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Hub-and-Spoke Cartels: Theory and Evidence from the Grocery Industry†

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Numerous recently uncovered cartels operated along the supply chain, with firms at one end facilitating collusion at the other—hub-and-spoke arrangements. These cartels are hard to rationalize because they induce double marginalization and higher costs. We examine Canada's alleged bread cartel and provide the first comprehensive analysis of hub-and-spoke collusion. Using court documents and pricing data, we make three contributions: (*i*) *we show that collusion was effective, increasing inflation by about 50 percent*; (*ii*) *we provide evidence that collusion existed at both ends of the supply chain*; *and* (*iii*) *we develop a model explaining why this form of collusion arose.* (*JEL* E31, K21, L12, L14, L22, L42, L81)

The substantial literature on collusion has focused almost exclusively on agreements between manufacturers or between retailers: *horizontal collusion*. However, a large number of recently uncovered and prosecuted cartels operated along the supply chain, with firms at one end facilitating collusion at the other—so-called *hub-and-spoke* cartels. The first US hub-and-spoke case, *Interstate Circuit, Inc. v. United States*, dates back to 1939 and involved an operator of first-run movies acting as the hub, coordinating the behavior of motion picture distributors in an effort to limit competition from subsequent-run movie theaters. More recently, the Department of Justice successfully prosecuted a hub-and-spoke case against Apple and five major book publishers (*United States v. Apple*, 791 F.3d 290 (2d Cir. 2015)) for raising e-book prices and exclusionary conduct (as a result of a most favored nation clause and since rival e-book distributor Amazon would be compelled to adopt an agency pricing model). Garrod, Harrington, and Olczak (2021) provide further examples.

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Despite the prevalence of hub-and-spoke cartels, the existence of collusion along the supply chain is difficult to identify empirically and hard to rationalize theoretically. From a theoretical point of view, manufacturers have incentive to limit market power in the retail sector, and vice versa, in order to avoid problems of double marginalization and of higher costs. As such, it is not clear what impact this sort of arrangement has on prices and why this form of cartel arises rather than, say, supplier-only or retailer-only collusion. From an empirical point of view, the challenge for antitrust authorities is to evaluate the involvement of firms at different levels of the supply chain in maintaining supracompetitive markups.

In this paper we address these challenges and provide the first comprehensive analysis of an actual hub-and-spoke collusive arrangement. Our focus is on the cartel uncovered in Canada's bread market. On January 31, 2018, the Competition Bureau of Canada outlined allegations that grocery retailers *and* suppliers had conspired to fix the retail *and* wholesale prices of fresh commercial bread.[1] The Competition 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 15 years and describe a collusive arrangement in which suppliers helped to coordinate retail prices and retailers helped to coordinate supplier prices.

Using documents submitted by the Competition Bureau to the courts that characterize the collusive arrangement, along with data on prices and market structure from Statistics Canada and Infogroup Canada, we make three contributions. First, we show that hub-and-spoke collusion was effective. We then provide evidence that both suppliers and retailers were involved in the cartel. Finally, to examine why coordination arose at both ends of the vertical chain, we develop a theoretical model explaining the emergence of supply chain collusion, applicable in a broad class of retail markets.

To confirm that the 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-difference approach in which we compare inflation rates of bread and control products around the start and end of the cartel. Our results suggest that bread prices grew at a faster rate than all other food categories over the entire period. At the end of the collusive period, we estimate that bread price inflation was roughly 50 percent higher because of the cartel's actions. Bread prices then fell faster than the prices of other products following the collapse of the cartel

The objective of the second part of our empirical analysis is to test the hypothesis that both ends of the supply chain were implicated in the collusive arrangement. The Competition Bureau documents and subsequent commentary offer compelling evidence that the suppliers colluded, periodically coordinating on 7 cent wholesale price increases (15 times between 2001 and 2016). In contrast, there is little direct evidence that retailers were coordinating, and the court documents characterize the

[1] Legal disclaimer: This paper analyzes 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. We base our understanding of the facts mostly on documents prepared by the Competition Bureau. Online Appendix A provides more details on these documents.

retail arrangement as being difficult to manage. Moreover, besides the informant, the retailers have denied the allegations. We use store-level data from Statistics Canada and market structure information from Infogroup Canada to analyze price levels and changes within and across cities, both during the coordination period (2001–2016) and during the months following the collapse of the agreement (2016–2018).

We provide evidence that most retailers passed through the proposed 7 cent wholesale price increases more than completely. The median store raised retail prices by 10 cents, consistent with the *7/10 convention* outlined in the Competition Bureau documents. We then demonstrate that pass-through of wholesale price increases during the cartel period and the subsequent collapse following the investigation was not uniform across markets and retailers. Looking *across markets*, we document that price increases were more pronounced the greater the extent of concentration and in markets with fewer discount chains. The end result was a higher pass-through rate in less competitive markets, consistent with the hypothesis that price coordination is easier in such environments. Similarly, looking *within markets*, we find that the collapse of the agreement was triggered by discount retailers, which reduced prices more than rival high-price stores. This increased within-market price dispersion following the public announcement of the investigation. Together, these results provide evidence supporting the claim that a group of retailers coordinated on uniform prices and supracompetitive margins.

What remains to be explained is why they settled on the particular arrangement observed. We are interested in understanding the incentives to collude and why collusion arose at both ends of the vertical supply chain, rather than retailer-only or supplier-only collusion. Existing explanations from the literature mostly involve settings featuring monopoly wholesalers, or markets in which suppliers successfully exclude rivals. They also focus on cases where one end of the vertical chain is a single entity acting as the hub helping to coordinate the behavior of the multiple spokes at the other. These features do not accurately characterize the settings of many hub-and-spoke cases. Two of the most famous are *Toys "R" Us v. FTC* and *Argos and Littlewoods v. OFT*. In the former, Toys "R" Us, acting as the hub, organized and enforced a horizontal agreement among its various suppliers. In the latter, supplier Hasbro coordinated pricing by retailers Argos and Littlewoods. In these cases, not only are there multiple spokes but also multiple players at the other end of the supply chain. In some instances they may each act as hubs and might also coordinate their activities. Garrod, Harrington, and Olczak (2021) describe a hub-and-spoke cartel in the UK dairy market where there was "a degree of direct co-ordination and contact between the processors themselves with the aim of implementing a market wide cheese retail price increase" (p. 80). Furthermore, we do not always observe exclusion. Rather, many business-to-business settings feature multisourcing, with a downstream firm contracting with multiple upstream suppliers. Our model addresses the shortcomings of the existing proposed explanations, while nesting their frameworks, by allowing for (i) multiple firms and the possibility of collusion at both ends of the supply chain and (ii) multisourcing.

Our model relies on two institutional features of the grocery industry that are present in the bread case. First, in addition to supplying their product, manufacturers are often expected to provide important services to retailers, including shelving, removal of unsold products, data analysis, etc. These are costly to provide but have a public good aspect, so that a single supplier's services benefit a retailer carrying the products of multiple providers. As a result, retailers have an incentive to select a *category captain* (or main supplier). Moreover, since shelf space is scarce and the service costly, the shelf-share allocation is typically decided at the chain level, with the captain awarded better shelf space across all of a given retailer's outlets. One or more "secondary" suppliers obtain the remaining shelf space. This creates an endogenous asymmetry between otherwise symmetric suppliers, which reduces the ability of firms to collude upstream.

A second important factor is that wholesale prices are the outcome of negotiations between the suppliers and retailers, with suppliers 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 toward rival suppliers. The resulting switching cost determines the relative leverage that the main supplier has in the wholesale price negotiations.

With retailers competing for consumer purchases and suppliers competing to be a retailer's main supplier, it is not surprising that retailers would like to collude on retail prices and suppliers collude on wholesale prices. One might even imagine that the suppliers would prefer the retailers to collude in order to increase available surplus in the wholesale price negotiations (e.g., if aggregate demand is inelastic). There would appear to be no reason, however, for retailers to support supplier collusion: doing so raises the retailers' costs and so shifts collusive profits from the retailers to the suppliers. Ultimately, the reason that retailers support supplier collusion is that failure to do so leads to noncollusive wholesale price responses by suppliers that destabilize the retailer collusion.

We show that the combination of the main supplier/secondary supplier arrangement and imperfect competition at the supplier level leads to asymmetries that make separate collusion by suppliers and retailers difficult. We identify three vertical spillovers negatively affecting the stability of horizontal cartels and caused by competition at one end of the supply chain. First, the asymmetry in shelf space between the main and secondary supplier makes independent collusion by the suppliers difficult: the secondary supplier has significant incentives to deviate. Second, we show that manufacturers respond to retailer-only collusion by competing for shelf space in a way that increases the dispersion of offers. This leads to important retailer cost asymmetries that make retail collusion more difficult. Finally, a supplier may benefit from inducing competition in the retail market to the extent that such competition shifts customers away from the retailer for which it is a secondary supplier and toward the retailer for which it is the main supplier. These spillovers undermine the ability of firms to collude strictly horizontally. The solution is to create a vertical collusive ring—bring wholesalers and retailers into a joint collusion agreement—and to do so in a way that reduces asymmetries between firms.

Related Literature.—Economists have only recently begun studying cartels linking both ends of the supply chain. 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 (2017), if retailers are left to their own devices, their interactions generate inefficiencies for the entire market. They assume demand is volatile (a la

Rotemberg and Saloner 1986) and that the monopoly supplier does not know the state. Information exchange between supplier and retailers can then increase profits of the vertical chain. In Van Cayseele and Miegielsen (2013); Giardino-Karlinger (2014); and Gilo and Yehezkel (2020), rewards or the threat of exclusion imposed by the supplier provide incentive to maintain the hub-and-spoke arrangement. In Van Cayseele and Miegielsen (2013) and in Gilo and Yehezkel (2020), the wholesale price is determined through a bilateral bargaining procedure, and the supplier can charge higher prices under retail collusion. In Giardino-Karlinger (2014), the supplier earns zero along the collusive path but absorbs all profits under punishment by exercising an exclusive dealing option.[2]

In addition, 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 (Pesendorfer 2000; Genesove and Mullin 2001; Roller and Steen 2006; Asker 2010; Harrington and Skrzypacz 2011; Clark and Houde 2013; and Igami and Sugaya 2022). Others have focused on distinguishing collusion from competition (Porter and Zona 1999; Bajari and Ye 2003; Conley and Decarolis 2016; Aryal and Gabrielli 2013; Schurter 2020; and Kawai and Nakabayashi 2022). Block, Nold, and Sidak (1981) examine collusion in the US bread market in the 1960s and 1970s. Ross (2004) reviews cartels in Canada.

We are also related to an extensive literature on facilitating practices. The notion that an outside (third) party can help organize the cartel has been considered, with a focus on the role of trade associations. Early models studying the function of trade associations for collusion were developed by Vives (1984) and Kirby (1988). More recently, Alé-Chilet and Atal (2020) empirically examine the role of a trade association for facilitating collusion among physicians in Chile. See Marshall and Marx (2012) for other examples. Greif, Milgrom, and Weingast (1994) characterize a repeated interaction between a city and merchants and describe how the city can help merchants organize into a guild. There is a long literature on the ability of vertical relations (i.e., resale price maintenance, integration, advertising restrictions) to facilitate collusion. See, for instance, Matthewson and Winter (1998); Nocke and White (2007); Normann (2009); Rey and Vergé (2010); Jullien and Rey (2007); Foros and Steen (2013); 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. Hyytinen, Steen, and Toivanen (2019) study legal cartels in Finland and show that cartels that allocate market shares often include a vertical element. In a recent paper Asker and Hemphill (2020) study conduct in the Canadian sugar industry and describe a setting that featured both horizontal and vertical coalitions and highlight the interplay between exclusion and collusion along the supply chain. Finally, in a new paper, Chaves and Duarte (forthcoming) study a hub-and-spoke arrangement in which gasoline distributors helped to coordinate a collusive arrangement among retailer stations.

A number of papers have noted the anticompetitive effects of slotting allowance (see Shaffer 1991; Sudhir and Rao 2006; Marx and Shaffer 2010), and there is a small literature on so-called *category captains*. This term is given to suppliers who

[2] See Sahuguet and Walckiers (2014); Van Cayseele and Miegielsen (2014); and Garrod, Harrington, and Olczak (2021) for discussion.

provide extensive advice to retailers. Some papers have alluded to the possibility that this could facilitate collusion (see, for instance, Kurtulus and Toktay 2011; Gabrielson, Johansen, and Shaffer 2018; and Zhu 2022).

Finally, we are related to a number of papers studying the grocery sector. This includes the literature on slotting contracts (for a discussion, see Wright 2007 or Wright and Klein 2007)[3] 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 2022).

Outline.—The paper proceeds as follows. In the next section, we describe the market, including the vertical arrangements that characterize it. In Sections II and III, we present the data and the evidence that collusion was successful and involved both ends of the supply chain. Section IV contains the model, which explains why supply chain collusion arose. Finally, Section V concludes.

I. 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. Approximately 58 percent of food sales were through grocery stores, which are currently dominated by three players: Loblaws, Sobeys, and Metro. According to the court documents, these three retailers accounted for 33.5 percent, 18.9 percent, and 15.5 percent of the grocery market, respectively. Other important players are Walmart with 8.8 percent, Giant Tiger with 1.4 percent, and Overwaitea, which is geographically focused on Western Canada, at 2.2 percent. There are also thousands of smaller outlets ranging from tiny independent convenience stores to high-end specialty food providers. The big three each have a number of discount banners. Loblaws and its supermarket banners had 1,501 stores in 2009. Sobeys had 1,351, and Metro had 1,483.

Wholesale Sector.—The commercial bread industry in Canada had US$2.2 billion in sales in 2017. Commercial bread is baked and shipped daily by suppliers. Two main suppliers, George Weston Ltd. and Canada Bread Co. (purchased from Maple Leaf Foods by Grupo Bimbo in 2014), dominated the market with 21.5 percent and 16.7 percent market share, respectively, in 2016 (European Commission 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 Competition Bureau documents (described in the next section), Weston and Canada Bread issue price increases for their products on a national basis.[4]

Horizontal Mergers.—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

[3] See also Shaffer (1991); Sudhir and Rao (2006); Marx and Shaffer (2010); and FTC (2001).

[4] Similar pricing has been documented for grocery products in the United States by Gentzkow and DellaVigna (2019).

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 percent. This acquisition led Metro to acquire Loeb in June 1999, formerly owned by Provigo, which 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 (aka Pride of Montreal). 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, Vasconcelos 2005; Miller and Weinberg 2017; Igami and Sugaya 2022; and Loertscher and Marx 2021).

The retail market also experienced a number of acquisitions throughout the cartel period. Metro acquired The Great Atlantic and Pacific Tea Company, Inc. in July 2005. Sobeys acquired Safeway in June 2013. Loblaws acquired Shoppers Drug Mart in July 2013.

Vertical Arrangements.—In the Canadian bread industry, and in other markets too, the most common type of vertical arrangement features asymmetric long-term contracts between each downstream chain and the two bread suppliers. In the marketing literature, this type of arrangement is known as a category captain contract (see Kurtulus and Toktay 2011; Gabrielson, Johansen, and Shaffer 2018; and Zhu 2022). In this setting, a number of 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., multisourcing). 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, data analytics). Fourth, the nature of these services and scarce shelf space imply retailers want one producer to be their main supplier, or category captain. Fifth, there is an asymmetry in shelf-share 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. They 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, if the main supplier arrives with a higher wholesale price quote than its rival, the retailer typically goes back to the main supplier to ask it to match the lower bid, and matching occurs often.[5,6]

Although the details of the arrangements between grocery chains and manufacturers are kept secret, observations of product assortments at different retailers

[5] The presence of these features in the Canadian bread industry in the period leading up to the start of the cartel has been substantiated by conversations with industry insiders.

[6] In some instances category captains are also responsible for determining shelf space and even prices for the entire category. From our conversations with industry insiders, this is not the case in the Canadian bread market, where retailers maintain these powers.

confirm that shelf space is allocated unequally across brands. For instance, Canada Bread is dominant at both Metro and Sobeys, while Weston is vertically integrated with Loblaws. In each case, there are many more products available belonging to the dominant supplier than the secondary supplier.[7]

This sort of asymmetric arrangement in which retailers multisource but have one main supplier is common in many retail environments and in business-to-business settings. The US bread industry also features two dominant suppliers: Grupo Bimbo and Flowers Foods, and there is evidence that they provided services to retailers at which they were dominant.

II. Data

To study the effect of the cartel on prices at both ends of the supply chain, we make use of the following data sources. First, we use information from the Redacted Information to Obtain Search Warrants, filed in the Ontario Superior Court of Justice (East Region) in 2017 to learn about the functioning of the cartel and about wholesale price changes during the cartel period. Henceforth, we refer to these as the *court documents* (OntarioCourts 2017). 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.[8]

Second, we collected national pricing data from Statistics Canada. We gathered information on the average retail price of a loaf (675 grams) of bread across the country (StatsCan 2019b).[9] We use these data to verify the information on wholesale price coordination contained in the court documents and to illustrate the impact on retail prices. Since prices at the loaf level are not comparable to prices of other products, we also collected data for the *Bread*, *rolls*, *and buns* subcategory from the Monthly Consumer Price Index of Statistics Canada for 1995 to 2018 (StatsCan 2019c).[10] 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."

For comparison, we also collected information on a number of different product categories that represent suitable controls. We collected information on the general *Food* price index as well as the price index from five other subcategories of the *Bakery and cereal products* category that contains *Bread*, *rolls*, *and buns* and that likely experienced similar cost shocks to bread and for which there are no allegations of collusion. These subcategories are (i) *Other bakery products*, (ii) *Flour*, (iii) *Cookies*, (iv) *Pasta*, and (v) *Breakfast cereal*.[11] We also collected information on the price index for *Hard spring wheat flour* (StatsCan 2019d), which is the main input into bread production (i.e., a proxy for average variable cost),[12] and we have gathered similar price

[7] Table B1 in online Appendix B illustrates this point using data on the number of products of each brand offered online by the three main retailers.

[8] Further details on these documents can be found in online Appendix A.

[9] These data are compiled from Statistics Canada Table 18-10-0002-01 (formerly CANSIM 326-0012).

[10] Statistics Canada Table 18-10-0004-01 (formerly CANSIM 326-0020).

[11] See online Appendix C for a breakdown of the Statistics Canada product classification.

[12] The wheat flour data were gathered from Statistics Canada Table 182121, Monthly Industrial Product Price Index.

information for US bread from the US Bureau of Labor Statistics (USBLS 2019).[13] All price indexes are normalized to 100 in the year 2002.

Third, Statistics Canada has granted us access to their CDER-CPI Research store-level dataset (StatsCan 2019a). This dataset 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 dataset for 2009 to 2018, which allows us to study the last seven years of the coordination period and also the impact of the collapse of the cartel. These prices are available at 328 stores in 41 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 have access to these data for *bread*, *rolls*, *and buns* and for the other five subcategories of *Bakery and cereal products* listed above. Data are at the item level, with information on four different items in the *bread*, *rolls*, *and buns* category and between three and four items in each of the other subcategories.[14]

We use these data in conjunction with our fourth dataset, from Infogroup Canada, to study heterogeneity in cartel impact across different market structures (Infogroup 2019). Using Infogroup data, we characterize the downstream concentration of each market (in terms of store presence) as well as the relative importance of discount chains. The dataset 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 the 2014 data to construct our variables. Table 1 provides summary statistics from the Infogroup dataset for the 41 markets for which we can match it with the CDER-CPI dataset. From this, we can see that the mean market size is 171 grocery and convenience stores, of which Statistics Canada surveys on average 6.73 when constructing its price index. The top 3 retail chains (Loblaws, Sobeys, and Metro) are present in most markets and control 58 percent of establishments with more than 20 employees. The presence of convenience stores and pharmacies selling bakery products substantially reduces concentration in the market. Finally, each major chain offers a brand of discount grocery stores, competing with independent discount chains like Giant Tiger. Importantly, at least one discount grocery chain is present in every city, but 61 percent of cities have just a single discount chain.

III. The Cartel: Impact and Arrangement

In this section, we evaluate the claim that firms at both ends of the supply chain successfully colluded using a hub-and-spoke arrangement. We first characterize the overall impact of the cartel, focusing on price increases during the coordination period (2001–2016) and the size of the price decrease following the collapse of the cartel (2016–2018). We then provide evidence from the court documents that coordinated price increases were initiated by upstream suppliers, and we present

[13] US Bread prices: Series Id APU0000702111, Title–Bread, white, pan, per lb. (453.6 gm) in US city average, average price, not seasonally adjusted. Note that the BLS reports prices for white bread alone, not the amalgam of bread, rolls, and buns like in Statistics Canada. This index is also not adjusted for exchange rate differences.

[14] Further details on this dataset, including summary statistics, can be found in online Appendix C.

Table 1—Market Structure Summary Statistics

Variable	Mean	SD	Min.	Max.
HHI (all)	0.05	0.03	0	0.18
HHI (20 employees)	0.31	0.12	0.08	0.56
Top 3 share of stores	0.22	0.07	0.05	0.48
Top 3 share of stores (20+ empl.)	0.58	0.11	0.28	0.8
Single discounter	0.61	0.49	0	1
Total number of stores	171.02	220.77	15	1,136
Total number of stores (20+ empl.)	46.34	48.36	4	192
Number of stores surveyed (avg.)	6.73	5.10	2	23
Observations		41		

a set of empirical results that confirm the participation of retailers in the collusive arrangement.

A. *Evidence of Cartel Impact*

According to the allegations contained in the court documents, the collusive arrangement started toward the end of 2001 following conversations between participants at an industry event attended by retailers and suppliers (see paragraph 4.24 of OntarioCourts 2017, reproduced in online Appendix A along with the other paragraphs referenced in this section). The court documents allege that during these conversations, annual price increases in other industries, such as cereal and other grain-based products, were pointed to as a model for the bakery industry (paragraphs 4.25 and 4.26). Bread prices were underperforming, and representatives 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).

On March 3, 2015, Weston and Loblaws informed the Competition Bureau of a collusive arrangement in the bread market through the Bureau's immunity program. Under this program, the first party to disclose an undetected offense or provide evidence leading to a case referral to the Public Prosecution Service of Canada may receive immunity from prosecution. On January 4, 2016, allegations of collusion were leveled by the *Canadian Federation of Independent Grocers* (CFIG).[15] On August 11, 2017, the Competition Commissioner commenced an inquiry (extended in October).

Figure 1 combines data from price indexes for 1995 to 2018 (with 2002 = 100) for (i) bread, rolls, and buns; (ii) the aggregate food category; (iii) hard spring wheat flour; and (iv) US bread prices. The vertical lines indicate the alleged start date of the cartel (solid), the date of the immunity marker (dash), the date of the allegations by the Canadian Federation of Independent Grocers (dash-dot), and the date at which we detect a structural break in the index (long dash, discussed below). The index for bread, rolls, and buns experienced similar evolution to the indexes for the

[15] One might wonder why independent grocers complained about the arrangement, thinking that it would provide them with the opportunity to raise their prices (to price under the *umbrella* of the cartel). However, some of the independent grocers purchased product directly from the bigger grocers, such that the cartel would in fact have raised their prices. See Competition Bureau (2023).

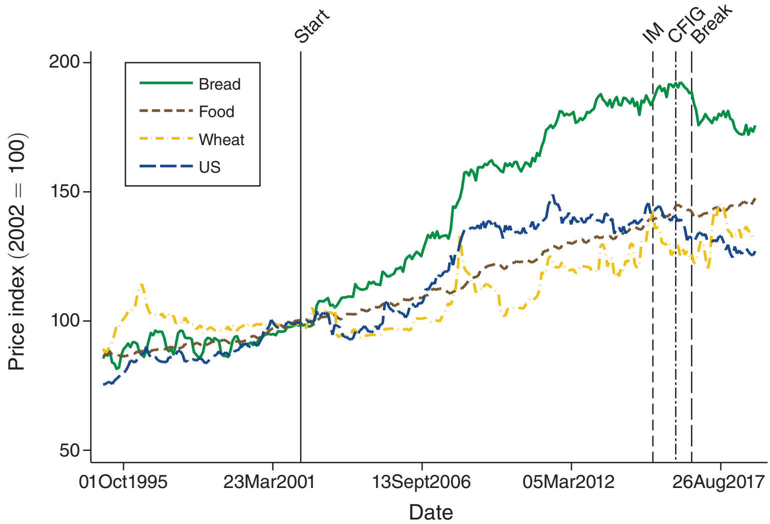

FIGURE 1. NATIONAL PRICE INDEXES—BREAD VERSUS OTHER PRODUCTS

Note: Vertical lines: Solid = April 2002 (first coordinated price increase), dash = March 2015 (immunity agreement), dash-dot = January 2016 (CFIG complaint), long dash = August 2016 (end of coordination period).

other categories prior to the start of the cartel. Beginning in 2002, the bread, rolls, and buns index steadily increases, diverging from the other indexes.[16] Wheat flour experienced a much less pronounced inflation during the coordination period, suggesting 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.[17] 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. US bread prices experience similar increases following the cost shocks, but other increases are much less pronounced such that overall inflation is much lower than in Canada.[18]

These findings suggest that the Canadian bread industry successfully sustained supracompetitive prices for an extended period of time, "progressively" coordinating price increases from 2002 onward.[19] Table 2 quantifies the impact, presenting differences in annual inflation rates between bread and each of the five subcategories, plus food. From the first column, we can see that bread prices increased from 100 in 2002 to 192 in 2016. The top row of the other columns presents the differences between the CPI for bread and each of the other products in 2016. Compared to all

[16] Grier (2018) shows a similar pattern during the coordination period.
[17] See, for instance, Wiggins, Keats, and Compton (2010).
[18] Figure D1 in online Appendix D presents the same information for the five categories from which items are drawn for our micro dataset used in the next subsection. In each case, inflation is outpaced by *bread*, *rolls*, *and buns*.
[19] This is similar to the behavior of other known cartels, although the period of increase would appear to be much longer in this case. For instance, Igami and Sugaya (2022) document that vitamin C margins reached stable levels roughly three years after the start of the arrangement. See also Byrne and deRoos (2019) and Alé-Chilet (2018).

Table 2—Cumulative Differences in Inflation: Bread CPI versus Other Products

	Coordination: 2002–2016		Collapse: 2016–2019	
	P^b_{16}	$\frac{\Delta P^b}{T}$	P^b_{19}	$\frac{\Delta P^b}{T}$
Bread CPI (2002 = 100)	192.06	6.28	179.63	−5.32
	$P^b_{16} - P^c_{16}$	$\frac{\Delta P^b - \Delta P^c}{T}$	$P^b_{19} - P^c_{19}$	$\frac{\Delta P^b - \Delta P^c}{T}$
Differences: Bread versus others				
Food	49.33	3.36	30.49	−8.08
Flour	41.81	2.85	30.47	−4.86
Cookies	47.92	3.27	28.83	−8.18
Other bakery	39.91	2.72	23.00	−7.25
Pasta	28.04	1.91	26.89	−0.49
Breakfast cereal	66.91	4.56	54.08	−5.50

Notes: P^b_t and P^c_t denote bread and (other) category CPI in year t, respectively. The top panel reports the CPI index (columns 1 and 3) and the annual rate of inflation for bread (columns 2 and 4). The bottom panel reports the difference in the CPI index for bread relative to other categories for last period (columns 1 and 3) and the difference in the annual rate of inflation between bread and other categories. The number of years T for the coordination period is 14.66 years, and the number of years for the collapse period is 2.3 years.

categories we consider, bread inflation is much greater. For instance, compared to food, bread prices grew 49 percent more over the coordination period, translating into a 3.36 percent higher annual rate.

Next, we examine the impact of the cartel collapse on prices. Figure 1 shows prices remained elevated following the immunity request in March 2015 and even for a period following the Canadian Federation of Independent Grocers complaint. As we will discuss below, there is evidence that one last price coordination took place shortly after the CFIG complaint. Prices then fell sharply, well before the official inquiry launched by the Competition Bureau in August 2017. We conjecture that the informal investigation that began following the CFIG complaint triggered the collapse of the cartel. To formally identify the end of the cartel, we use structural break tests to identify the best candidate date for the end of the cartel. Specifically, we calculate the Quandt Likelihood Ratio (QLR) statistic, 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 QLR statistic selects the largest of the resulting F-statistics to determine the best candidate break.[20] Results show that the best candidate break occurred in late summer/early fall of 2016, and we use this as the start date for the collapse period.[21]

Table 2 quantifies the decline in bread prices relative to the other categories. The bread CPI decreased from 192 to 179.63 between 2016 and 2019. Note that the decrease is smaller than the increase that occurred during the coordination period, possibly because there was less time for prices to adjust.[22] Despite the decline, from the third column in the table, we can see that the price index for bread in 2019

[20] 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 behavior (see, for instance, Harrington 2008; Clark and Houde 2014; Boswijk, Bun, and Schinkel 2018; Crede 2019).

[21] Results are presented in online Appendix D.

[22] Or because cartel participants strategically price above the competitive price following the collapse of the cartel knowing that antitrust authorities use postcollapse prices to calculate damages (Harrington 2004). Alternatively, it could be that only retailers lowered prices, while suppliers kept theirs constant. We discuss this in the next section.

remained 30.49 points higher for food and between 26 and 54 points higher for the different categories. Overall, the collapse led to an 8.08 percent annual decline in bread price relative to the food price index and between −8.18 percent and −0.49 percent relative to the other categories.[23]

B. *Evidence of Supply Chain Collusion*

We have shown that the cartel was successful at raising prices but not that both ends of the supply chain were involved in the collusive arrangement. We turn to this next and start by using the court documents to describe the role of suppliers and retailers in the alleged price-fixing scheme.

The court documents and subsequent commentary provide credible evidence that suppliers coordinated their pricing strategies. The allegations suggest that top executives at the suppliers were aware of the price increases that occurred. Weston admitted to participation via the Competition Bureau's immunity program in 2015, and in 2023 Canada Bread's new owners, Grupo Bimbo, pleaded guilty to charges of price fixing and paid a C$50 million fine. The court 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 4.81, 4.82, and 4.83).

The court documents allege the two leading suppliers increased prices periodically (around once per year) by 7 cents per loaf of bread (paragraph 4.34). The documents describe 15 occasions during which price increases were coordinated. These are summarized in Table 3, created using information from OntarioCourts (2017). In each case the suppliers issue a *price-increase letter* in which they announce that they will be increasing the price at a specific point in time (the *effective date*) by 7 cents (or equivalently, 4 percent).[24] On two occasions, larger increases (double in size) are coordinated.[25] One price-increase attempt seems to have failed (winter 2012). Weston did not announce an increase for certain types of bread; Canada Bread then rescinded its increase, and Weston responded by doing the same (paragraph 4.62). Figure 2 plots the 15 alleged price increases against data from Statistics Canada on the average retail price of a loaf (675 grams) of bread across the country. The alleged coordinated price increases appear to line up very closely with retail price increases observed in the data at a national level.

On the retail side, the court documents describe the role of grocers as being to serve as information conduits between suppliers during the *socialization* process of a price increase (paragraph 4.94). Information on proposed increases (dates/magnitude) was

[23] One might be concerned that the announcement of the federal investigation itself could affect consumers' awareness of a national bread cartel and that the collapse in retail prices after the cartel is a response to time-varying demand and not the prospect of a retail cartel being discovered (see, for example, Rotemberg 2011 on demand and fairness in pricing). However, the timing is such that the sharp price decrease can be observed to occur in mid-2016, while the public announcement of the investigation only came in the fall of 2017.

[24] 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). We can see that sometimes the price increase was listed as 8 cents, but according to the documents, they were always 7 cents (paragraph 4.53).

[25] Price increases 8 and 11 are listed in Table 3 as being 16 cents and 8 percent, respectively. These were doubles, joint with price increases 7 and 11, respectively (paragraph 4.48).

Table 3—Court Documents: Price Increases

	Supplier 1			Supplier 2		
Events	Date of letter	Effective date	Amount (C$)	Date of letter	Effective date	Amount (C$)
1	Feb-02	Apr-02	0.07	20-Feb-02	29-Apr-02	0.07
2	N/A	03-Nov-02	0.07	13-Sept-02	03-Nov-02	N/A
3	N/A	N/A	N/A	14-Jan-04	21-Mar-04	∼ 0.08
4	N/A	N/A	N/A	03-Feb-05	17-Apr-05	N/A
5	N/A	N/A	N/A	08-Nov-05	05-Feb-06	N/A
6	27-July-06	15-Oct-06	0.07/0.06	08-Aug-06	22-Oct-06	N/A
7	N/A	N/A	N/A	N/A	21-Oct-07	0.08
8	N/A	N/A	N/A	10-Sept-07	21-Oct-07	0.16
9	23-Mar-10	13-June-10	0.07	09-Apr-10	20-June-10	∼ 4%
10	Dec-10	01-Feb-11	4%	10-Jan-11	27-Mar-11	∼ 4%
11	N/A	N/A	N/A	03-Feb-11	27-Mar-11	∼ 8%
12	Feb-12	29-Apr-12	0.07[a]	01-Mar-12	06-May-12	N/A[a]
13	24-Oct-12	27-Jan-13	∼ 0.07	16-Oct-12	27-Jan-13	∼ 0.07
14	15-Jan-15	19-Apr-15	∼ 0.07	21-Jan-15	12-Apr-15	∼ 0.07
15	02-Dec-15	28-Feb-16	0.07	30-Nov-15	06-Mar-16	0.07

Notes: Reproduced from the November 1, 2017 ITO. "Amount (C$)" refers to the sizes of the suggested price increase. "N/A" refers to price increase events for which the date of one letter is unknown.

[a]Indicates failed attempt.

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 information transmission between suppliers. The court documents also allege that retailers would only go along with price increases if they were assured that wholesale prices were also rising for their competitors and that increases would translate into higher retail prices (paragraph 4.80). Similar concerns have been expressed in previously analyzed retail cartels. Retailers are naturally hesitant to increase prices unilaterally (especially for homogeneous products like bread), and successful cartels orchestrate the timing of price changes to limit price dispersion across retailers. The collusive arrangement achieved this by asking retailers to coordinate on uniform retail price increases. Specifically, the court documents allege a 7/10 *convention* (paragraph 4.34), whereby the 7 cents per unit wholesale price increases were to be followed by retail price increases of 10 cents (or 20 cents in the case of a double wholesale price increase). Simultaneously raising prices by a common amount across products, outlets, and time periods is consistent with retailer collusion, whether tacit or explicit (Harrington 2006).[26]

The court documents also suggest that the biggest point of contention, in this case, has to do with the participation of retailers in the collusive arrangement. The court documents describe the retail arrangement as being "difficult to manage," providing reference to a number of instances where coordination on the 10 cents proposed increase was "disturbed" (paragraphs 4.85, 4.88, 4.91). Moreover, in contrast to

[26]In online Appendix E we use external data on input price shocks to show that wholesale price changes can be associated with input price increases of 3.5 or 4 cents, implying suppliers more than fully passed through input price increases, overshooting by 3 or 4 cents. Since retailers too overshoot by 3 cents, we conclude that, nominally, retailers and wholesalers are sharing the pie, each marking up a further 3 to 4 cents on their respective cost increase.

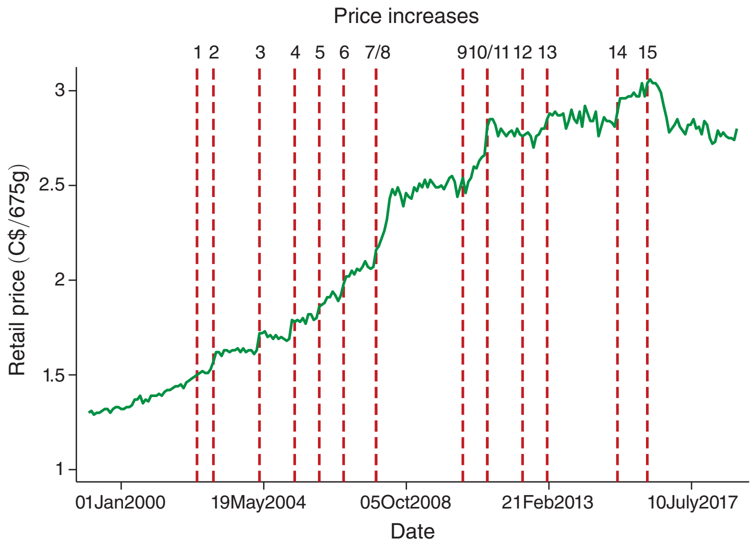

FIGURE 2. AVERAGE BREAD PRICES AND ALLEGED WHOLESALE PRICE INCREASES

Note: Vertical lines correspond to the 15 alleged price increases mentioned in the letters sent by suppliers.

suppliers, and despite the allegations against them, with the exception of Loblaws, the retailers alleged to have participated have denied the allegations.[27]

Therefore, in order to confirm that a supply chain arrangement was in place, it is necessary to provide evidence that retailers were colluding (at least partially). To do so, we take advantage of our outlet-level panel to analyze the distribution of prices within and across markets during the 2009–2018 period, which includes both the collapse phase and the last seven years of the coordination phase. We provide three pieces of evidence to support the Competition Bureau's allegations. First, we test the hypothesis that retailers passed through the proposed wholesale price increases by raising retail prices by 10 cents, consistent with the 7/10 convention. We then study differences in pass-through across markets to validate the claim that retail coordination was difficult and not uniform across cities (but instead a function of market structure). Finally, we provide evidence that the observed decline in prices post-2016 was caused by a change in retail conduct, from collusion on a (near) uniform price to noncollusive pricing, as opposed to a uniform drop in wholesale prices.

Existence of the 7/10 Convention.—We confirm the involvement of retailers by first providing evidence of the existence of the 7/10 price convention using our store-level dataset. The micro data start only in 2009, and so we focus on the five successful price-increase episodes (of either 10 or 20 cents) that occurred between

[27] See, for instance, https://www.thestar.com/business/2018/06/29/who-started-canadas-alleged-bread-cartel.html or https://business.financialpost.com/news/retail-marketing/why-the-hell-are-they-at-1-88-inside-the-damning-allegations-of-collusion-between-grocers-producers-to-fix-bread-prices.

2009 and the end of the coordination period. For comparison, we also consider two other "placebo" episodes: the failed increase of 2012 and a period in 2014 in which there was no proposed change. Together, these provide us with seven nonoverlapping episodes to study.

For each, we create *before* and *after* periods and base our definition of these periods on information from the price-increase letters. We define the episode date "0" as the month corresponding to the *effective date* of the price change indicated in the letter. The *before* period corresponds to the two-month period starting five months prior to the episode date, while *after* corresponds to the two-month period immediately following the episode. We eliminate month 0 (episode date) since many price increases occurred late in the month and we do not know the survey date. Similarly, we drop the three months immediately prior to the episode month since price increases are typically announced three months before the actual increase (*date of letter*).[28]

For each episode, (i,j,t), we calculate the change in the maximum price from before to after the proposed price change (whether successful, failed, or placebo):

$$\Delta p_{i,j,t} = \max\left\{p_{i,j,t+1}, p_{i,j,t+2}\right\} - \max\left\{p_{i,j,t-4}, p_{i,j,t-5}\right\},$$

where t denotes the episode date, i a store, and j an item. To compare these pass-through measures across episodes, we construct the following price adjustment ratio:

$$\textit{Price-change ratio}_{i,j,t} = \frac{\Delta p_{i,j,t}}{\bar{\Delta}_t},$$

where $\bar{\Delta}_t$ is the proposed increase (either 10 or 20 cents). A ratio of 1 indicates retail price changes that match the proposed increase.[29]

Figure 3 displays the distribution of price-change ratios for bread (rounded to the nearest 0.5), and the results are striking. During the coordination period, the median price-change ratio across outlets is 1, implying that bread price increases are exactly equal in size to the proposed price change (either 10 or 20 cents). The modal (rounded) price-change ratio is 1. In contrast, the distribution of price changes is clearly centered at zero for categories other than bread (Figure 3, panel A), and similarly for bread during the two placebo periods (Figure 3, panel B).[30] The figure also shows that a number of stores do not follow the proposed price increase, with

[28] For each outlet/item/episode sequence, we drop the following observations: (i) the entire sequence if it includes a product substitution and (ii) sales month.

[29] The price survey contains a significant number of large price changes that reflect permanent changes in an item's regular price. For instance, changes in the product's size leading to discrete change in the price per gram, temporary sales not recorded by the enumerator, or measurement error. This leads to outlier price ratios. Since our objective is to focus on "regular" price changes, we drop the top and bottom 5 percent of the distribution of price-change ratios.

[30] The median price change across outlets for bread is exactly equal in size to the proposed price change (either 10 or 20 cents) for each of the five successful price increases. In most cases, the median outlet does not experience any change in prices for the other products. The only exception is the 2011 price increase, which was likely triggered by an industry-wide shock to the price of wheat.

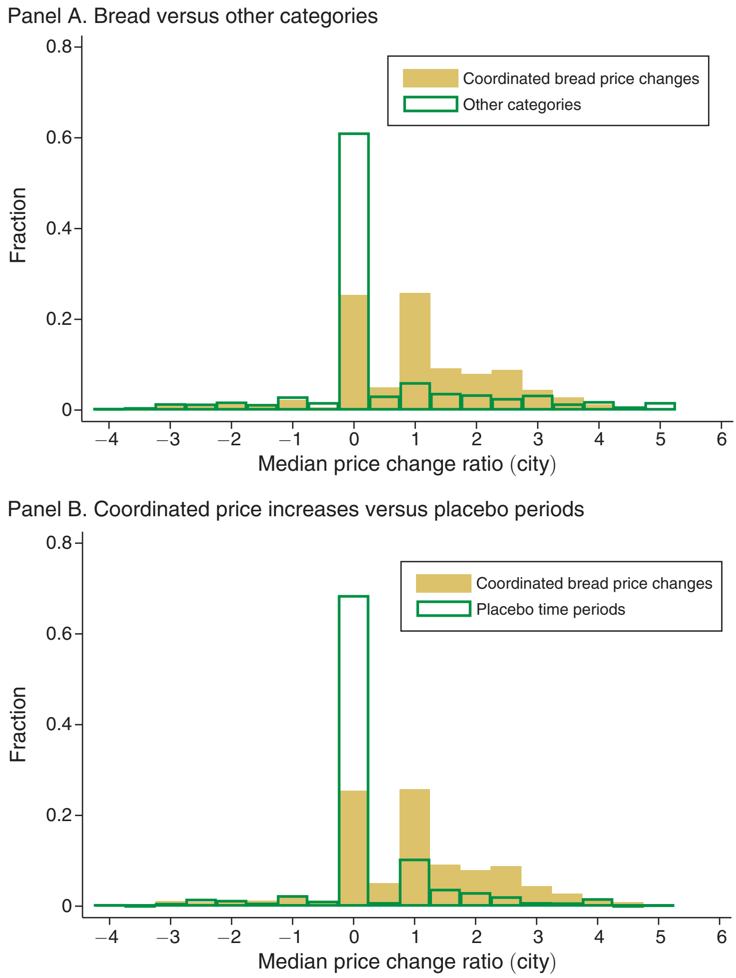

FIGURE 3. DISTRIBUTION OF PRICE CHANGES

just over 20 percent not changing prices at all ($\Delta p_{i,j,t} = 0$), others raising prices by more than was proposed, and a few actually lowering prices. We study the determinants of this heterogeneity in pass-through next.

Overall, these findings are consistent with the existence of a 7/10 price convention. Most retail outlets in our sample coordinated on a common 10 or 20 cent price increase, the timing of these changes coincided with the proposed wholesale price increases, and they took place (except on one occasion) only in the bread category.

Heterogeneity in Pass-Through across Markets.—Next, we analyze the stability of the arrangement across markets by analyzing the market-level determinants of heterogeneity in pass-through. Figure 4, panel A motivates our analysis by showing how the across-market dispersion in prices changed from 2009 to 2018.

We measure the "market price" of each item as the median price among outlets competing in the same city/month pair. The figure plots the 90–10 percentile range of this variable for the bread category relative to others.[31] It displays an inverted-U pattern. In June 2015, around the time of the leniency request, the difference between the ninetieth percentile city and tenth percentile city was on average 10 percent (or roughly 20 cents) higher for bread, compared to other categories. This was up from −5 percent in 2009. In contrast, starting in 2017, prices became more uniform across cities. The decrease in dispersion was particularly pronounced after the public announcement of the Competition Bureau investigation in 2018. This pattern is consistent with the fact that the pass-through of price increases proposed by suppliers and the decrease following the investigation were not uniform across markets.

To link this heterogeneity with stability of retail collusion across markets, we measure the correlation between pass-through of proposed price increases and retail market structure. If differences across markets are due to retail collusion, we would expect pass-through to be greater in concentrated retail markets and markets with fewer low-price discounters that might be disrupting collusion. We aggregate price-change ratios across outlets by calculating the median price-change ratio within a city/item/episode. We use the median to further reduce the importance of outlier price changes. The size of each circle is proportional to the number of observations in each cell. Figure 5, panel A presents results, plotting the median price-change ratio for bread against HHI in the coordination period. It shows clearly that price-change ratios are larger the more concentrated the market.

We next investigate whether the reverse patterns were present during the collapse of the agreement. In particular, having shown that the 7/10 arrangement was most effective in concentrated markets, we measure the effect of the investigation on retailer conduct. Figure 5, panel B plots the median change in log price (at the city level) against HHI. The findings demonstrate clearly that the median decrease in log price is larger in more concentrated markets.[32]

These findings imply that more concentrated retail markets were (i) more likely to successfully collude and change prices following the 7/10 convention and (ii) experience declines in prices post-2016. This is consistent with the Competition Bureau's claim that retail collusion was difficult to sustain since not every market was able to successfully raise prices by the full 10 cents.

Collusion on (Near) Uniform Prices.—In addition to more than fully passing through wholesale price increases, the court documents allege that successful collusion also involved coordination on a uniform retail price, with stores setting low prices pressured to set higher prices (paragraphs 4.27 and 4.91). Figure 4, panel B is consistent with this claim. It displays a city-level measure of price dispersion at the

[31] More specifically, we calculate

$$\sum_j \mathbf{1}\{j \in B\} \frac{1}{N_{t,B}} \frac{Median_{j,t}^{90} - Median_{j,t}^{10}}{Median_{j,t}^{50}} - \sum_j \mathbf{1}\{j \in O\} \frac{1}{N_{t,O}} \frac{Median_{j,t}^{90} - Median_{j,t}^{10}}{Median_{j,t}^{50}},$$

where j indexes each time and B represents bread and O the other categories.

[32] To confirm that these patterns are robust, in online Appendix D we perform regressions to analyze the relationship between local market concentration and price change ratios/median changes in log price, for bread and for other products. Results are presented in Tables D3 and D4 in online Appendix D.

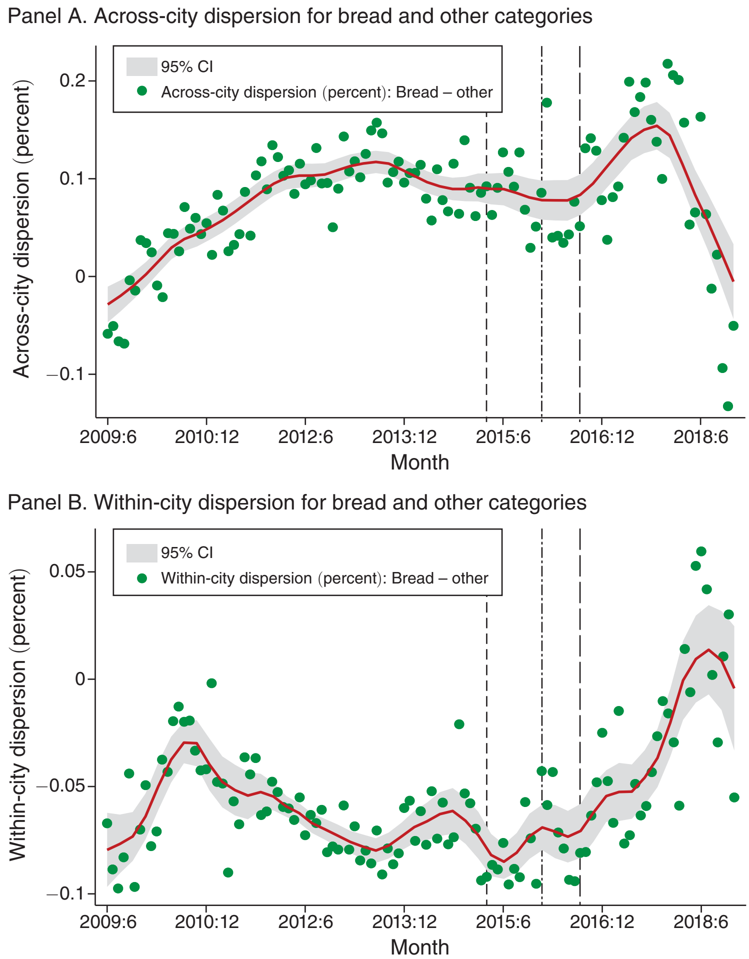

FIGURE 4. EVOLUTION OF ACROSS- AND WITHIN-MARKET DISPERSION

Notes: Vertical lines: Dash = March 2015 (immunity agreement), dash-dot = January 2016 (CFIG complaint), long dash = August 2016 (end of coordination period). Dispersion = across-city ($P90$–$P10$)/median.

item/month level averaged across markets and items within each category.[33] It shows that bread prices were less dispersed than other categories during the coordination

[33] Specifically, keeping only regular prices, we construct a city-level measure of dispersion at the item/month level:

$$Within\ Disp_{m,j,t} = \frac{p^{90}_{m,j,t} - p^{10}_{m,j,t}}{p^{50}_{m,j,t}},$$

where $p^{q}_{m,j,t}$ is the qth percentile of the distribution of prices (across outlets) in market m, for item j, in month t. We then calculate an average across markets and items within each category:

$$\overline{Within\ Disp}_{t,C} = \sum_{m,j} \mathbf{1}\{j \in C\} \frac{1}{N_{t,C}} Within\ Disp_{m,j,t}, C = Bread\ or\ Other,$$

where $N_{t,C}$ is the number of market/item observations in month t and category C. The figure then plots the difference between bread and other categories.

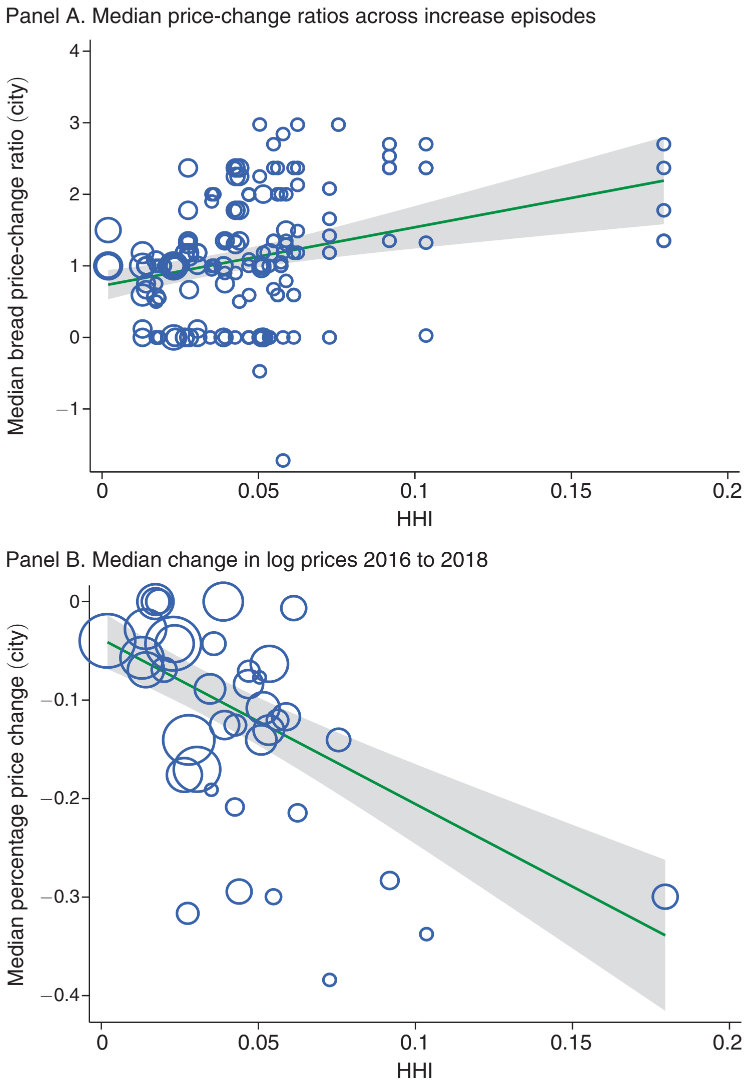

Figure 5. City-Level Bread Median Price Changes and HHI

Note: The size of each circle is proportional to the number of observations in each cell.

period and that when the cartel collapsed, within-city dispersion increased sharply. The inflection point in the figure, August 2016, coincides with the date of the cartel breakdown we estimated using a structural break test. The collapse of the agreement suggests a change in retailer conduct: from near-uniform prices during collusion, to price dispersion afterward.

Figure 6 shows that this increase in within-city price dispersion was caused by a pronounced decrease in prices at the bottom of the distribution. We calculate the within-city percentile in the regular price for each market/item and month. We focus on five percentiles: tenth, twenty-fifth, fiftieth, seventy-fifth, and ninetieth. We then express each percentile relative to the average between January and June of 2015:

$$\Delta p^{q}_{m,j,t} = p^{q}_{m,j,t} - E\left[p_{m,j,t} \middle| 01/2015 < t < 06/2015\right].$$

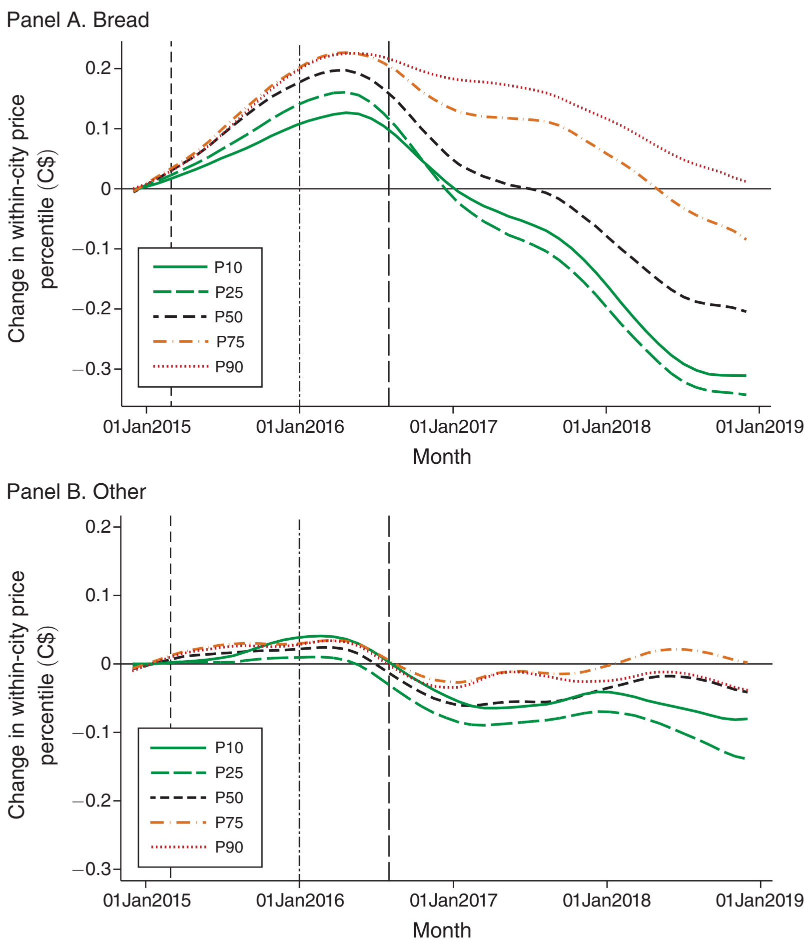

Figure 6. Decrease in Prices by Percentiles (*within city*)

Notes: Vertical lines: Dash = March 2015 (immunity agreement), dash-dot = January 2016 (CFIG complaint), long dash = August 2016 (end of coordination period). Price percentiles are expressed relative to the average first six months of 2015. Bandwidth = three months.

The fitted curve is estimated using a local-polynomial regression of $\Delta p^q_{m,j,t}$ on the count of months between January 2015 and December 2018. We use a 90-day bandwidth.

From Figure 6, panel A, we observe that the lowest-price outlets (e.g., discount stores) increase prices much less over the course of the last two coordinated price increases in 2015 and 2016 and that they more quickly and significantly lowered prices following the collapse.[34] Figure 6, panel B confirms these changes were not present in other categories. This pattern of price cuts within markets illustrates the role of asymmetry between retailers and explains the increase in within-market price dispersion post-2016. The collapse of the collusive agreement was led by low-price

[34] We do not calculate the percentiles as of a particular date, so one might be concerned about rank reversals in the data, which would make our interpretation of the bottom percentile as *lowest-price outlets* or *discount stores* inappropriate. However, as demonstrated in Table D5 in online Appendix D, there are very few rank reversals.

chains, consistent with the theory that stores facing more elastic demand and/or lower costs are more likely to deviate from a collusive agreement (e.g., Jacquemin and Slade 1989).

IV. A Model of Supply Chain Collusion

Our analysis of the court documents and data provides evidence of successful collusion at both ends of the vertical chain. The question is why the participants chose this sort of arrangement. Here, we develop a model of supply chain collusion that addresses this question. We sketch the key elements in this section and provide a more detailed derivation in online Appendix F. The model incorporates imperfect competition at both ends of the chain and retailers sourcing from multiple suppliers, with one supplier acting as the main supplier.

The model is an infinite horizon discrete time model, with two upstream suppliers, labeled $i = 1,2$, selling their products to two downstream retailers, labeled $j = a,b$, that sell only these products to a measure 1 of consumers. Consumers view the two products as identical but the retailers as differentiated, so that each buys at most one of the products from one of the retailers. Each retailer sets a common price, p_j, for the two products, and consumers observe prices prior to purchase. Consumer behavior is summarized by demand functions for retailers given by $Q_j(p_j, p_{j'})$. Suppliers' costs of production are identical and given by a constant unit cost, $c \geq 0$. The only variable costs retailers incur are the wholesale prices, w_i^j, paid to the suppliers. Both supplier and retailer payoffs are given by the present value of the stream of expected per period profits accruing to each, respectively, with both having a common discount factor β, $0 \leq \beta \leq 1$.

Each period, each retailer chooses one supplier to be its *main supplier*; the other becomes its *secondary supplier*. The main supplier is promised a share of quantity sold—a shelf share—$s > 0.5$ and is paid its wholesale price bid for each unit supplied. In exchange for greater shelf share, the main supplier provides services to the retailer that result in a fixed cost of $F > 0$. The other supplier becomes the secondary and is paid its price offer. It obtains the remaining $1 - s$ share of quantity sold but incurs no fixed cost of serving the retailer. The relationship formed between a retailer and its main supplier makes it costly to switch to rival suppliers. We model this as a fixed switching cost denoted Δ, which is assumed to be a random variable that is identically and independently distributed both across time and across retailers and privately observed by each retailer.

The period game at time t is composed of three-stage games. In the first, suppliers simultaneously make wholesale price offers to retailers conditional on the state variable $x = (x_a, x_b)$. This variable denotes the supply relationship—main (M) or secondary (S)—that supplier 1 had with retailers a and b at the end of period $t - 1$, leading to four possible states: $X = \{(M,M),(M,S),(S,M),(S,S)\}$. In the second stage, the values of the switching cost, Δ_j, are realized. Retailer j observes its own switching cost along with its wholesale bids but not the wholesale offers of the other retailer or its switching cost. Based on this information, retailers then simultaneously decide either to retain or switch main suppliers. In the third stage of the game, switching decisions are observed—the state transitions from x to x'—and the retailers simultaneously set prices.

In the noncollusive environment, we restrict suppliers and retailers to using Markov strategies and define equilibrium as a symmetric Markov Perfect Equilibrium (MPE).

Noncollusive Equilibrium.—In the last stage of the game, the marginal cost of retailer j is given by the new contractual state x' and the wholesale price offers w_j: $\bar{w}_j = \sigma_j(x')w_1^j(x) + [1 - \sigma_j(x')]w_2^j(x)$, where $\sigma_j(x') = s$ if supplier 1 is the main supplier of retailer j in state x' and $1 - s$ otherwise. This leads to a pure-strategy Bertrand-Nash equilibrium, with prices and quantities denoted by $p_j(\mathbf{w}\,|\,x',x)$ and $Q_j(\mathbf{w}\,|\,x',x)$, where $\mathbf{w}$ is the vector of wholesale price bids.

The second stage is a discrete-choice game with asymmetric information. Retailers' equilibrium decisions are characterized by Markov Perfect switching probabilities that are increasing in the main supplier's bid and decreasing in the secondary supplier's bid. This leads to a Markov transition probability process for the contracting state vector: $H(x'|x,\mathbf{w})$.

In the first stage, suppliers anticipate the retailers' contract and pricing strategies and simultaneously submit wholesale price bids w_i^j to maximize the expected discounted sum of profits in each state x. Supplier i's equilibrium bid to retailer a in state x is defined by the following FOCs:

$$(1)\quad 0 = \sum_{x'} \Bigg\{ \underbrace{\frac{\partial H(x'|x,\mathbf{w})}{\partial w_i^a} v_i(x'|x,\mathbf{w})}_{\text{Competition for shelf share}} + \underbrace{H(x'|x,\mathbf{w})\sigma_a(x')Q_a(\mathbf{w}\,|\,x',x)}_{\text{Direct price effect}}$$

$$+ \underbrace{H(x'|x,\mathbf{w})\left[\sigma_a(x')\frac{\partial Q_a(\mathbf{w}\,|\,x',x)}{\partial w_i^a}(w_i^a - c) + \sigma_b(x')\frac{\partial Q_b(\mathbf{w}\,|\,x',x)}{\partial w_i^a}(w_i^b - c)\right]}_{\text{Competition for consumers}} \Bigg\},$$

where $\mathbf{w} = \{w_1^a(x), w_1^b(x), w_2^a(x), w_2^b(x)\}_{x\in X}$ and $v_i(x'|x,\mathbf{w})$ is the present value of the stream of expected per period profits for supplier i given bids $\mathbf{w}$. Note that, since retailers do not observe offers made to their rivals, supplier i can affect demand from retailer b only indirectly through the price response of retailer a (i.e., business-stealing effect).

In the noncollusive equilibrium both retailers choose $s = 1$ and offer exclusive contracts to the main supplier. Setting $s = 1$ is attractive to retailers because it creates more intense price competition among suppliers and, in our numerical example, is a dominant strategy. In addition, because of this asymmetry in shelf space and the presence of switching costs, the main suppliers bid higher wholesale prices than do secondary suppliers. The resulting wholesale price offer gap is especially pronounced when one supplier is the main to both retailers. These two asymmetries prove particularly important for understanding the benefit of joint versus independent collusion.

Collusive Rings along the Supply Chain.—To understand incentives for joint collusion, we need some notion of what distinguishes it from independent-supplier or independent-retailer collusion. The key difference is that independent collusion refers to a situation in which one side of the market colludes, while the other continues to set prices noncollusively.

Under independent-supplier collusion, suppliers choose a common wholesale price bid, w^c, regardless of whether they are the main or secondary supplier; retailers play the noncollusive strategies given this common wholesale price. Under independent-retailer collusion, retailers are assumed to choose a common retail price, p^c, but to set shelf share noncollusively; suppliers choose wholesale price bids using the noncollusive Markov Perfect Equilibrium strategies given retailer shelf-share choice and the collusive retail price p^c. In each of these cases, it is a dominant strategy for the retailers to set $s = 1$. Under joint collusion, retailers and suppliers jointly decide on a common value for the wholesale price, w^c, a common value for the retail price, p^c, and a common shelf share, s^c. Note that unlike independent-retailer collusion, under joint collusion, shelf share can be part of the collusive arrangement because suppliers act as a perfect monitor should retailers deviate.

For simplicity, in each collusive scenario, we restrict the colluding parties to stationary, symmetric strategies and assume deviations from the collusive arrangement are punished by reversion to the noncollusive equilibrium strategies in the following period. For independent-supplier collusion, supplier strategies can be conditioned on all past wholesale price bids. Deviation by either supplier from the common collusive price, w^c, at time t results in reversion at $t + 1$ to the noncollusive equilibrium. The relevant incentive constraint for supplier 1 is given by the decision to undercut w^c when it is the secondary supplier to both retailers. For independent-retailer collusion, the stage 3 retailer pricing strategies can be conditioned on all past retail price outcomes. The stage 2 contracting strategies continue to be the stage 2 noncollusive equilibrium strategies given wholesale price bids and the collusive retail pricing strategies. Deviation by either retailer from the common collusive price, p^c, at time t results in reversion at $t + 1$ to the noncollusive equilibrium. The relevant incentive constraint for retailer a is given by the decision to undercut p^c following a change of supplier in state $x = (S,S)$ (i.e., $x' = (M,S)$). This represents the largest gain from deviation since wholesale price competition leads to the lowest realization of $\bar{w}_a(x',x)$. Under joint collusion, both supplier and retailer pricing strategies can be conditioned on all past wholesale prices, retail prices, and shelf-share outcomes (the switching decision continues to be made using the noncollusive strategy given w^c, p^c, s^c). Under joint collusion, incentive constraints for the retailers and suppliers analogous to the ones defined above for the independent-collusion cases must be satisfied.[35]

Ultimately, the downfall of independent collusion is the asymmetry in the wholesale market created by the supply arrangement. The asymmetries in shelf share and wholesale prices that result create three sorts of problems. First, the shelf-share asymmetry makes independent-supplier collusion difficult: the secondary supplier has a significant incentive to deviate if shelf-share asymmetries are large. With supplier collusion difficult, independent-retailer collusion becomes difficult for two possible reasons. One is that when retailers collude on a fixed price, the gap between the main and secondary supplier price bids increases. This is because retail price

[35] In each case, equilibrium is defined as the perfect Bayesian equilibrium given the specified strategy restrictions.

collusion makes the demand of suppliers less elastic by eliminating all quantity competition effects. This widening in the wholesale price gap increases potential cost asymmetries between retailers and so makes retail collusion more difficult. The other is that if retail collusion is only marginally sustainable, competition at the wholesale level can additionally spill over into the retail level, as suppliers offer price reductions to induce a retailer to cut prices and so break the collusive arrangement. The solution is for the group to enter a joint agreement that reduces asymmetries and punishes any deviation with full reversion to the noncollusive outcome. In the next section, we use a calibrated example to illustrate both the difficulties with independent collusion and the benefits provided by joint collusion.

Calibrated Example.—This section illustrates how two of the challenges mentioned above—asymmetries in supplier shelf shares and asymmetries in retailer costs due to upstream competition—impact the ability of retailers to collude and how joint collusion can resolve these problems.[36] We use a calibrated example to illustrate these forces and quantify the impact of joint collusion on the stability of collusive arrangements.

We use a logistic functional form to parameterize the distribution of switching costs and retail demand. The model is defined by the following parameters: the shelf-share allocation (s), the discount factor (β), the fixed cost of managing the shelves (F), the outside option price p_0, the marginal wholesale cost c, the demand slope α, and the two parameters determining the retention probability $\left(\bar{\Delta}, \sigma_{\Delta}\right)$. The first four parameters are fixed, and we calibrate the other four parameters by matching moments obtained from our reduced-form analysis of the life cycle of the cartel as well as grocery industry statistics from Kilts Marketing (KiltsCenter 2018). We use the same moments to identify the level of prices under collusion: $p^c = \text{C\$2.5}$ and $w^c = \text{C\$1.60}$. Finally, we consider two alternative values for the price of the outside retail option. Specification (1), our baseline specification, assumes that p_o is C$3, while Specification (2) sets it to C$2.50. We use the second specification to analyze the role of competition from retailers outside the cartel. Online Appendix F provides (i) additional details on our model calibration, (ii) a description of the algorithm used to solve the game, and (iii) additional numerical results mentioned here in the text. The results are generated using Ox (Doornik 2007).

Independent Collusion: Consider first the asymmetry in shelf-share allocation and how it affects suppliers' ability to collude. If the retailers act noncollusively, then, from above, shelf share is set at $s = 1$. Consider an extreme example with $\Delta = 0, \beta \rightarrow 1$. In this case, the secondary supplier has every incentive to undercut a collusive arrangement if market structure transitions to the $(S,S)/(M,M)$ state. This is because the secondary supplier earns zero profits under collusion but strictly positive profit if it undercuts the main. Figure 7, panel A confirms this result in our stochastic switching cost example. The solid green line plots suppliers' incentives

[36] It does not capture the possibility that a supplier offers a discount to incentivize a retailer to cut prices in a way that disrupts retail collusion. The reason is that, under the adopted parameterization, suppliers extract a significant amount of the retailers' collusive profits.

to collude as β varies. Suppliers are able to collude independently of retailers only if β is greater than roughly 0.8.

Next, consider the retailers' ability to collude when suppliers act noncollusively. Unlike in standard models of downstream collusion, here, suppliers react to retailer conduct by adjusting their wholesale prices. When retailers collude on a fixed price, the demand of suppliers is less elastic, as the *competition for consumers* effect is not present (third term of equation (1)). The main supplier optimally raises its price to extract part of the retailers' collusive profits. This increases the profit from becoming the main supplier so that the secondary supplier has greater incentive to compete for shelf share ($\downarrow w_S$). As a result, the difference between w_M and w_S increases (relative to the MPE), as do the cost asymmetries between retailers.

Table F7, panel (b) in online Appendix F illustrates this point numerically. Rather than continuing to offer the noncollusive wholesale prices, the main supplier takes advantage of the switching cost and extracts some of the retailer's collusive profits by raising w_M from 1.4 to 1.54. The opposite is true for the secondary supplier, which, in this example, lowers its bid from 0.655 to 0.593. Figure 7, panel B illustrates that this response causes the retail cartel to become unstable.[37] The solid green line plots the gain from collusion for a retailer that switches suppliers assuming that wholesale prices are set at their noncollusive levels (i.e., w^{mpe}). In this case, retailers can sustain collusion as long as β is greater than approximately 0.4. The dashed line plots the same values for the case where suppliers respond to retail collusion. A retailer that switches supplier now gains from collusion only if β is greater than 0.6.

Note that the fact that suppliers can extract collusive profit from retailers implies retail collusion creates a positive externality for suppliers. Therefore, in this parameterization, suppliers have incentive to promote retail collusion, even when not colluding themselves. If the discount factor is low enough, suppliers' noncollusive behavior foils retail collusion and their own ability to extract profits. This means that both suppliers and retailers have incentive to form a collusive arrangement.

Joint Collusion: By colluding jointly, retailers can share information on wholesale prices, and suppliers can share information on retail prices and shelf shares. This information sharing makes it possible for retailers to set shelf shares of less than 1 and allows for punishments that collapse the entire collusive arrangement. This means that joint collusion can reduce asymmetries among suppliers and so facilitate upstream collusion. Information sharing about wholesale prices allows both sides to reduce wholesale price differences, thereby making retailer collusion more sustainable.[38]

Table 4 presents the critical discount factors that sustain collusion under independent and joint collusion under our two model specifications and for three values of s: 0.8, 0.9, and 1. Focusing on Specification (1) and $s = 1$, independent-retail collusion is not feasible when β is less than 0.6, and supplier collusion when β is less than 0.77. When suppliers agree to collude on a common wholesale price, retailers' critical discount factor drops to 0.26, while it increases to 0.8 for

[37] Figure F4 in online Appendix F presents the same results for Specification (2).

[38] In practice, retailers can "help" suppliers by changing other aspects of their procurement strategies. For instance, they could agree to stay with the same supplier and cancel their call for bids entirely.

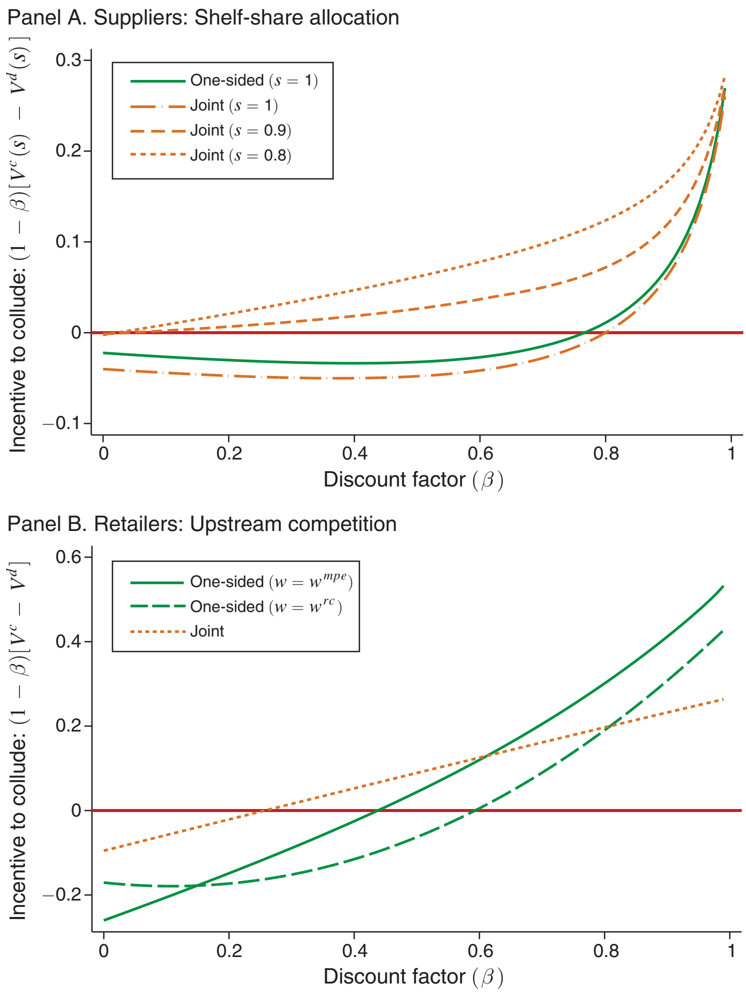

Figure 7. Vertical Externalities and the Incentive of Each Side to Collude Independently

Notes: Incentive constraints calculated using parameter estimates from Specification (1): $p_o = 2.5$ and higher Δ. Panel A plots the gain from collusion for suppliers for three values of s, and panel B the gain from collusion for retailers when suppliers post prices valid in MPE (w^{mpe}) and when suppliers optimally respond to retail collusion (w^c).

suppliers. Clearly, joint collusion is not feasible unless s is reduced. By agreeing on $s = 0.9$, the critical discount factor of suppliers falls to 0.04, and it stays constant for retailers. Joint collusion is feasible so long as β is greater than $0.26 = \max\{0.26, 0.04\}$. Therefore, from the point of view of retailers, joint collusion increases the stability of the cartel by decreasing the critical discount factor from 0.6 to 0.26. Moreover, both sides sacrifice relatively little value by forming this joint agreement. As Table F7, panel (d) in online Appendix F shows, retailer value decreases from 3.18 to 2.72 when suppliers join the cartel, while supplier value decreases from 2.02 to 1.97 (in the (M, S) state).[39]

[39] See Table F8, panel (d) in online Appendix F for similar results for Specification (2).

TABLE 4—CRITICAL DISCOUNT FACTOR SUSTAINING INDEPENDENT AND JOINT COLLUSION

Scope of collusion	Shelf space	Critical discount factor β^{min}	
	(s)	1. $p_0 = 3$	2. $p_0 = 2.5$
One-sided:			
Retailers	1	0.6	0.87
Suppliers	1	0.77	0.78
Joint:			
Retailers	1	0.26	0.54
Suppliers	0.8	0.03	0.42
	0.9	0.04	0.64
	1	0.8	0.9
Combined	0.8	0.26	0.54
	0.9	0.26	0.64
	1	0.8	0.9

Notes: The "Joint" rows refer to the incentive constraint of retailers assuming that suppliers collude on w^c (vice versa for suppliers). The "Shelf space" column refers to the agreed-upon shelf-space split under joint collusion. Note that we evaluate the incentive constraint of the retailers only at $s = 1$ since the retailer's incentive to collude is independent of s under joint collusion. The "One-sided" rows refer to the incentive constraint of retailers assuming that suppliers noncooperatively best respond to the retailers' collusive strategy p^c (vice versa for suppliers). The critical discount factor of retailers is the smallest value of β that sustains collusion when the retailer accepts an offer from the secondary supplier in the asymmetric market-structure state (i.e., $(x, x') = ((S,S),(M,S))$). The critical discount factor of suppliers is the smallest value of β that sustains collusion for the secondary supplier in the state $x = (S,S)$. The "Combined" critical discount factor is the maximum of β^{min}_{retail} and $\beta^{min}_{supplier}$. Collusive prices: $p^c = 2.5$ and $w^c = 1.6$.

So far, we have focused on the case in which retailers face relatively little competition (i.e., $p_o = 3$). Specification (2) studies a market structure in which retailers compete with a more competitive fringe ($p_o = 2.5$). We use this specification to highlight the impact of competition from noncartel members on the stability of the joint collusive agreement. Recall that in the bread case, grocery chains affiliated with the Canadian Federation of Independent Grocers were the first outside parties to raise concerns about collusion with the Competition Bureau. Our empirical results suggest that markets with a larger share of independent grocers were unable to sustain supracompetitive retail profit margins.

The second row of Table 4 reports critical discount factors under Specification (2). Competition from a fringe has a considerable impact on the stability of collusion, especially for retailers. When $s = 1$, independent-retail collusion is sustainable only if $\beta > 0.87$ (compared to 0.6 earlier). This is due to the fact that the gain from deviating is larger when stores' residual demand is more elastic. The effect of retail competition is more muted for suppliers because of the incomplete pass-through of wholesale price changes. Overall, this suggests that retailers are more likely to form vertical collusive arrangements when downstream competition is important.

The effect of downstream competition on stability of the joint agreement is important for both sides. With $s = 1$, both critical discount factors increase significantly when we lower the price of the fringe: from 0.78 to 0.9 for suppliers and from 0.26 to 0.54 for retailers. These increases are even larger for lower values of s. As Figure 7, panel A illustrates, decreasing asymmetries between suppliers increases the gain from collusion.

V. Conclusions and Policy Discussion

We provide the first comprehensive analysis of a hub-and-spoke cartel using as a case study the cartel that operated in the Canadian bread market. Over a period of 15 years, suppliers helped to coordinate retail prices, and retailers helped to coordinate supplier prices. Our empirical analysis shows that this joint coordination resulted in bread price inflation that was 50 percent higher than for food. We also provide documentary and empirical evidence that the cartel operated at both ends of the vertical supply chain. Our model provides an explanation for this sort of cartel based on the fact that there is price competition at both ends of the supply chain—retail and wholesale—and that the large retail stores stock both wholesalers' products using a main supplier/secondary supplier allocation of shelf space. The endogeneity of wholesale prices and asymmetries in payoffs induced by the main supplier/secondary supplier approach ultimately results in wholesalers undermining any independent collusion. This problem is resolved by joint collusion.

Our findings have important policy implications. First, it is often claimed that hub-and-spoke collusion is unlikely to arise since (i) it is hard for firms at one end of the supply chain to agree through only indirect communication on the subject and level of collusion and (ii) third-party hubs are likely to have different incentives than the spokes.[40] The latter point is especially true for hub-and-spoke arrangements where the retailer acts as hub and the suppliers as spokes (so-called reverse hub-and-spoke cartels). Our empirical results confirm the existence of an arrangement involving both ends of the supply chain.

Second, the legal determination that a hub-and-spoke cartel exists and actual enforcement against the arrangement can be challenging. There can often be legitimate explanations as to why retailers and suppliers communicate and exchange information. Since communication can be for procompetitive or efficiency-enhancing reasons, it is necessary for authorities to establish underlying motivations and intentions if they hope to prove that the law was violated. To this end, our empirical results confirm that hub-and-spoke can have a significant effect on prices, providing a profit motive for this sort of arrangement.

Our findings also shed light on the economic environments that can give rise to hub-and-spoke collusion. It has been argued that market power at one or both ends of the supply chain may encourage the formation of hub-and spoke cartels,[41] and it is possible that the increase in retailer concentration may have played a role in the development of the cartel. With fewer retailers competing, collusion becomes easier. However, traditional coordinated effects do not take into account the structure of the upstream market. If the supply side is perfectly competitive, then the typical story of coordinated effects holds. In contrast, if the upstream market is concentrated, as it is in the bread market, then retailer collusion could be undone by the suppliers, especially in cases where competition is more intense and greater asymmetries exist.

[40] See https://one.oecd.org/document/DAF/COMP/M(2019)2/ANN3/FINAL/en/pdf.
[41] See, for example, https://one.oecd.org/document/DAF/COMP/M(2019)2/ANN4/FINAL/en/pdf.

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