. Finally, wholesale prices are negotiated intermittently at the national level between suppliers and retailer, with suppliers competing to be main supplier.

Asymmetry: The asymmetry described above leads to a very unequal split of shelf space across the brands. Table 1 illustrates this point using data on the number of products of each brand offered online by the three main retailers. We focus our attention on the shopping platforms available for these retailers at mid-size cities in Ontario and Quebec.⁶ We count the number of different bread products offered by all suppliers (including private label) and then determine the share of total offering represented by each of the two big suppliers (Canada Bread and Weston), by private labels, and by other producers. Weston is dominant at Loblaws, while Canada Bread is

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⁶Sobeys itself does not have an online shopping platform. We look instead at IGA, the Sobeys banner in Quebec, which does have an online shopping platform.
dominant at both Metro and Sobeys. In each case there are at least five times as many products available belonging to the dominant supplier than the secondary supplier.\(^7\) It should be pointed out that Weston and Loblaws are vertically integrated, which explains why Weston is the main supplier for Loblaws. As discussed below, together they were the immunity applicants.

This sort of asymmetric arrangement in which retailers multi-source, but have one main supplier, is common in many retail environments and also in many business-to-business settings. In the US bread industry there are also two dominant suppliers: Grupo Bimbo and Flowers Foods. In 2017 Bimbo had 26.8% market share, while Flowers had 20.8%.\(^8\) Moreover, there is evidence that they provided services to retailers at which they were dominant. In Appendix B we provide descriptions from a trade magazine of the types of services that each of these suppliers provided at certain retail chains.

**Wholesale pricing:** Wholesale price setting is done once every nine to twelve months, and wholesale prices are essentially committed to for the period. Wholesale prices are negotiated at the national / overall chain level and the process essentially involves the grocery chain taking wholesale price proposals / bids from the two bread makers. Because of the asymmetry retailers view it as costly to switch from one bread maker to the other. However, according to our contact, if the main supplier comes in with a higher wholesale price quote than the competitor supplier, the retailer typically goes back to the main supplier to ask the supplier to match the lower bid. Matching often happens, in our contact’s experience.

### 3 Data

To study the effect of the cartel on prices at both ends of the supply chain we make use of the following four data sources.

First, we use information from the court documents to learn about wholesale price changes that occurred during the cartel period. As we explain in the next section, the court documents summarize information from the pricing letters that the bread producers sent to retailers in order to coordinate price increases.

Second, we collected national pricing data from Statistics Canada. We gathered information on the average retail price of a loaf (675gr) of bread across the country.\(^9\) We use these data to verify the information on wholesale price coordination contained in the court documents, and to get a first sense of the impact on retail prices. Since prices at the loaf level are not comparable to prices of other products, we also collected data from the Monthly Consumer Price Index of Statistics Canada.

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\(^7\)From Table 1 we can see that Sobeys does not offer any Weston products through its IGA online shopping platform, but in its Ontario stores it stocks both Canada Bread and Weston products, although the former are much more prominent.


\(^9\)These data are compiled from Statistics Canada Table: 18-10-0002-01 (formerly CANSIM 326-0012).
Canada. Specifically, we collected price-index information for the Bread, rolls, and buns category from 1995 to 2018 (September). This sample period covers five years prior to the start of the alleged collusion, as well as roughly two years following the public announcement of the investigation. We label the period between 2001 and 2015 the “coordination period”, and the period between 2016 and 2018 the “collapse period”.

In addition to the price index for bread, rolls and buns, we collected information on the general “food” price index, as well as the price index from two other categories: “cereal” and “other bakery products”. We also collected information on the price index for “hard spring wheat flour”, which is the main input into bread production (i.e. proxy for average variable cost), and we have gathered similar price-index information for US bread prices from the U.S. Bureau of Labor Statistics (BLS). Note that the BLS reports prices for white bread alone, as opposed to the amalgam of bread, rolls, and buns that we see with Statistics Canada. All price indices are normalized to 100 in the year 2002.

Third, from Statistics Canada, we have also been granted access to their CDER-CPI Research store-level data set. This data set includes prices for a sample of commodities of unchanged or equivalent quantity and quality used in the construction of the Canadian Consumer Price Index. We have access to this for the period 2009-2018, which allows us to study the impact of the collapse of the cartel. These prices are available at 225 stores in 38 markets throughout Canada. A market is defined as a census metropolitan area (CMA). Note that the store identity is anonymized, preventing us from analyzing differences across chains.

We use these data in conjunction with our fourth data set, from Infogroup Canada, to study heterogeneity in the impact of the cartel. Using the Infogroup data set we characterize the downstream market-structure of each city. This data set provides information on the addresses, industry classifications and number of employees for businesses across the country for all grocery store establishments. The panel dimension of the data is not reliable, and so we use this data set to construct cross-sectional variables describing each market. Table 2 provides summary statistics from the Infogroup data set for the 38 markets for which we can match it with the CDER-CPI data set. From this we can see that the mean market size is almost 16 grocery stores, of which Statistics Canada surveys on average 6.71 when constructing its price index.

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10 (Table: 18-10-0004-03 (formerly CANSIM 326-0020).
11 The wheat flour data were gathered from the Monthly Industrial Product Price Index (Table: 182121).
12 US Bread prices: Series Id - APU0000702111, Series Title - Bread, white, pan, per lb. (453.6 gm) in U.S. city average, average price, not seasonally adjusted.
13 This price index is also not adjusted for exchange rate differences.
14 Infogroup includes grocery stores of all sizes, we focus on stores with 20 or more employees to restrict attention to the main players in the grocery sector.
Table 2: Market structure summary statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min.</th>
<th>Max.</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of stores (20+ empl.)</td>
<td>15.66</td>
<td>15.81</td>
<td>1</td>
<td>60</td>
<td>38</td>
</tr>
<tr>
<td>HHI (20 employees)</td>
<td>0.33</td>
<td>0.16</td>
<td>0.08</td>
<td>1</td>
<td>38</td>
</tr>
<tr>
<td>Share of discount stores</td>
<td>0.15</td>
<td>0.08</td>
<td>0</td>
<td>0.31</td>
<td>38</td>
</tr>
<tr>
<td>Single discounter</td>
<td>0.63</td>
<td>0.49</td>
<td>0</td>
<td>1</td>
<td>38</td>
</tr>
<tr>
<td>Loblaw markets</td>
<td>0.03</td>
<td>0.16</td>
<td>0</td>
<td>1</td>
<td>38</td>
</tr>
<tr>
<td>Loblaw + Metro or Sobeys</td>
<td>0.79</td>
<td>0.41</td>
<td>0</td>
<td>1</td>
<td>38</td>
</tr>
<tr>
<td>All three</td>
<td>0.18</td>
<td>0.39</td>
<td>0</td>
<td>1</td>
<td>38</td>
</tr>
<tr>
<td>Number of outlets surveyed (avg.)</td>
<td>6.71</td>
<td>5.5</td>
<td>2</td>
<td>24</td>
<td>38</td>
</tr>
</tbody>
</table>

4 The Cartel: Arrangement and Impact

On March 3rd 2015, Weston and Loblaw informed the Bureau of a collusive arrangement in the commercial bread market through the Bureau’s immunity program. Under this program, the first party to disclose an offense not yet detected, or to provide evidence leading to a case referral to the Public Prosecution Service of Canada, may receive immunity from prosecution. On January 4th 2016 allegations of collusion were leveled by the Canadian Federation of Independent Grocers (CFIG). On August 11th 2017 the Competition Commissioner commenced an inquiry (extended in October). In 2018 Canada Bread acknowledged the investigation and released a statement that it was looking into the wrong doings, which, it pointed out, allegedly took place under previous ownership. In contrast, with the exception of Loblaw, the retailers alleged to have participated have denied the allegations, and so it is our understanding that the biggest point of contention is the participation of retailers in the collusive arrangement.

In this section we use the court documents along with the data on prices and market structure described above to evaluate the claim that firms at both ends of the supply chain successfully colluded using a hub-and-spoke arrangement. We first characterize the impact of the cartel, focusing on the magnitude and patterns of price increases during the coordination period (2001-2015). We make use of court documents to describe the coordinated price increases initiated by upstream suppliers, and price-index data for bread, for other food segments and for the U.S. bread industry, to evaluate the extent to which the industry successfully maintained supra-competitive margins. We then use store-level data covering the collapse period to test the hypothesis that collusion took place at both ends of the supply chain. The court documents describe how coordinated price increases were initiated by upstream suppliers. However, there is much less evidence that retailers participated, making the arrangement a two-sided hub-and-spoke cartel. To confirm the role of

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retailers, we exploit differences in market structure to test the hypothesis that more concentrated retail markets sustained higher markups during the coordination period, providing evidence that collusion took place not only upstream, but also downstream.

4.1 Evidence of cartel impact

According to the allegations contained in the court documents, the collusive arrangement started towards the end of 2001 following conversations between participants at an industry event attended by retailers and suppliers (see paragraph 4.24, reproduced in the appendix along with the other paragraphs referenced in this section). The court documents allege that during these conversations, annual price increases in other industries were pointed to as a model for the bakery industry (paragraphs 4.25 and 4.26). Bread prices were underperforming and persons from the suppliers described a plan to achieve buy-in for price increases and an objective of orchestrating alignment through the retail community (paragraph 4.27).

The allegations suggest that top executives at the suppliers were aware of the price increases that occurred. The documents describe an active network of salespeople working for suppliers who communicated with retailers. Their job was to ensure alignment of prices across retailers by communicating one retailer’s acceptance of a price increase to the others and by coordinating the timing of price changes (paragraphs 4.90 and 4.91).

Retailers acted as information conduits between suppliers during the socialization process of a price increase (paragraph 4.94). Information on proposed price increases (dates/magnitude) was passed through retailers from one supplier to another (paragraphs 4.95 and 4.96). The fact that all retail chains stock products from both suppliers facilitated this information transmission between suppliers. This is similar to the network centrality role played by a particular convenience store chain in a recent gasoline price-fixing case studied in Clark and Houde (2013). This chain had long-term vertical contracts with all distributors, thereby allowing “legal” communications with its rival chains’ suppliers.

The court documents allege a 7/10 convention whereby the two leading wholesalers increased price periodically (around once per year) by 7 cents per unit (loaf of bread) and these increases were followed by retail price increases of 10 cents (paragraph 4.34). The documents describe fifteen occasions during which price increases were coordinated. These are summarized in Table 3. In each case the suppliers issue a price-increase letter in which they announce that they will be increasing price at a specific point in time (the effective date). According to the court documents, a price-increase chart was included announcing product names, universal product codes, the original price, and the posted-price increase per unit (paragraph 4.35). From the table we can see that sometimes the price increase was listed as 8 cents or 4%, but according to the court documents they were always 7 cents (paragraph 4.53). On one occasion, the price increase is listed as being 16 cents, but this was, in fact, a double increase (paragraph 4.48). Also, on one occasion, the price-increase
Table 3: Court documents: Price increases

<table>
<thead>
<tr>
<th>Supplier 1</th>
<th>Supplier 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price increase</td>
<td>Date of letter</td>
</tr>
<tr>
<td>1</td>
<td>Feb-02</td>
</tr>
<tr>
<td>2</td>
<td>Unknown</td>
</tr>
<tr>
<td>3</td>
<td>Unknown</td>
</tr>
<tr>
<td>4</td>
<td>Unknown</td>
</tr>
<tr>
<td>5</td>
<td>Unknown</td>
</tr>
<tr>
<td>6</td>
<td>27-Jul-06</td>
</tr>
<tr>
<td>7</td>
<td>Unknown</td>
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<tr>
<td>11</td>
<td>Unknown</td>
</tr>
<tr>
<td>12</td>
<td>Feb-12</td>
</tr>
<tr>
<td>15</td>
<td>02-Dec-15</td>
</tr>
</tbody>
</table>

* indicates failed attempt.

attempt seems to have failed. During the attempted increase in the winter of 2012, Weston did not announce a price increase on certain types of bread. As a result, Canada Bread rescinded its price increase and Weston responded by doing the same (paragraph 4.62).

In Figure 1a we plot these alleged increases against data from Statistics Canada on the average retail price of a loaf (675gr) of bread across the country. The alleged coordinated price increases appear to line up very closely, in terms of both timing and magnitude, with price increases observed in the data on a national level. This suggests that the wholesale price increases listed in the court documents translated into retail price increases.

Figure 1b combines data from consumer price indices for 1995 to 2018 (with 2002=100) for bread, cereal, other bakery, and the aggregate food category. The figure also depicts the price index for hard spring wheat flour and for US bread prices. The red vertical lines indicate the alleged start date of the cartel (Start), the date of the immunity marker (IM), and the date of the allegations by the Canadian Federation of Independent Grocers (CFIG).

The price index for bread grows rapidly starting in 2002, around the time the cartel was alleged to have started.\textsuperscript{17} It can also be seen that the price index falls sharply in 2016 around the time that allegations were made by the GFIG. This pattern can be compared to the pattern for wheat

\textsuperscript{17}Grier (2018) shows a similar pattern during the coordination period.
flour. Between 1995 and the end of 2001 wheat flour prices are similar to, if not greater than, those of bread, rolls, and buns. Wheat flour then experienced a much less pronounced inflation during the coordination period, suggesting that inflation in the bread category between 2002 and 2015 was mostly caused by an increase in the combined profit margin (i.e. retail+wholesale). Note that there were two sharp increases in the price of wheat flour during the coordination period. The first occurred in 2007-2008. This sudden and transitory shock was related to poor harvests, low stocks,
rising oil prices, and financial speculation.\(^\text{18}\) A second, more permanent price increase occurred in 2011. In both cases, the prices of bread, rolls, and buns increased sharply, but then did not fall back down.

Prices for other food categories also experience similar evolution to bread, rolls and buns prior to the start of the cartel, and less pronounced inflation during the coordination period, and do not break sharply at the end of the cartel period. The same is true of US bread prices, although from this series we can also see an increase in 2007-2008 at the time of the cost shock.

Figure 2 plots the difference between the price index of bread and each of the other categories.\(^\text{19}\) As hinted by the evolution of the CPI levels, the price differences are not significantly different from zero (or slightly negative) prior to the start of the cartel, but grow almost linearly afterwards. In each of the four figures, the price differences level-off after 2007. Between 2008 and 2016, the price index for bread is between 20% and 30% higher than the price index of other consumer good categories, and nearly 40% higher than the price of wheat.

The evolution of the price indices across segments and countries clearly displays a pattern of “progressive” coordinated price increases, consistent with the behavior of other known cartels. For instance, Igami and Sugaya (2018) document that vitamin C margins reached their stable levels roughly three years after the beginning of the collusive arrangement. Similarly Allé-Chillet (2018) documents that Chilean pharmacies sequentially raised prices of drugs, starting with the least elastic segments. In addition, the results suggest that markups in the Canadian bread industry during the stable period (2011-2016) were roughly 30 percent higher than for other food-related sectors, and roughly 20 percent higher than for bread in the US. Together with the description of price communications in the court documents, this suggests that the industry successfully sustained supra-competitive prices for an extended period of time.

### 4.2 Evidence of collusion at both ends of the supply chain

The first signs of instability for the cartel arose in March 2015 when Loblaws requested immunity from the Competition Bureau. Later that year, the Canadian Federation of Independent Grocers (CFIG) filed a formal complaint with the Bureau, alleging price fixing in the industry. As mentioned in the introduction to this section, with the exception of the immunity applicant, the retailers have denied the allegations. Therefore, in order to confirm that two-sided hub-and-spoke collusion took place it is necessary to provide evidence that retailers were colluding.

To investigate the role of retail chains in the collusive agreement, we use our outlet-level panel to analyze the decline in prices across markets. Our main hypothesis is that if retailers were engaging in price fixing prior to the CFIG complaint, heterogeneity in retail market structure should lead to differences in profit margins across markets. For instance, differences in chain-level concentration


\(^{19}\)The regression coefficients are available in Tables 6a and 6b in the Appendix.
Figure 2: Relative price differences: Bread vs other products

(a) Bread - Food

(b) Bread - Cereal

(c) Bread - Other bakery

(d) Bread - Wheat

(e) Bread - US vs CA

The confidence intervals and prediction lines are obtained by estimating the following linear regression separately for each category:

\[ CPI_{bt} - CPI_{it} = \alpha_i + \beta_1 \mathbf{1}(2001 < t < 2008) \times (t - t_0) + \beta_2 \mathbf{1}(t \geq 2008) + \varepsilon_t, \]

where \( p_{bt} \) is the bread price index, and \( p_{it} \) is the price index for category \( i \) (i.e. food, cereal, other bakery and wheat).
Table 4: Difference-in-Differences regression. Product controls.
End date: January 4th 2016

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post CFIG</td>
<td>-13.4</td>
<td>-10.3</td>
<td>-3.52</td>
<td>-11.1</td>
</tr>
<tr>
<td></td>
<td>(3.39)</td>
<td>(3.38)</td>
<td>(1.92)</td>
<td>(5.16)</td>
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<tr>
<td>Constant</td>
<td>49.9</td>
<td>41.8</td>
<td>48.8</td>
<td>59.1</td>
</tr>
<tr>
<td></td>
<td>(1.11)</td>
<td>(0.84)</td>
<td>(0.37)</td>
<td>(2.12)</td>
</tr>
<tr>
<td>Observations</td>
<td>72</td>
<td>72</td>
<td>72</td>
<td>72</td>
</tr>
</tbody>
</table>

Standard errors in parentheses.

or heterogeneity across players should affect the level of retail markups sustainable under a hub-and-spoke collusive agreement. To the extent that the investigation triggered the collapse of the agreement, we can indirectly infer the level of involvement on retail chains by testing for the presence of a heterogeneous response to the investigation. On the contrary, if collusion were taking place solely upstream (as opposed to at both ends of the chain), then, since wholesale prices are negotiated at the chain level and do not vary across markets for a given retailer, we should expect price declines that are uniform across markets, and independent of retail-market structure.

We start by formally testing the hypothesis that the allegations of collusion triggered the collapse of the cartel and, with it, a national price decline. We test this hypothesis formally using structural break tests to identify the best candidate date for the end of the cartel. Specifically, we calculate the Quandt Likelihood Ratio statistic, which is a modified Chow test that tests for breaks at all possible dates in some range. The hypothesis of a break at date $t$ is tested for each $t$ in the range using an F-statistic. The Quandt Likelihood Ratio statistic selects the largest of the resulting F-statistics to determine the best candidate break.\footnote{The test was developed by Quandt (1960) and distributional properties were established by Andrews (1993). This test has been suggested and used in previous work involving collusive behaviour (see for instance Harrington (2008), Clark and Houde (2014), Boswijk, Bun, and Schinkel (2018), Crede (2019)).} Results are presented in the appendix and show that the best candidate break occurred in the fall of 2016. Although this is a bit later than the CFIG complaint, we believe that it confirms that the cartel began to collapse prior to the inquiry launched by the Bureau in August 2017. We therefore use the CFIG complaint as the start date for the collapse period.\footnote{We have redone our difference-in-differences analysis below using this alternative break timing and our results are comparable, although the average price decline is slightly larger.}

Table 4 estimates the average bread price decline using alternative product categories as controls. We construct a difference-in-differences estimator that compares differences between bread prices and those of other categories in the two years before the CFIG allegations, with price differences
afterwards. Specifically, we estimate the following linear regression separately for each category:

\[ \text{CPI}_{bt} - \text{CPI}_{it} = \alpha_i + \beta_i 1(t \geq 2016) + \varepsilon_t, \]

where \( p_{bt} \) is the bread price index, and \( p_{it} \) is the price index for category \( i \) (i.e. food, cereal, other bakery and wheat). The results confirm that bread prices fell relative to prices of control groups following the CFIG complaint. The estimates are slightly larger (in absolute value) when using the later break time (fall 2016), suggesting that the collapse was not uniform across markets.

The impact of the cartel’s collapse on prices is smaller than the impact of its origination, although this could be because there has been less time for prices to adjust.\(^{22}\) There is also more heterogeneity across control categories. The CFIG allegations led to at most an 8% decline in relative price differences (for food). In contrast, relative to cereals, the decline is not statistically different from zero. One interpretation of this smaller magnitude is that collusion was taking place mostly upstream, where prices are more sticky due to long-term contracts. That is, we interpret the 6-8% decline as originating mostly from a fall in retail markups.

Next we study the distribution of prices across markets and retailers. Figure 3 illustrates how the distribution of prices changed between 2009 and 2018. Recall that between 2009 and 2012, bread prices increased by nearly 20 cents. This was partly due to a (temporary) increase in wheat flour. Figure 3a plots the distribution of quarterly average prices across cities, while Figure 3b shows the evolution of the inter-quartile range of prices across cities.\(^{23}\)

The first thing to note from these two figures is that there exists a large amount of price dispersion in the data. Note that we average the monthly data to the quarter level, and so this dispersion is not caused by temporary sales. Between 2009 and 2012 however, we see a significant increase in dispersion across cities; the inter-quartile range more than doubles during this time period. It then levels off. This suggests that the important price increase initiated by suppliers in 2011 following the cost shock was not passed-through equally across markets. Figure 3a suggests that the retail price increase was larger in magnitude in “high-price” cities.

The second important takeaway is the sharp decline in price dispersion that took place after the CFIG complaint. Starting in the first quarter of 2016, prices became more uniform across cities. In 2018, the level of price dispersion across cities is equal to the levels observed prior to 2011. This suggests that profit margins in the retail sector declined after the collapse of the agreement.

To analyze the source of this heterogeneity across markets, we combine all the control categories together and run a series of difference-in-differences regressions at the city level. We focus on the

\(^{22}\) Alternatively it could be because cartel participants strategically price above the competitive price following the collapse of the cartel knowing that antitrust authorities use post-collapse prices to calculate damages. See Harrington (2004).

\(^{23}\) The CDER-CPI data set contains information on four different items in the bread, rolls, and buns category. We use the lowest-price item from this group to construct these two distributions, but the results are comparable across all four items.
effect of the collapse of the cartel, again using the allegations made by the Canadian Federation of Independent Grocers. For each city, we calculate the change in the average price for each product category. Specifically, $\bar{p}_{i,m,2018} - \bar{p}_{i,m,2015}$ is the change in the average price of product $i$ in city $m$ from 2015 to 2018. To construct this measure we first remove outlier prices (top/bottom 0.1%). We then drop carry-forward and out-of-stock prices.

Figure 4 plots the distribution of changes in relative prices at the city level (i.e. city-level DiD estimate). Between 2015 and 2018, the median city experienced a $0.26$ decline in bread prices relative to other categories. The figure also shows substantial heterogeneity. More than 10% of cities experienced bread price declines larger than $0.75$ after the beginning of the investigation, while roughly 25% experienced economically small declines or even positive changes.

This heterogeneity helps rationalize the decline in dispersion observed in Figure 3. Some markets reacted very strongly to the price-fixing investigation, while others had very muted responses. In Table 5, we relate this heterogeneity to market structure. In particular, we estimate the following heterogeneous treatment effect regression:

$$\bar{p}_{i,m,2018} - \bar{p}_{i,m,2015} = \alpha + \gamma_m + \beta_1 I(i = b) + \beta_2 I(i = b) \times x_m + \epsilon,$$

where $\gamma_m$ is a city fixed effect, $I(i = b)$ is an indicator for bread, and $x_m$ includes market structure variables. The bread indicator measures the average change in the bread category relative to the other categories in the same city. We also estimate the same regression using the change in within city coefficient of variation (CV) as dependent variable. This allows us to discuss the role of chain heterogeneity in the stability of retail collusion.

Results from the city-level analysis are presented in Table 5. The first two columns present
Figure 4: Distribution of relative bread price decline across cities

<table>
<thead>
<tr>
<th>Percentiles</th>
<th>10%</th>
<th>25%</th>
<th>Median</th>
<th>75%</th>
<th>90%</th>
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<tbody>
<tr>
<td>Relative price change ($)</td>
<td>-.774</td>
<td>-.563</td>
<td>-.256</td>
<td>-.0974</td>
<td>.0685</td>
</tr>
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</table>

Table 5: Effect of market-structure on the decline in bread prices

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1) Avg.</th>
<th>(2) Avg.</th>
<th>(3) CV</th>
<th>(4) CV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(Bread cat)</td>
<td>-0.324***</td>
<td>-0.0159</td>
<td>0.0244</td>
<td>0.0916**</td>
</tr>
<tr>
<td>Bread x HHI (20+)</td>
<td>-0.652**</td>
<td>-0.0284</td>
<td>(0.269)</td>
<td>(0.0655)</td>
</tr>
<tr>
<td>Bread x Single discounter</td>
<td>-0.144</td>
<td>-0.0903***</td>
<td>(0.110)</td>
<td>(0.0283)</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.0225*</td>
<td>-0.0225**</td>
<td>0.0503***</td>
<td>0.0503***</td>
</tr>
<tr>
<td>Observations</td>
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<td>216</td>
<td>216</td>
<td>216</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.255</td>
<td>0.269</td>
<td>0.179</td>
<td>0.214</td>
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</table>

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
results for the change in average price, while the second two show results for the coefficient of variation. Recall that, in both cases, the bread dummy measures the average change in the bread category relative to other categories in the same city. Looking first at the impact on average prices, we can see from column 1 that the point estimate is about -30 cents (approximately 10% of the 2015 average prices). Column 2 looks at the impact of market structure. The results show that the decline was more pronounced in more concentrated markets. The presence of a monopoly discount chain is associated to a larger price decline (14 cents), but the effect is imprecisely estimated.

Turning to the second two columns we see that there is a small increase in within-city dispersion of bread prices relative to other categories. This is mostly felt in markets featuring multiple discounting chains. In markets where there is more than one discounter chain, dispersion increased by 9 percentage points for bread. This is quite large. The coefficient of variation is about 30%. So it is almost a third of the average coefficient of variation.

Together these results suggest that discounter market structure is mostly affecting price dispersion. This is consistent with the idea that in markets with more intense competition among discounters, there seems to be a more important break in collusion. Since this is mostly affecting the dispersion measure, it seems that we are capturing a partial deviation from collusion in those markets.

**Summary:** Our analysis of the court documents and data provides evidence of successful collusion at both ends of the vertical chain. From the court documents it is quite clear that the suppliers coordinated their pricing, but it is less obvious that retailers did. The assumption being tested here is that the CGIF complaint destabilized the cartel, and did so more in markets that were sustaining supra-competitive margins. Under the null hypothesis that retailers were not colluding, the effect of the allegations should not be a function of retail-market structure – the price decrease should be uniform across markets. This is not what we find. The decline was more pronounced in more concentrated grocery markets. This is consistent with retail markups going down to non-cooperative levels in more concentrated markets. Most likely because retailers were coordinating on higher markups in more concentrated markets. Price dispersion increased in markets with more discount chains competition. Uniform prices are often interpreted as a flag of retail collusion. Markets with multiple discount chains broke from “uniform” prices after the announcement. The two-sided hub-and-spoke arrangement led to markups in the Canadian bread industry that were roughly 30% higher than in other food-related sectors.

What remains to be shown is why the arrangement that they settled on was one of two-sided hub-and-spoke. Put differently, why did the participants at either end of the vertical supply chain not form their own cartel that operated separately from the other end of the chain, or why did a simply hub-and-spoke arrangement not develop? To answer these questions, we turn to theory and develop a model that illustrates why a two-sided hub-and-spoke arrangement facilitated collusion.
5  A Model of Two-Sided Hub-and-Spoke Collusion

In this section we propose a model of the bread supply chain. Our objective is to provide insight into (i) the incentives for firms at both ends of the supply chain to collude, and (ii) the reasons a hub-and-spoke arrangement arose. The model also serves to address some of the elements lacking in the previous models of hub-and-spoke collusion. Specifically, our model allows for competition at both ends of the vertical chain, does not involve exclusion (i.e. features multi-sourcing) and explains why collusion should involve competitors at both ends of the chain (i.e. be two-sided in nature).

A basic element of the model is that upstream firms – the wholesalers – provide important services to retailers. These services are costly for the wholesaler to provide but have a public good aspect, so that a single wholesaler’s services benefit a retailer carrying the products of multiple wholesalers. The consequence is that each retailer wants a single wholesaler to be its “main” supplier. Because shelf space is scarce and the service costly, the retailer allocates a larger share of the scarce shelf space to its main supplier. One or more “secondary” suppliers obtain the remaining shelf space share. This main supplier-secondary supplier dichotomy creates and asymmetry between wholesalers and forms a crucial element of our analysis. A second fundamental element is that wholesale prices are the outcome of negotiations between wholesalers and retailers, with wholesalers competing to be the main supplier. We assume that switching main suppliers is costly for the retailer as it must work out service details with a new main supplier. The size of the switching cost determines the relative leverage that the main supplier has in the wholesale price negotiations.

On the retail side, we assume that consumers incur costs if they move across retailers to make purchases. The more consumers who are shoppers and the more sensitive these consumers are to differences in bread prices across retailers, the greater the competition in the retail market for bread. We model these features of the retail bread market by assuming that retailers are separately located in space and compete in price for those consumers willing to shop across locations. A greater fraction of price sensitive consumers induces lower retail prices. A combination of low costs for the retailers of switching suppliers and low costs for consumers of switching retailers induces a situation in which neither the bread makers nor the retailers are making any significant profits.

The combination of an asymmetric supply relationship and endogenous wholesale price setting makes two-sided hub-and-spoke collusion easier to sustain than either supplier-only or retailer-only collusion. Supplier-only collusion is difficult to sustain because the secondary supplier has an incentive to undercut the arrangement and become the main supplier: the asymmetry problem. Retailer-only collusion is hard to sustain because of the incentive that a main supplier has to offer the retailer a lower wholesale price – the endogeneity problem – to induce retail price cutting. Doing so shifts customers from rival retailers at which the wholesaler is not the main supplier to the one at which it is, thereby increasing the wholesaler’s profits. Among other things, joint collusion allows i) retailers to coordinate their shelf share allocations between main and secondary suppliers and ii) wholesalers to coordinate their price offers in ways that resolve both the asymmetry and
endogeneity problems, thereby facilitating coordination.

5.1 Model details

We consider a market in which there are two producers of bread, designated $i = 1, 2$, that produce potentially differentiated varieties. Bread maker 1’s variety is labeled $B_1$ and bread maker 2’s variety $B_2$. Each bread maker produces its variety at a constant unit cost of $c \geq 0$, with the value of $c$ identical across bread makers. Bread makers’ products are sold via retail grocery stores. For simplicity, we assume that there are two grocery retailers, labeled $j = a, b$, operating in locales $L_a$ and $L_b$ respectively. We assume that there are $N_a$ consumers residing in locale $L_a$ and $N_b$ consumers residing in locale $L_b$. We assume in what follows that $N_a = N_b = 1$. Consumers demand at most one unit of one of the two varieties of bread. A consumer in a given locale can be one of three possible types, 1, 2, or 3. A type 1 consumer has a valuation of $v$ for variety $B_1$ and a valuation $g$ for variety $B_2$. Type 2 consumers have the opposite preferences, valuing the variety $B_1$ at $v$ and the variety $B_2$ at $g$. The fraction of type 1 consumers in each locale is the same, as is the fraction of type 2 consumers. These fractions are given by $\phi_1$ and $\phi_2$ respectively. For simplicity, we assume that $\phi_1 = \phi_2 = \phi$. The remaining fraction of consumers in each locale are type 3 consumers. These consumers view the two varieties of bread as identical, having a common valuation of $v$. The three types of consumers’ valuations are such that $v > g > c > v$.

For simplicity, we assume that the type 1 and type 2 consumers in any locale always purchase from the retailer in that locale, if at all. The type 3 consumers in each locale are the potential shoppers. The fraction of homogeneous types that may shop is given by a shopping-propensity parameter, $\tau \in [0, 1]$. The value of $\tau$ can be thought of as a retailer density measure, capturing the fraction of shoppers that find it “cheap” to move across locations. Whether or not these type 3 consumers shop depends on the retail bread price difference between locales, $p_a^{\text{min}} - p_b^{\text{min}}$, where $p_a^{\text{min}}$ gives the minimum retail price of bread in locale $a$ and $p_b^{\text{min}}$ the minimum retail price of bread in locale $b$. A type 3 consumer who shops will purchase at the lower-priced locale if $| p_a^{\text{min}} - p_b^{\text{min}} | > \Psi > 0$. The parameter $\Psi$ reflects their degree of loyalty to their retailer. We assume that shopping consumers are heterogeneous in $\Psi$. For simplicity, we assume that $\Psi$ is uniformly distributed on the interval $[0, \bar{\Psi}]$, with density $1/\bar{\Psi} = d$.

The state of retail competition is determined by the pair $[\tau, \bar{\Psi}]$, with greater competition as $\tau$ increases and $\bar{\Psi}$ decreases. That is, if either $\tau = 0$ or $\bar{\Psi}$ large enough, then the two retailers have local monopolies in the sense that, either there are no shoppers or the duopoly price exceeds consumers willingness-to-pay. By contrast, when $\bar{\Psi}$ is small and $\tau = 1$, then duopoly competition for the type 3 consumers results in low retail prices.

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24This specification is meant to capture the idea that grocery retailers are spatially separated and that consumers tend to frequent a grocery store near them. We imagine that at least some of the customers of any given retailer are shoppers in the sense that a sufficiently large price difference across retailers would induce these consumers to switch retail locations.
Given our focus only on bread, and not the full range of products that large grocery stores sell, we assume for the model that the only cost of selling a particular variety of bread for the retailer is the wholesale price, $w_i$, paid to bread maker $i$. Retail bread prices are assumed to be set sequentially after wholesale bread prices. This assumption is consistent with industry practice in which wholesale prices are negotiated intermittently at the chain-wide level. When determining its retail price(s), each retailer is assumed to observe the selection of varieties that its competitor carries and which wholesaler is the main supplier. A retailer is assumed not to observe the actual wholesale prices that its competitor negotiated with its wholesale suppliers. Given knowledge of their own wholesale prices and the anticipated equilibrium wholesale prices for their competitor, each retailer simultaneously sets retail bread prices to maximize profits.

The wholesale price negotiation process involves each grocery retailer taking wholesale price proposals / bids from each of the two bread makers. The “winning” bidder becomes the main supplier and is paid its wholesale price bid for each unit supplied. As the main supplier, the wholesaler obtains a share of shelf space – a shelf share – $s > .5$. In exchange for the greater shelf share, the main supplier provides “free-of-charge” services to the retailer. These services result in a fixed cost of, $F_I$ for the wholesaler. The other wholesaler – the “losing” bidder – becomes the secondary supplier and is paid its price bid. The secondary supplier obtains a shelf share of $1 - s$ and incurs some lower fixed cost of supplying the retailer denoted by $F_S < F_I$. The shelf shares are set so that the larger share at least compensates for the higher fixed cost.

In keeping with observed features of the industry, at the beginning of the wholesale price negotiation process, one of the two suppliers is the incumbent main supplier. Switching main suppliers is assumed costly for the retailer as new arrangements must be put in place for the retail services provided. We model this switching cost as a fixed cost, $\Delta$, incurred by the retailer should it switch main suppliers. The value of $\Delta$ is not known to the bread suppliers prior to submitting their wholesale price bids. Rather, suppliers view $\Delta$ as a random variable which, for simplicity, we assume has a uniform distribution on the interval $[0, \bar{\Delta}]$. The existence of this switching cost gives the incumbent supplier an advantage in the wholesale price negotiations in that it can offer a wholesale price above that of the secondary supplier and still maintain its incumbent status with non-trivial probability. As will be seen subsequently, the size of $\bar{\Delta}$ is a measure of the leverage that the incumbent supplier has in the wholesale price negotiation game, with incumbent profits increasing in $\Delta$.

The wholesale pricing game involves each of the two wholesalers simultaneously making wholesale price bids to each of the two retailers. The wholesalers make these bids knowing who is the incumbent supplier to each retailer. Each wholesaler chooses bids to maximize the expected value of its profits, anticipating how its bids affect the retail pricing equilibrium. The equilibrium to the one-shot game is the symmetric perfect Bayesian equilibrium to the sequential pricing game.\footnote{This assumption is in keeping with the assumption in much of the contracting literature. It also provides a direct information role for joint retailer-wholesaler collusion.}
We start our analysis by first determining the equilibrium for static one-shot pricing game. We do so by solving the game backwards, looking first at the retailer pricing game and then studying how the wholesalers price. Subsequently, we analyze both wholesale and retail price setting in a repeated game to understand the value of two-sided hub-and-spoke collusion.

5.2 Static setting

5.2.1 Retail pricing

Since $\Psi$ is uniformly distributed on the interval $[0, \bar{\Psi}]$, with density $1/\bar{\Psi} = d$, if retail prices are $p_a$, $p_b \leq v$, then demand for retailer $a$ is given by:\[Q^R_a = [1 + \tau d (1 - 2\phi)(p_b - p_a)].\]

Profits for retailer $a$ are

$$\pi^R_a = (p_a - W_a)[1 + \tau d (1 - 2\phi)(p_b - p_a)],$$

where $W_a = sw_M + (1 - s)w_S$ is the shelf share weighted average of the wholesale prices, $(w_M, w_S)$ paid by retailer $a$ to its main supplier and secondary supplier respectively. Retailer $a$’s profits maximizing price, given some price, $p_b$, for retailer $b$ is given by

$$[1 + \tau d (1 - 2\phi)(p_b - p_a)] - [\tau d (1 - 2\phi)](p_a - W_a) = 0,$$

or

$$p_a = \frac{1}{2} (p_b + W_a) + \frac{1}{2} \tau d (1 - 2\phi).$$

The Nash equilibrium retail price for retailers $a$ and $b$, given average wholesale prices $(W_a, W_b)$ are then:

$$p^*_a(W_a, W_b) = \frac{1}{\tau d (1 - 2\phi)} + \frac{2}{3} W_a + \frac{1}{3} W_b,$$

$$p^*_b(W_a, W_b) = \frac{1}{\tau d (1 - 2\phi)} + \frac{2}{3} W_b + \frac{1}{3} W_a.$$ 

Note that as either $\phi$ shrinks or $t$ increases, there are more shoppers and $p^*_j$ falls. When $d$ increases, $p^*_j$ falls also. In this case, $d$ increasing implies that $\Psi$ shrinks, so there are also more shoppers (less local-retailer loyalty).

\[\text{26} \text{We assume here and in what follows that parameters are such that it is more profitable for a retailer to serve all types at a common price than to serve only types 1 and 2. This assumption is a restriction on the numbers of type 1 and 2 consumers and the values of } F_I \text{ and } F_S.\]
In a symmetric equilibrium (i.e. symmetric prices at both wholesale and retail level), the expected quantity sold by each retailer is 1 and expected profits are

\[ E\pi^R_j = (EW + \frac{1}{\tau d(1 - 2\phi)} - EW) = \frac{1}{\tau d(1 - 2\phi)}. \]  

(8)

where \( EW \) gives the expected value of the average wholesale price in equilibrium. Note that expected profits are declining in \( t \) and \( d \) and increasing in \( \phi \).27

Finally, a local monopoly must ensue if

\[ p^* = (W + \frac{1}{\tau d(1 - 2\phi)}) > v, \]

which will occur if \( \tau \) is small, and/or \( d \) is small (i.e. \( \Psi \) is big).

### 5.2.2 Wholesale pricing

Suppose that, initially, wholesaler 1 is the incumbent main supplier to retailer \( a \) and wholesaler 2 the incumbent main supplier to retailer \( b \). Then, given wholesale price bids to retailer \( a \) by wholesalers 1 and 2 of \( (w^a_1, w^a_2) \), wholesaler 1 remains the main supplier if \( w^a_1 - w^a_2 \leq \Delta \). If, however, \( w^a_1 - w^a_2 > \Delta \) then retailer \( a \) switches and makes wholesaler 2 the main supplier. Given the assumption that \( \Delta \) is uniformly distributed, this means that retailer \( a \) switches main suppliers with probability \( \frac{w^a_1 - w^a_2}{\Delta} \). The same would apply for wholesaler 2 as the incumbent to retailer \( b \).

To establish some initial results on wholesale pricing, we begin with the case in which retailers are local monopolies. We then extend the analysis to the case of competing duopoly retailers.

#### Local monopoly

If the two retailers are local monopolies, then we have that, for any bid pair \( (w^a_1, w^a_2) \) to retailer \( a \), the expected profit for wholesaler 1, as the incumbent supplier to retailer \( a \) is:

\[ \pi^w_1(w^a_1; w^a_2) = (w^a_1 - c) \left[ s \left( 1 - \frac{w^a_1 - w^a_2}{\Delta} \right) + (1 - s) \left( \frac{w^a_1 - w^a_2}{\Delta} \right) \right] - F_I + (F_I - F_S) \frac{w^a_1 - w^a_2}{\Delta}. \]

For the same bid pair, the expected profit for wholesaler 2 as the secondary supplier to retailer \( a \) is:

\[ \pi^w_2(w^a_1; w^a_2) = (w^a_2 - c) \left[ (1 - s) \left( 1 - \frac{w^a_1 - w^a_2}{\Delta} \right) + s \left( \frac{w^a_1 - w^a_2}{\Delta} \right) \right] - F_S - (F_I - F_S) \frac{w^a_1 - w^a_2}{\Delta}. \]

---

27 Note that expected profits are independent of the expected value of \( W \) in the symmetric equilibrium. This does not mean, of course, that a retailer is indifferent about the value of \( W \). Given any value of \( W \), retailer \( a \) would strictly prefer to have a lower value of \( W \).
For bids to retailer b, the retailer for which wholesaler 2 is the incumbent, the opposite holds in terms of expected profits.28

Given the retailers are local monopolists, we can examine the wholesale price bidding to each retailer separately. In this case, the profit maximizing values of \( w_1^a \) and \( w_2^a \) offered to retailer a by wholesalers 1 and 2 respectively, given main supplier shelf share \( s \), are given by

\[
\frac{d\pi^w}{dw_1^a} = 0 \quad \Leftrightarrow \quad s - \frac{w_1^a - w_2^a}{\Delta} (2s - 1) - (w_1^a - c) \frac{2s - 1}{\Delta} + \frac{(F_I - F_S)}{\Delta} = 0, \\
\frac{d\pi^w}{dw_2^a} = 0 \quad \Leftrightarrow \quad 1 - s + \frac{w_1^a - w_2^a}{\Delta} (2s - 1) - (w_2^a - c) \frac{2s - 1}{\Delta} + \frac{(F_I - F_S)}{\Delta} = 0.
\]

Solving these two equations, we obtain the equilibrium bids, \((w_1^{a*}, w_2^{a*})\):

\[
w_1^{a*} = c + \frac{\Delta (s + 1)}{3(2s - 1)} + \frac{F_I - F_S}{2s - 1}, \quad w_2^{a*} = c + \frac{\Delta (2 - s)}{3(2s - 1)} + \frac{F_I - F_S}{2s - 1}.
\]

Since \( s > 1/2 \), we have that \( w_1^{a*} > w_2^{a*} > c \). Indeed, it is straightforward to show that \( w_1^{a*} - w_2^{a*} = \Delta / 3 \). This means that, under the equilibrium bidding strategies, wholesaler 1 remains the main supplier with probability 2/3, while wholesaler 2 becomes the main supplier with probability 1/3. This implies that, in the local monopoly equilibrium, a retailer’s expected unit costs are:

\[
EW(s) = c + \frac{F_I - F_S}{2s - 1} + \frac{\Delta}{3} \frac{1}{2s - 1}.
\]  

(10)

Note that this expression is a decreasing function of \( s \), which means that the retailer’s profit maximizing choice of \( s \) must be to set \( s \) as large as possible consistent with wholesaler 2 participating when it is the secondary supplier. That is, the value of \( s \) is defined so that \((w_2^{a*} - c)(1 - s) = F_s\). This yields the local monopoly equilibrium shelf share, \( s^* \) as:

\[
F_I \frac{\Delta (2 - s)(1 - s)}{3(2s - 1) + \Delta (2 - s)(1 - s)} = F_s.
\]

**Duopoly**

Turning next to the case of duopoly retailers, now when a wholesaler chooses its wholesale price bids, the wholesaler must anticipate the duopoly retail pricing outcomes that may arise and the ensuing quantities that each retailer sells. These quantities determine the wholesaler’s sales to each retailer. The value of these sales to the wholesaler depends on whether the wholesaler is the main or secondary supplier to a given retailer. As a consequence, wholesale price competition is now not just about a competition for the larger shelf share but also about shifting the duopoly retail

28Because the markets are symmetric, we will examine the equilibrium bids to retailer a in what follows.
equilibrium in a way that is expected to favor a given wholesaler.

Recall from the retail pricing section that the price set by each retailer depends on the average wholesale price faced by that retailer. When wholesaler 1 makes a wholesale price bid of \( w_1 \) to retailer \( a \) and expects wholesaler 2 to make the duopoly equilibrium bid \( w_2^{a*} \), then the average wholesale price that wholesaler 1 expects retailer \( a \) to face is:

\[
W(w_1, w_2^{a*}) = sw_1 + (1 - s)w_2^{a*} + [(1 - s)w_1 + sw_2^{a*}] \frac{w_1 - w_2^{a*}}{\Delta},
\]

or

\[
W(w_1, w_2^{a*}) = sw_1 + (1 - s)w_2^{a*} - \left( \frac{w_1 - w_2^{a*}}{\Delta} \right)^2 (2s - 1).
\]

An analogous expression holds for the average wholesale price that wholesaler 1 expects retailer \( b \) to face, \( W(w_2^{b*}, w_1) \), with \( w_2^{b*} \) replacing \( w_1 \) and \( w_1 \) replacing \( w_2^{a*} \).\(^{29}\) The implications of these information assumptions become clear when considering possible wholesale price deviations. For instance, suppose that wholesaler 1, the incumbent wholesaler for retailer \( a \) and secondary supplier for retailer \( b \), considers a wholesale price deviation to one or both retailers of \( (\tilde{w}_1^a, \tilde{w}_1^b) \). In this case, retailer \( a \) only observes the deviation \( \tilde{w}_1^a \) and retailer \( b \) only the deviation \( \tilde{w}_1^b \). Each retailer assumes that the other retailer faces the equilibrium set of wholesale prices and sets retail prices accordingly. Therefore, when wholesaler 1 considers prices deviations to retailers \( a \) and \( b \) respectively, wholesaler 1 assumes that retailer \( a(b) \) sets its retail price as a best response to retailer \( b(a) \) pricing based on obtaining the equilibrium wholesale price bids. These assumptions determine the quantities that wholesaler 1 anticipates selling via retailers \( a \) and \( b \) under the deviation, and therefore, whether the deviation is profitable. We utilize them below to determine the duopoly equilibrium wholesale bids.

Recall from the retail pricing section that the price set by each retailer depends on the average wholesale price faced by that retailer. When wholesaler 1 makes a wholesale price bid of \( w_1 \) to retailer \( a \) and expects wholesaler 2 to make the duopoly equilibrium bid \( w_2^{a*} \), then the average wholesale price that wholesaler 1 expects retailer \( a \) to face is (assuming, as before, that wholesaler 1 is the incumbent supplier to retailer \( a \) and the secondary supplier to retailer \( b \)):

\[
W(w_1, w_2^{a*}) = sw_1 + (1 - s)w_2^{a*} - \left( \frac{w_1 - w_2^{a*}}{\Delta} \right)^2 (2s - 1).
\]

An analogous expression holds for the average wholesale price that wholesaler 1 expects retailer \( b \) to face, \( W(w_2^{b*}, w_1) \), with \( w_2^{b*} \) replacing \( w_1 \) and \( w_1 \) replacing \( w_2^{a*} \).\(^{30}\)

\(^{29}\)In the average wholesale price expression, \( W(., .) \), the first value is the wholesale price bid of the incumbent and the second the bid of the secondary supplier.

\(^{30}\)In the average wholesale price expression, \( W(., .) \), the first value is the wholesale price bid of the incumbent and
If retailer $a$’s wholesale price bids are $(w_1^a, w_2^a)$ and if it anticipates that retailer $b$ has received equilibrium wholesale price bids of $(w_2^{bs}, w_1^{bs})$, then from the previous section, retailer $a$’s expected price is:

\[
\frac{2}{3} \bar{W}(w_1^a, w_2^a) + \frac{1}{3} \bar{W}(w_2^{bs}, w_1^{bs}) + \frac{1}{td(1 - 2\phi)}.
\]

Similarly, if retailer $b$’s wholesale price bids are $(w_1^{bs}, w_2^b)$ and if it anticipates that retailer $a$ has received equilibrium wholesale price bids of $(w_1^{as}, w_2^{as})$, then from above, retailer $b$’s expected price is:

\[
\frac{2}{3} \bar{W}(w_2^{bs}, w_1^b) + \frac{1}{3} \bar{W}(w_1^{as}, w_2^{as}) + \frac{1}{td(1 - 2\phi)}.
\]

Finally, if wholesaler 1 offers wholesale price bid $w_1$ to retailer $a$ and $w_1^b$ to retailer $b$, anticipating that wholesaler 2 will offer equilibrium bids, then the quantities that wholesaler 1 expects that retailers $a$ and $b$ sell under this bidding scheme are (recall that $Q_j = 1 + td(1 - 2\phi)(p_j - p_{-j})$):

\[
Q_a(w_1^a, w_2^a, w_2^{bs}, w_1^{bs}) = 1 + \frac{2}{3} td(1 - 2\phi)(\bar{W}(w_2^{bs}, w_1^b) - \bar{W}(w_1^a, w_2^{as}))
\]

\[
Q_b(w_2^{bs}, w_1^b, w_1^a, w_2^{as}) = 1 + \frac{2}{3} td(1 - 2\phi)(\bar{W}(w_1^a, w_2^{as}) - \bar{W}(w_2^{bs}, w_1^b)).
\]

Given these expected quantities, wholesaler 1’s expected profit from wholesale price bids $(w_1^a, w_1^b)$ can be written as:

\[
\pi_1(w_1^a, w_1^b) = (w_1^a - c)((1 - \frac{w_1^a - w_2^{as}}{\Delta})(1 - s)Q_a(w_1^a, w_2^a, w_2^{bs}, w_1^{bs}) - F_I + (F_I - F_S)\frac{w_1^a - w_2^{as}}{\Delta} + (w_1^b - w_2^{bs})(1 - s)\frac{w_2^{bs} - w_1^b}{\Delta}Q_b(w_2^{bs}, w_1^b, w_1^a, w_2^{as}) - F_S - (F_I - F_S)\frac{w_2^{bs} - w_1^b}{\Delta}.
\]

Wholesaler 1’s equilibrium bids will be values of $w_1^a, w_1^b$ that maximize its expected profits. In a symmetric equilibrium, these bids will satisfy the following two first-order conditions:

\[
\left[ s - (2s - 1)\frac{w_1^a - w_2^{as}}{\Delta} - \frac{1}{\Delta}(w_1^a - c)(2s - 1) \right] + \frac{F_I - F_S}{\Delta} + \left[ (w_1^a - c)s - (w_1^a - c)(2s - 1)\frac{w_1^a - w_2^{as}}{\Delta} \right] \frac{dQ_a}{dw_1^a} + \left[ (w_1^b - c)(1 - s) + (w_1^b - c)(2s - 1)\frac{w_2^{bs} - w_1^b}{\Delta} \right] \frac{dQ_b}{dw_1^a} = 0
\]

the second the bid of the secondary supplier.
and
\[
\left[1 - s + (2s - 1) \frac{w^b_2 - w^b_1}{\Delta} - \frac{1}{\Delta} (w^b_1 - c)(2s - 1)\right] + \frac{F_I - F_S}{\Delta}
+ \left[(w^b_1 - c)(1 - s) + (w^b_1 - c)(2s - 1) \frac{w^b_2 - w^b_1}{\Delta}\right] \frac{dQ_b}{dw^b_1}
+ \left[(w^a_1 - c)s - (w^a_1 - c)(2s - 1) \frac{w^a_1 - w^a_2}{\Delta}\right] \frac{dQ_a}{dw^a_1} = 0
\]  
(12)

where \(\frac{dQ_a}{dw^a_1} = -\frac{2}{3}td(1 - 2\phi)\frac{dW}{dw^a_1} < 0\) and \(\frac{dQ_b}{dw^b_1} = -\frac{dQ_a}{dw^a_1}\) (and similarly for derivatives with respect to \(w^b_1\)).

Note that, if we evaluate the above first-order conditions at the local monopoly wholesale price bids for each wholesaler, then the first bracketed expression is zero in both. The second and third bracketed expressions are just expected per unit profits and so are positive. Further, since wholesaler 1 is the incumbent for retailer \(a\) and the secondray supplier for retailer \(b\), expected per unit profits from \(a\) (the second bracketed expression) are larger than those from \(b\) (the third expression). Since \(\frac{dQ_b}{dw^b_1} = -\frac{dQ_a}{dw^a_1}\), this means that wholesaler 1 gains by reducing its wholesale bid to retailer \(a\). Doing so obviously steals profits from itself in market \(b\) but this is more than made up by increased profits in market \(a\) where 1 is the incumbent. The opposite will hold for retailer \(b\), where wholesaler 1 is the secondary supplier. Here, 1 will want to raise its wholesale price bid to retailer \(b\). In essence, wholesaler 1 wants to adjust its price bids to drive customers away from retailer \(b\), where it is the secondary supplier, and toward retailer \(a\), where it is the main supplier. Symmetrically, wholesaler 2 wants to adjust its wholesale price bids to do the opposite.

The following proposition characterizes the duopoly equilibrium. Proofs are provided in the appendix.

**Proposition 1.** If wholesaler 1 the incumbent in market \(a\) and the secondary supplier in market \(b\), then, in the symmetric duopoly equilibrium, relative to the local monopoly case i) the relative wholesale price \(w^a_1/(w^a_2)\) is lower, ii) the difference in prices \((w^a_1 - w^a_2)\) is lower, implying that iii) the probability that the retailer switches incumbent suppliers is lower, and iv) the average wholesale price is lower. In addition, wholesale prices are decreasing in \(t\) and \(d\). If the same wholesaler is the incumbent supplier to both retailers, then wholesale prices are set at the local monopoly level.

### 5.3 Collusive rings along the supply chain

We know from the duopoly pricing results that, when \(t\) and \(d\) are high, retail prices are low for any given value of \(W\). Further, from the wholesale pricing section, we have that the equilibrium wholesale prices are also declining in \(t\) and \(d\). In this case, both wholesalers and retailers have incentives to collude in order to raise their respective prices. The issue that must be addressed, however, is what the wholesalers and retailers gain from forming a joint collusive ring rather than each group just colluding separately.
What proves fundamental to gaining an advantage for the joint collusive arrangement is the asymmetry in the wholesale market induced by the main supplier-secondary supplier arrangement. This asymmetry has two effects. First, as is usual, it makes independent collusion by the wholesalers difficult: the secondary supplier has significant incentives to deviate. In addition, as was demonstrated above, the incumbent supplier has incentives to induce price competition in the retail market in order to shift customers away from the retailer for which it is a secondary supplier. If the wholesalers are not able to collude effectively, this spillover of wholesale competition into the retail market can undermine retailer collusion. The solution is for the group to form a collusive ring.

In the analysis to follow we demonstrate these claims. In particular, we show that a jointly collusive ring relaxes the standard repeated game incentive constraints associated with separate wholesaler and retailer collusion. By so doing, the jointly collusive arrangement expands the set of prices / parameters for which collusion is sustainable. In this sense, it enhances collusion relative to separate collusive practices.

5.3.1 The repeated game setting

To start, we assume a standard repeated game setting in which there is a countable infinity of periods labeled \( t = 1, 2, \ldots \). In each period, the two retailers first hold simultaneous and independent auctions with the two wholesalers to determine wholesale prices and shelf space allocations. Once the wholesale prices and shelf space allocations are determined, the two retailers simultaneously choose retail prices.\(^{31}\) As before, each retailer knows its own wholesale prices and shelf space allocation and the identity of the other retailer’s main supplier before setting its retail price. At the end of the period, all prices and shelf space allocations are known to all players. We restrict players’ strategy choices to stationary Markov strategies and assume that they choose these strategies to maximize the expected present value of profits. Players share a common discount factor given by \( \beta \) with \( 0 \leq \beta \leq 1 \). We look for symmetric, Markov perfect equilibrium outcomes.

To address the question of joint versus independent collusive behavior, we need some notion of how to distinguish one from the other. For the wholesalers, we consider independent wholesaler collusion to involve two elements. First, the collusive wholesale prices must mimic the non-cooperative solution in the sense of having the difference between the incumbent and secondary supplier prices identical to those in the non-cooperative equilibrium. Second, retailers continue to set shelf share allocations so that profits of the secondary supplier are zero. The essence of the assumption is that, in the case of independent wholesaler collusion, the wholesalers choose prices so as not to reveal their collusive behavior to the (non-cooperating) retailers and retailers continue to respond by allocating shelf space to minimize wholesaler profits. For retailers, independent retailer collu-

\(^{31}\)This timing of wholesale and retail price determination is not completely in keeping with the facts of the bread market where wholesale prices are committed to for a period of up to 1 year.
sion involves separate and independent wholesale price negotiations and shelf share allocations but cooperation on retail prices. Finally, with independent collusion, deviation results in reversion to the non-cooperative equilibrium only in the markets – wholesale or retail – in which the deviation occurred.

For joint collusion, the wholesalers and retailers can jointly decide on wholesale and retail prices and shelf share allocation. The only constraint is that the collusive outcomes satisfy the relevant repeated game incentive constraints. With joint collusion, these constraints can allow for any deviation by any party to result in reversion to the non-cooperative equilibrium for all parties.

5.3.2 A note on the non-cooperative wholesale equilibrium

The one-shot wholesale bidding game analysed so far can be thought of as a multi-period setting in which $\beta = 0$. In this setting, the wholesalers compete solely to obtain the larger shelf share allocated to the supplier chosen as the main supplier. The existing (incumbent) main supplier has an advantage in this bidding game because of the cost, $\Delta$, that the retailer incurs in switching main suppliers. This switching cost allows the incumbent main supplier to set a higher wholesale price and yet still maintain a significant chance of continuing as the main supplier. As a result, in equilibrium, the incumbent sets a higher wholesale price than the secondary supplier and obtains a higher expected profit.

When $\beta > 0$, the profit differential enjoyed by the incumbent main supplier becomes an additional (i.e., beyond the larger shelf share) source of wholesale price competition. The non-cooperative equilibrium must account for this added source of competition when we shift to a repeated game setting. The non-cooperative equilibrium in the repeated game will be the symmetric, stationary, Markov perfect equilibrium that solves the following problem:

\[
V_{IS}^*(w_1^a, w_2^a, w_1^b, w_2^b) = \max_{w_1^a, w_1^b} [(w_1^a - c)s - (w_1^a - c)(2s - 1)\frac{w_1^a - w_1^b}{\Delta}]Q_a
+ [(w_1^b - c)(1 - s) + (w_1^b - c)(2s - 1)\frac{w_1^a - w_1^b}{\Delta}]Q_b
- F_I + (F_I - F_S)\frac{w_1^a - w_2^a}{\Delta} - F_S - (F_I - F_S)\frac{w_1^b - w_1^b}{\Delta}
+ \beta \{V_{IS}^* + (1 - \frac{w_1^a - w_2^a}{\Delta})(\frac{w_1^a - w_1^b}{\Delta})(V_{II}^* - V_{IS}^*) - (1 - \frac{w_1^a - w_2^a}{\Delta})(\frac{w_1^a - w_1^b}{\Delta})(V_{IS}^* - V_{SS}^*)\}
\]

and

\[
V_{SS}^*(w_S, w_I^*) = \max_{w_S} 2[(w_S - c)(1 - s) + (w_S - c)(2s - 1)\frac{w_I^* - w_S}{\Delta}]Q - 2F_S - 2(F_I - F_S)\frac{w_I^* - w_S}{\Delta}
+ \beta \{V_{SS}^* + (2 - \frac{w_I^* - w_S}{\Delta})(\frac{w_I^* - w_S}{\Delta})(V_{IS}^* - V_{SS}^*) + (\frac{w_I^* - w_S}{\Delta})^2(V_{II}^* - V_{IS}^*)\}\]
and

\[ V_{II}^*(w_I, w_S^*) = \max_{w_I} 2[(w_I - c)s - (w_I - c)(2s - 1)\frac{w_I - w_S^*}{\Delta}Q - 2F_I + 2(F_I - F_S)\frac{w_I - w_S^*}{\Delta} + \beta\{V_{II}^* - (2 - \frac{w_I^* - w_S}{\Delta})(\frac{w_I^* - w_S}{\Delta})(V_{II}^* - V_{IS}^*) - (\frac{w_I^* - w_S}{\Delta})^2(V_{IS}^* - V_{SS}^*)\} \]

and where \( w_I(w_S) \) is the common price set by a wholesaler who is the incumbent (secondary) supplier to both retailers, \( E_S V_I^* \) is the expected value to the wholesaler should it become the incumbent supplier to one retailer in the bidding game and given it is the secondary supplier for the other retailer. The other expectations are defined similarly.

The important property of this equilibrium is that, in the \( IS \) state, the incentive for both the incumbent and secondary suppliers is to set lower wholesale prices than in the static duopoly situation. Doing so increases the odds of remaining / becoming the incumbent supplier and capturing the rents from that state. In the \( II \) state, the wholesale prices are the ones that arise in the multiperiod local monopoly setting.

### 5.3.3 Independent versus joint collusion

The most straightforward way to understand the benefit of joint collusion, is to consider the problem of the retailers colluding independently of the wholesalers. If, in this case, they set some common retail price, \( p_c > p^* \), then, for some average wholesale price of \( \overline{W} \), they obtain collusive profits of:

\[ \pi^c_j = \frac{1}{1 - \beta}(p^c - \overline{W}^*)N. \]  

(13)

Assuming Nash reversion occurs after any deviation, then the incentive constraint for retailer only collusion is:

\[ \frac{1}{1 - \beta}(p^c - \overline{W}) \geq (\hat{p} - \overline{W})Q(\hat{p}, p^c) + \frac{\beta}{1 - \beta}(p^* - \overline{W}) \]

(14)

where \( \hat{p} \) is the best one-shot deviation price, given the other retailer is setting a price of \( p^c \), and \( Q(\hat{p}, p^c) \) is the associated quantity sold.

Of course, in contrast to the typical retailer collusive incentive constraint, the above constraint is different because the value of \( \overline{W} \) is not a parameter. Rather, its value is determined by the wholesale market equilibrium and the state of competition there. So if, for instance, the wholesalers do not collude, the value of \( \overline{W} \) that would induce though, depends on how successfully the retailers are colluding. If there is no profitable price deviation that a wholesaler can make that induces retailers to lower price below \( p_c \), as would be the case if \( \beta \) were close to 1, then the one-shot equilibrium in the wholesale market is the local monopoly wholesale price equilibrium. As the value of \( \beta \) declines, however, the wholesalers are able to induce a price cut by altering wholesale price, as in the duopoly equilibrium, and so destroy the collusive arrangement.
The basic point is that, because the value of $W$ is endogenous, the wholesale collusive outcomes and the retail collusive outcomes can only be defined jointly. If we define the state $\Sigma$ as either $IS$ (a wholesaler is the incumbent to one retailer and secondary supplier to the other) or $II$ (a wholesaler is the incumbent supplier to both retailers), then the symmetric collusive outcomes giving retail price, $p^c$, incumbent wholesale price, $w^Ic$, secondary supplier wholesale price, $w^Sc$, and shelf share, $s^c$, are defined by the set $p^c, w^Ic, w^Sc, s^c$ that satisfy appropriate incentive constraints for both the wholesalers and the retailers. The set may also have to satisfy other constraints depending on whether collusion is independent or joint.

For joint collusion, the collusive group of retailers and wholesalers are free to choose any values of for prices and shelf share. Further, we assume that deviation by any party to the collusive arrangement destroys collusion for all parties: the game reverts to the one-shot Nash play for both retailers and wholesalers. In this case, the set of collusive outcomes is the set, $p^{hc}, w^{Ihc}, w^{Shc}, s^{hc}$, that satisfies the following set of incentive constraints:

$$(p^{hc} - W_{\Sigma})Q + \beta \Pi^{hc}_{\Sigma} \geq (\bar{p} - W_{\Sigma})Q(\bar{p}, p^{hc}) + \beta \Pi^{*}_{\Sigma}V^{hc}_{\Sigma}\geq \bar{\Pi}w_{\Sigma} + \beta V^{*}_{\Sigma}$$

where $\bar{p}$ gives the best price deviation for the retailer and $\bar{\Pi}w_{\Sigma}$ gives the best one-shot deviation for the wholesaler. The incentive constraints for independent collusion are defined analogously.

For independent collusion, as referenced above, the wholesalers are constrained to choose values of wholesale prices such that the difference $w^{lc} - w^{Sc}$ is the same as in the non-cooperative solution. Further, the value of $s^c$ is set such that the secondary supplier earns zero profits. Further, we have that, in this case, i) retailer deviation only results in Nash reversion in the retailer market and ii) wholesaler deviation only results in Nash reversion in the retail market if the deviation also induces retailer deviation. So, for independent collusion, we have that the collusive outcome is described by the set $p^c, w^{Ic}, w^{Sc}, s^c$ that satisfy the wholesale price difference and share constraints and the following incentive constraints:

$$V^{IS}(w^a_1, w^b_2, w^a_2, w^b_1) = \max_{w^a_1, w^b_1}[(w^a_1 - c)s - (w^a_1 - c)(2s - 1)\frac{w^a_1 - w^a_2}{\Delta}]Q_a$$
$$+ [(w^b_1 - c)(1 - s) + (w^b_1 - c)(2s - 1)\frac{w^b_1 - w^b_2}{\Delta}]Q_b$$
$$- F_{IS} + \beta E_{IS}V^*,$$

and

$$V^{SS}(w_S, w_I^*) = \max_{w_S}2[(w_S - c)(1 - s) + (w_S - c)(2s - 1)\frac{w_I^* - w_S}{\Delta}]Q$$
$$- 2F_{SS} + \beta 2E_{SS}V^*$$
and

\[ V_{II}^*(w_I, w_S) = \max_{w_I} 2[(w_I - c)s - (w_I - c)(2s - 1)\frac{w_I - w_S^*}{\Delta}]Q - 2F_{II} + \beta E_{II}V^*. \]

and where \( w_I(w_S) \) is the common price set by a wholesaler who is the incumbent (secondary) supplier to both retailers. The expression \( E_{IS}V^* \) gives the expectation of the value function evaluated along the equilibrium path and conditional on a wholesaler being initially in state \( IS \) (incumbent to one retailer and secondary supplier to the other); the others are defined analogously. Finally, \( E_{IS} \) gives the expected fixed cost in the current period given the wholesaler begins the period in the state \( IS \).

5.3.4 An illustration

The parameter values I am assuming are: \( c = 0 \Delta = .5 \) \( F_I = .215 \) \( F_S = .185 \). In this case, the local monopoly outcomes are: \( s = .7 \) \( w_I = .78 \) \( w_S = .617 \) and the average per unit cost is XX if the incumbent remains the main supplier and XX if the retailer switches main suppliers (which happens if the realized value of \( \Delta \) is small). The main supplier makes profits of XX while the secondary supplier, by construction, earns zero. The probability that the retailer switches main suppliers is XX.

For the duopoly situation when the state is \( IS \), the additional parameter assumptions are: \( \tau = 1 \) \( d = 1.5 \phi = .1 \). The solution for the duopoly problem in this case is a value \( s^{IS} \), and values for the wholesale prices for the incumbent in any market, \( w_I^{IS} \) and for the secondary supplier, \( w_S^{IS} \) that solves the following three equations:

\[
\left[ s^{IS} - (2s^{IS} - 1)\frac{w_I^{IS} - w_S^{IS}}{\Delta} - \frac{1}{\Delta}(w_I^{IS})(2s^{IS} - 1) \right] + \frac{F_I - F_S}{\Delta} \\
+ \left[ (w_I^{IS})s^{IS} - (w_I^{IS})(2s^{IS} - 1)\frac{w_I^{IS} - w_S^{IS}}{\Delta} \right] \frac{dQ_a}{dw_I^{IS}} + \left[ (w_S^{IS})(1 - s^{IS}) + (w_S^{IS})(2s^{IS} - 1)\frac{w_I^{IS} - w_S^{IS}}{\Delta} \right] \frac{dQ_b}{dw_I^{IS}} = 0
\]

and

\[
\left[ 1 - s^{IS} + (2s^{IS} - 1)\frac{w_I^{IS} - w_S^{IS}}{\Delta} - \frac{1}{\Delta}(w_S^{IS})(2s^{IS} - 1) \right] + \frac{F_I - F_S}{\Delta} \\
+ \left[ (w_S^{IS})(1 - s^{IS}) + (w_I^{IS})(2s^{IS} - 1)\frac{w_I^{IS} - w_S^{IS}}{\Delta} \right] \frac{dQ_a}{dw_S^{IS}} + \left[ (w_I^{IS})s^{IS} - (w_S^{IS})(2s^{IS} - 1)\frac{w_I^{IS} - w_S^{IS}}{\Delta} \right] \frac{dQ_b}{dw_S^{IS}} = 0
\]

where \( \frac{dQ_a}{dw_I^{IS}} = -\frac{2}{3}td(1 - 2\phi)[s^{IS} - \frac{4s^{IS} - 2 w_I^{IS} - w_S^{IS}}{\Delta}] < 0 \) and \( \frac{dQ_b}{dw_I^{IS}} = -\frac{dQ_a}{dw_S^{IS}} \) (and similarly for derivatives with respect to \( w_S^{IS} \)). For the latter, the derivative is \( -\frac{2}{3}td(1 - 2\phi)(1 - s^{IS}) - \frac{4s^{IS} - 2 w_I^{IS} - w_S^{IS}}{\Delta} < 0 \). The final equation is the zero profit condition for the secondary supplier: \( w_I^{IS}(1 - s^{IS}) = F_S \).
The wholesale prices for the other duopoly state, II are just the local monopoly prices above for the incumbent and secondary suppliers.

Transition Matrix

\[
\begin{pmatrix}
\left(\frac{(w^I_S-w^I_S)^2}{2(\Delta^I_w-w^I_S)}\right)^2 + \left(1 - \frac{(w^I_S-w^I_S)^2}{2(\Delta^I_w-w^I_S)}\right)^2 & 2\left(\frac{(w^I_S-w^I_S)}{\Delta^I_w}\right)\left(1 - \frac{(w^I_S-w^I_S)}{\Delta^I_w}\right) \\
2\left(\frac{(w^I_S-w^I_S)}{\Delta^I_w}\right)\left(1 - \frac{(w^I_S-w^I_S)}{\Delta^I_w}\right) & \left(\frac{(w^I_S-w^I_S)}{\Delta^I_w}\right)^2 + \left(1 - \frac{(w^I_S-w^I_S)}{\Delta^I_w}\right)^2
\end{pmatrix}
\]

Steady-state probabilities of being in IS and II are \(P^*_{IS}\) and \(P^*_{II}\), given by:

\[
P^*_{IS} = \frac{2(w^I_L-w^I_S)\left(1 - \frac{(w^I_S-w^I_S)}{\Delta^I_w}\right)}{2(w^I_S-w^I_S)\left(1 - \frac{(w^I_S-w^I_S)}{\Delta^I_w}\right) + 2\left(w^I_L-w^I_S\right)\left(1 - \frac{(w^I_S-w^I_S)}{\Delta^I_w}\right)}
\]

\[
P^*_{II} = \frac{2(w^I_L-w^I_S)\left(1 - \frac{(w^I_S-w^I_S)}{\Delta^I_w}\right)}{2(w^I_S-w^I_S)\left(1 - \frac{(w^I_S-w^I_S)}{\Delta^I_w}\right) + 2\left(w^I_L-w^I_S\right)\left(1 - \frac{(w^I_S-w^I_S)}{\Delta^I_w}\right)}
\]

Multiperiod Local Monopoly

For the multiperiod local monopoly wholesale price, the equations to be solved are:

\[
V^*_I(w_I, w^*_S) = \max_{w_I} [(w_I)s - (w_I)(2s - 1)\frac{w^*_I - w^*_S}{\Delta}]
\]

\[
- \ F_I + (F_I - F_S)\frac{w^*_I - w^*_S}{\Delta} + \beta V^*_I - \beta (V^*_I - V^*_S)\frac{w^*_I - w^*_S}{\Delta},
\]

and

\[
V^*_S(w_S, w^*_I) = \max_{w_S} [(w_S)(1 - s) + (w_S)(2s - 1)\frac{w^*_I - w^*_S}{\Delta}]
\]

\[
- \ F_S - (F_I - F_S)\frac{w^*_I - w^*_S}{\Delta} + \beta V^*_S + \beta (V^*_I - V^*_S)\frac{w^*_I - w^*_S}{\Delta}.
\]

The first order conditions for the maximization problems above are:

\[
\left[ s - (2s - 1)\frac{w^*_I - w^*_S}{\Delta} - \frac{1}{\Delta}(w_I)(2s - 1) \right] + \frac{F_I - F_S}{\Delta} - \frac{V^*_I - V^*_S}{\Delta}
\]

and

\[
\left[ 1 - s + (2s - 1)\frac{w^*_I - w^*_S}{\Delta} - \frac{1}{\Delta}(w_S)(2s - 1) \right] + \frac{F_I - F_S}{\Delta} - \frac{V^*_I - V^*_S}{\Delta}
\]
I think the best thing to do is just iterate on the value function. That is, start with the one-shot game local monopoly values of \( w_I \) and \( w_S \) and posit the values .44 and .2 for \( V_I^* \) and \( V_S^* \) respectively. That will give a new value for the value functions and then just iteratively solve the FOC’s. Assume that the value of \( \beta \) is .5.

6 Conclusion

In this paper we study a two-sided hub-and-spoke cartel that operated in the Canadian bread market. Over a period of about fifteen years suppliers helped to coordinate retail prices and retailers helped to coordinate supplier prices. Our empirical analysis showed that this joint coordination resulted in bread price inflation that was 20-30% higher than for various control products. We also provided evidence that the cartel operated at both ends of the vertical supply chain by showing that the collapse of the cartel led to heterogeneous changes in pricing across retail markets and that this heterogeneity depended on retail-market structure.

We developed a model to explain why suppliers and retailers had incentive to engage in collusion, that addressed the shortcomings of the existing proposed explanations. We allowed for (i) competition at both ends of the supply chain, (ii) multi-sourcing, and (iii) the possibility of two-sided hub-and-spoke collusion. Features of the vertical arrangement imply that both suppliers and retailers may have had incentive to engage in collusion because of limited market power and low profits. Our main contribution is to show that supplier-only and retailer-only collusion are more difficult to sustain than a two-sided hub-and-spoke arrangement.
References


Grier, K. (2018). Bread price fixing impact?


A Court documents

For the purpose of this paper, we base our understanding of the facts with respect to the alleged bread cartel case mostly on documents prepared by the Competition Bureau related to the investigation into allegations that Canada Bread Company, Limited; Weston Foods, Incorporated; Loblaw Companies Limited; Wal-Mart Canada Corporation; Sobeys Incorporated; Metro Incorporated; Giant Tiger Stores Limited and others persons known and unknown have engaged in conduct contrary to paragraphs 45(1)(b) and (c) of the Competition Act as it existed from 2001-2010) and paragraph 45(1)(a) of the Act, as amended in 2010.

The Competition Bureau filed a first application for (Information to Obtain - ITO) search warrants in this matter on October 24th 2017 with the Ontario Superior Court of Justice (East Region). With the initial ITO, the Bureau was seeking warrants to search eight premises. Of these, seven belonged to the targets of the investigation (list them), and one to a third party. On October 30th, the Bureau submitted a revised version of the ITO in which it sought three additional search warrants for premises belonging to the Immunity Applicant. On October 31st 2017, Bureau officers began executing search warrants, at which point they discovered that additional warrants were required and so on the same day another ITO was filed for four additional search warrants. Finally, one additional site was identified and a companion ITO was filed on November 1st 2018.

The ITOs (henceforth to be referred to as the Competition Bureau documents or court documents) explain that on August 11th 2017, the Commissioner commenced an inquiry to investigate allegations of price fixing. The inquiry was expanded on the 23rd of October 2017 to cover the time period from November 2001 to the time of the ITOs. Loblaw Companies Limited (LCL), George Weston Limited and Weston Foods (Canada) are, collectively, the Immunity Applicant. The targets of the investigation were Canada Bread, Walmart, Sobeys, Metro and Giant Tiger.

Paragraph 1.12.1 of the November 1st 2017 ITO alleges that Canada Bread and Weston Bakeries agreed to increase their respective wholesale prices for the sale of fresh commercial bread via direct communications between senior officers in their organizations. According to paragraph 1.12.2, the suppliers then met individually with their retail customers to inform them of the price increase and obtain acceptance of the agreed-upon price. This was known as socialization of a price increase.

The ITOs explain that the investigation arose following (i) the application on March 3rd 2015 by LCL to the Bureau’s immunity program (paragraph 4.1) and (ii) the reception of an email on January 4th 2016 from the Canadian Federation of Independent Grocers (CFIG) alleging collusion between Canada Bread and Weston Bakers with respect to a price increase for fresh commercial bread (paragraph 4.2).

This paper analyses the alleged cartel case strictly from an economic point of view. The investigation into, and prosecution of, firms involved in the alleged conspiracy is ongoing. The allegations have not been proven in a court of justice. However, for the purpose of this paper, we take these facts as established. The analysis is preliminary and incomplete, and the findings are still subject to
change. We base our understanding of the facts mostly on documents prepared by the Competition Bureau.

B Evidence of asymmetry and services provided

The following passages describe the category management roles played by Bimbo and Flowers in the US bread market:\(^{32}\)

- **Bimbo** helped a Southeast regional grocer build same-store sales, using space-to-sales recommendations that yielded overall growth while the rest of the market held flat. Developing the right assortment on a store-by-store basis allowed consumers to see more selection, while delivering the freshest product available and driving down waste. Identifying stores by different demographics enabled vendors to focus on the main items that are selling for each subcategory.

- **Flowers Foods** delivered impactful benchmarking, promotion analysis, assortment studies and outstanding in-store execution. Leveraging the latest technology, Flowers automated the process of generating consistent, store-specific planograms across thousands of stores, using a retailer rule-based approach that allows for accurate, on-the-fly adjustments and provides real value to retailers.

\(^{32}\)Source: https://progressivegrocer.com/winnng-game-plans.
C  Paragraphs from court documents

C.1  The Bureau’s case

4.109  The evidence collected by the Bureau to date indicates that the price of fresh commercial bread was increased via secretive agreements made by senior executives at the Suppliers. Further, the price increases were facilitated by key decision-makers at both Suppliers and Retailers which enabled the alleged cartel to raise wholesale and retail prices. These are both qualitative factors that speak to the unreasonableness of the methods employed to raise the price of fresh commercial bread.
C.2 Cartel origins

4.24 On 20-21 December 2016, I conducted an interview of [redacted] During the interview, [redacted] informed me that, at some point [redacted] was approached by [redacted], an employee of Canada Bread [redacted] believes that the approach may have occurred during an industry event called the [redacted] where all the retailers and manufacturers/suppliers got together.

(a) Industry event

4.25 [redacted] recalled that during a conversation, [redacted] stated: "You know, this industry is crazy. In the [redacted] business, increase [redacted] prices every year. There's no reason the bakery business shouldn't do the same."

(b) Looking at other industries

4.26 [redacted] recounted that [redacted] showed [redacted] a PowerPoint presentation that [redacted] had prepared. [redacted] allegedly informed [redacted] that "I have a document that [redacted] taking out to the retail community to show them the power of pricing in bakery". [redacted] stated that "the basis of this presentation was that the profitability of the fresh bakery shelf at retail was underperforming, and then the wholesale side, the manufacturers, were underperforming as well from a price realization standpoint, and [redacted] did comparisons for retailers."

(c) Looking at other industries

4.27 [redacted] recounted that [redacted] was informed, by [redacted], of a plan whereby [redacted] was going to the retailers to get their buy-in for a price increase with the goal of orchestrating alignment through the retail community. [redacted] stated that "clearly when [redacted] left the meeting, [redacted] had a feeling and a sense that I was anxious and willing on behalf of Weston Bakeries to comply with an increase."

(d) Buy-in
C.3 Cartel organization

4.34 [redacted] described how this first increase was the point in time during which 7 cents at wholesale and 10 cents at retail became the pattern for increases. This pattern became colloquially known as “the 7/10 Convention”.

4.35 I have reviewed a product price increase chart issued by Canada Bread. The price increase chart identifies that Canada Bread had announced a price increase (the date of the announcement is not specified) with an effective date of 3 November 2002. The chart features numerous product names with their corresponding UPCs (universal product codes) along with the former price per unit and a post-price increase price per unit. The chart specifies an increase of 7 cents per unit.

4.48 [redacted] stated that given the deviation from the 7/10 Convention, namely, that this price increase was – in fact – a “double”, likely meant that the suppliers had coordinated this deviation from the norm to make sure that the price increase letters reflected the “double” rather than the usual “single”.

4.53 I reviewed a price increase letter from Weston Bakeries in which Weston Bakeries announced its own price increase of “approximately 4%” on 10 January 2011 with an effective date of 27 March 2011.

4.62 Notably, Weston Bakeries did not announce a price increase on plain white bread (including Weston’s Wonder and Gadoua brands) or private label bread. [redacted] informed me that Canada Bread responded by rescinding its price increase which, in turn, led to Weston Bakeries not implementing its price increase.
C.3.1 Supplier activity

4.90 (R) stated that, during discussions with Suppliers, they would look for confirmation from the Suppliers regarding competing Retailers. For instance, (R) would inquire as to whether specific Retailers would continue to aggressively price a Supplier’s product. Further, (R) would ask for the Supplier to go back to the Retailer who was pricing aggressively and explain to them that such prices were not in their best interest. (R) confirmed that the Suppliers would come back to (R) and tell exactly what the competing Retailer had said.

4.91 (S) stated that the Retailers frequently complained to Weston Bakeries about prices, at their retail competitors, that they did not like. In reviewing an example of one such complaint memorialized in an email dated 24 April 2015, (S) explained that “[Ken Kunkel (Metro)] is essentially asking ‘why the hell are they [Giant Tiger] at $1.88? The price increase just happened. Why would they go this cheap? You’re upsetting the market. One crazy retail will cause other [Retailers] to [decrease their retail prices] and it’ll get aggressive and therefore drive the overall retails down.”
C.3.2 Retailer activity

4.94 According to Canada Bread and Weston Bakeries each used the Retailers as conduits of information during the “socialization” process of a price increase.

4.95 (R) recalled that during the first price increase in which he was involved, Weston Bakeries had approached indicating that they wanted to take a price increase (R) then recalls being instructed by to have pricing conversations with Canada Bread to determine whether Canada Bread was also interested in taking a price increase.

4.97 (R) then recalls acting upon instructions from and calling Rory Lesperance of Canada Bread. As part of that conversation, (R) stated that would communicate Weston Bakeries’ pricing intentions to Canada Bread along with the date of the proposed price increase.
C.4 Additional tables and figures

![Bread Price Index (2002=100)]  

Date  
2014m1 2015m7 2017m1 2018m7  
Bread Price Index (2002=100)

Figure 5: Test for structural break in the bread price index

- Quandt Likelihood Ratio statistic: modified Chow test, test for breaks at all possible dates in range
  - Hypothesis of break at date $t$ tested using an F-statistic
  - QLR selects the largest of the resulting F-stats to determine the break
- Best candidate break: September 2016 (significant at 1%)
Table 6: Coordinated price increase regressions

(a) Overall impact

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1) Food</th>
<th>(2) Other bakery</th>
<th>(3) Cereal</th>
<th>(4) Wheat flour</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(t &gt; 2001)</td>
<td>30.1</td>
<td>23.0</td>
<td>33.5</td>
<td>46.5</td>
</tr>
<tr>
<td></td>
<td>(4.95)</td>
<td>(4.12)</td>
<td>(4.45)</td>
<td>(5.79)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.43</td>
<td>0.63</td>
<td>-4.59</td>
<td>-8.02</td>
</tr>
<tr>
<td></td>
<td>(0.86)</td>
<td>(0.98)</td>
<td>(0.88)</td>
<td>(1.49)</td>
</tr>
<tr>
<td>Observations</td>
<td>243</td>
<td>243</td>
<td>243</td>
<td>243</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(b) Progressive increase and steady state

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1) Food</th>
<th>(2) Other bakery</th>
<th>(3) Cereal</th>
<th>(4) Wheat flour</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(t &gt; 2007)</td>
<td>45.3</td>
<td>35.2</td>
<td>45.3</td>
<td>60.8</td>
</tr>
<tr>
<td></td>
<td>(2.00)</td>
<td>(2.49)</td>
<td>(2.61)</td>
<td>(2.91)</td>
</tr>
<tr>
<td>1(2008 &gt; t &gt; 2001) × (t - T0)</td>
<td>0.33</td>
<td>0.26</td>
<td>0.47</td>
<td>0.64</td>
</tr>
<tr>
<td></td>
<td>(0.023)</td>
<td>(0.035)</td>
<td>(0.017)</td>
<td>(0.042)</td>
</tr>
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<td>Constant</td>
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<td>-4.18</td>
<td>-6.59</td>
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<td>(0.75)</td>
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<td>Observations</td>
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<td>243</td>
<td>243</td>
</tr>
</tbody>
</table>

Standard errors in parentheses
D Mathematical Appendix

Proof of Proposition 1:

Note that, for any value of $s$ with $0.5 \leq s \leq 1$, the sum of the second and third terms of equation (X) is negative while the sum of the second and third terms of equation (Y) is positive. This means that the first term in equation (X) must be positive while the first term in equation (Y) must be negative. These terms, when equal to zero, give the local monopoly equilibrium equations for the incumbent (equation (X)) and secondary supplier (equation (Y)) wholesale prices for that given value of $s$. If we set the value of $s$ to the duopoly equilibrium value, then the symmetric duopoly equilibrium wholesale prices, $w^a_1 = w^b_2$ and $w^a_2 = w^b_1$ must be such that (Give these two equation numbers)

**Equation (X)**

$$s - (2s - 1) \frac{w^a_1 - w^a_2}{\Delta} - \frac{1}{\Delta} (w^a_1 - c)(2s - 1) + \frac{F_I - F_S}{\Delta} > 0$$

and

**Equation (Y)**

$$1 - s + (2s - 1) \frac{w^a_1 - w^a_2}{\Delta} - \frac{1}{\Delta} (w^a_2 - c)(2s - 1) + \frac{F_I - F_S}{\Delta} < 0$$

This has two implications regarding duopoly equilibrium wholesale prices relative to the local monopoly ones corresponding to the duopoly equilibrium shelf share:

price of main supplier relative to secondary supplier declines To see this, note that we can re-write the above two inequalities as:

**Equation (X)**

$$\frac{s\bar{\Delta}}{(2s - 1)} + \frac{F_I - F_S}{2s - 1} + c - w^a_2 \left(\frac{2w^a_1}{w^a_2} - 1\right) > 0$$

and

**Equation (Y)**

$$\frac{(1 - s)\bar{\Delta}}{(2s - 1)} + \frac{F_I - F_S}{2s - 1} + c - w^a_2 \left(2 - \frac{2w^a_1}{w^a_2}\right) < 0$$

If the value of $w^a_2$ is larger than the local monopoly value, then the value of $w^a_1 / w^a_2$ must be lower than the local monopoly one for the first inequality to be satisfied. If the value of $w^a_2$ is smaller than the local monopoly value, then the value of $w^a_1 / w^a_2$ must be lower than the local monopoly one for the second inequality to be satisfied.

difference in price of main supplier relative to secondary supplier declines To see this, note that the LHS of both of inequalities (A1 and A2) are increasing in $w_2$ and decreasing in $w_1$. Thus, the values of $(w_1, w_2)$ that make the first inequality positive must lie above and to the left of the locus of $(w_1, w_2)$ pairs that set the it exactly to zero. The same is true for the second inequality. The duopoly equilibrium must lie in the intersection of these two sets. This intersection features three possibilities: i) the values of $(w^a_1,)$ are such that $w^a_1$ is smaller than the local monopoly value
and $w^*_a \geq w^*_b$ is larger than the local monopoly value. In this case, the difference $w^*_a - w^*_b$ is clearly smaller than the local monopoly value; ii) the value of $w^*_a$ is larger than the local monopoly value. In this case, the first inequality can only hold if the value of $w^*_b$ is also be larger and such that the difference, $w^*_a - w^*_b$, is smaller; iii) the value of $w^*_b$ is smaller than the local monopoly value. In this case, the second inequality can hold only if the value of $w^*_a$ is also smaller and such that the difference, $w^*_a - w^*_b$, is smaller. Since the difference in local monopoly equilibrium prices is independent of the value of $s$, the probability of switching main suppliers is lower in the duopoly equilibrium relative to the local monopoly one.

**expected average wholesale price**

Finally, the fact that inequality A1 is positive means that, for fixed expected quantity sold, the expected wholesale payments to the main supplier are lower than at the local monopoly prices for the same value of $s$. The fact that inequality A2 is negative implies the same for the secondary supplier. In equilibrium, the expected quantity sold in both the duopoly equilibrium and the local monopoly equilibrium is the same: 1. Therefore, the expected per-unit wholesale payments / cost for the retailer are lower in the duopoly equilibrium than in the local monopoly equilibrium with the same shelf share. Since the duopoly equilibrium shelf space is chosen to minimize expected unit payments, the same must also be true when comparing the local monopoly equilibrium expected unit payments with those at the duopoly equilibrium.

*****

The FOC for the multistage game will be the following: For the II state there will be 2 first order conditions, one for the firm that is the incumbent in both markets and giving the common wholesale price $w_I$ that the wholesaler sets for both retailers. The other will be the wholesale price that the secondary supplier in both markets sets, $w_S$. The 2 FOC’s will have 2 components. For each there will be the one-shot game local monopoly FOC. They are

\[
\Rightarrow s - \frac{w^*_a - w^*_b}{\Delta} (2s - 1) - (w^*_a - c) \frac{2s - 1}{\Delta} + \frac{(F_I - F_S)}{\Delta},
\]

\[
\Rightarrow 1 - s + \frac{w^*_a - w^*_b}{\Delta} (2s - 1) - (w^*_a - c) \frac{2s - 1}{\Delta} + \frac{(F_I - F_S)}{\Delta}.
\]

$w^*_a$ will be $w_I$ and $w^*_b$ will be $w_S$. The second component will be the future value component. That will be:

\[
\beta \left[ - \frac{V^*_{II}}{\Delta} (1 - \frac{w_I - w_S}{\Delta}) + \frac{V^*_{IS}}{\Delta} w_I - \frac{V^*_{IS}}{\Delta} - \frac{2V^*_{IS}}{\Delta} \frac{w_I - w_S}{\Delta} \right] \tag{19}
\]

for the $w_I$ FOC and for the $w_S$ FOC it will be:

\[
\beta \left[ \frac{V^*_{SS}}{\Delta} (1 - \frac{w_I - w_S}{\Delta}) - \frac{V^*_{II}}{\Delta} w_I - \frac{V^*_{IS}}{\Delta} + \frac{2V^*_{IS}}{\Delta} \frac{w_I - w_S}{\Delta} \right] \tag{20}
\]

When in the IS state, there will be different values for the wholesale price set by the representa-
tive incumbent, \( w_{IS}^I \) and secondary supplier, \( w_{IS}^S \). In this case, the two FOC’s again have 2 parts. The first is the 2 FOC from the one-shot duopoly game from before. These will be:

\[
\left[ s_{IS} - (2s_{IS} - 1) \frac{w_{IS}^I - w_{IS}^S}{\Delta} - \frac{1}{\Delta} (w_{IS}^I)(2s_{IS} - 1) \right] + \frac{F_I - F_S}{\Delta} \\
+ \left[ (w_{IS}^I)s_{IS} - (w_{IS}^I)(2s_{IS} - 1) \frac{w_{IS}^I - w_{IS}^S}{\Delta} \right] \frac{dQ_a}{dw_{IS}^I} + \left[ (w_{IS}^I)(1 - s_{IS}) + (w_{IS}^S)(2s_{IS} - 1) \frac{w_{IS}^I - w_{IS}^S}{\Delta} \right] \frac{dQ_b}{dw_{IS}^I}
\]

and

\[
\left[ 1 - s_{IS} + (2s_{IS} - 1) \frac{w_{IS}^I - w_{IS}^S}{\Delta} - \frac{1}{\Delta} (w_{IS}^I)(2s_{IS} - 1) \right] + \frac{F_I - F_S}{\Delta} \\
+ \left[ (w_{IS}^I)(1 - s_{IS}) + (w_{IS}^S)(2s_{IS} - 1) \frac{w_{IS}^I - w_{IS}^S}{\Delta} \right] \frac{dQ_a}{dw_{IS}^I} + \left[ (w_{IS}^I)s_{IS} - (w_{IS}^I)(2s_{IS} - 1) \frac{w_{IS}^I - w_{IS}^S}{\Delta} \right] \frac{dQ_b}{dw_{IS}^I}
\]

where \( \frac{dQ_a}{dw_{IS}^I} = -\frac{2}{3} t \phi [s_{IS} - \frac{4}{\Delta} w_{IS}^I - \frac{4}{\Delta} s_{IS} - \frac{1}{\Delta} ] < 0 \) and \( \frac{dQ_b}{dw_{IS}^I} = -\frac{dQ_a}{dw_{IS}^I} \) (and similarly for derivatives with respect to \( w_{IS}^S \)). For the latter, the derivative is \(-\frac{2}{3} t \phi [1 - 2\phi] (1 - s_{IS}) - \frac{4}{\Delta} w_{IS}^I - \frac{4}{\Delta} s_{IS} - \frac{1}{\Delta} < 0 \).

The second part will be the future value derivatives. They will be:

\[
\beta \left[ (w_{IS}^I - w_{IS}^S) \frac{2}{\Delta^2} \right] V_{II}^* + \frac{1}{\Delta} (1 - \frac{w_{IS}^I - w_{IS}^S}{\Delta}) V_{SS}^* + \frac{1}{\Delta} \frac{w_{IS}^I - w_{IS}^S}{\Delta} V_{IS}^* - \frac{1}{\Delta} (1 - \frac{w_{IS}^I - w_{IS}^S}{\Delta}) V_{IS}^* + \frac{4}{\Delta} \left( \frac{w_{IS}^I - w_{IS}^S}{\Delta} \right) V_{IS}^* \]

for \( w_{IS}^I \) and for \( w_{IS}^S \) it will be:

\[
\beta \left[ (w_{IS}^I - w_{IS}^S) \frac{2}{\Delta^2} \right] V_{SS}^* - \frac{1}{\Delta} (1 - \frac{w_{IS}^I - w_{IS}^S}{\Delta}) V_{II}^* + \frac{1}{\Delta} \frac{w_{IS}^I - w_{IS}^S}{\Delta} V_{IS}^* + \frac{4}{\Delta} \left( \frac{w_{IS}^I - w_{IS}^S}{\Delta} \right) V_{IS}^* + \frac{1}{\Delta} (1 - \frac{w_{IS}^I - w_{IS}^S}{\Delta}) V_{IS}^* \]

(22)