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Using list prices to collude or to compete?

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Abstract

It is often argued that collusion is not possible in wholesale markets where suppliers and buyers privately negotiate discounts off list prices and sales quotas are unfeasible. However, this would go against allegations in court of suppliers being able to collude by publicly announcing list prices. It would also go against recent evidence from Chile's wholesale fresh-egg market: a sudden interruption in the publication of list prices in the local newspaper led to a significant drop in the prices effectively paid by different buyers, large and small. We develop a theory consistent with this evidence, whether suppliers collude or compete. Two effects are at work. When suppliers collude, public announcements of list prices enlarge collusion possibilities from small to large buyers (the multibuyer contact effect). When suppliers compete, these announcements provide them with commitment to unilaterally negotiate better terms with large buyers (the commitment effect).

Keywords: list prices, collusion, Nash bargaining.

JEL Classifications: D43, K21, L12, L13.

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1 Introduction

Collusion in retail markets usually involves firms agreeing to charge prices above competitive levels and then monitoring prices for compliance. Collusion in wholesale markets also involves suppliers agreeing on prices but, as long noticed by Stigler (1964), compliance is more problematic because there are buyers who rarely pay posted prices or so-called list prices. They often buy at a substantial discount off the list price, which is privately negotiated. This explains why some cartels in these intermediate markets have also agreed to sales quotas (or some other market-segmentation scheme), and monitoring involved comparing actual sales with agreed-upon sales (see, e.g., Harrington and Skrzypacz, 2007 and 2011; Bernheim and Madsen, 2017).

It appears that coordinating just on prices would not be possible in wholesale markets. However, as explained by Boshoff and Paha (2021) and Harrington and Ye (2019), this would go against recent allegations on both sides of the Atlantic of suppliers effectively coordinating on list prices. A problem courts face in deciding these cases is that defendants often claim that, due to pervasive secret discounts, any ostensible list price coordination cannot have any anticompetitive effect. Here is what a member of the thread cartel explained in court:[1]

> ...list prices have more of a political importance than a competitive one. Only very small clients pay the prices contained in the lists. As the official price lists issued by each competitor are based on large profit margins, customers regularly negotiate rebates, but no clear or fixed amount of rebates is granted. ... [T]he list prices are essentially 'fictitious' prices.

According to this cartel member, list prices would not only constitute costless messages—cheap talk, using the languaje of Crawford and Sobel (1982)—but also be uninformative. Courts have expressed different views on this matter. In the fiberglass cartel, for example, the Seventh Circuit Court indicated that list prices[2]

> ....would be, to put it mildly, an awkward facilitator of price collusion because the industry practice of providing discounts to individual customers ensured that list price did not reflect the actual transaction price.

In contrast, in the polyurethane cartel the Tenth Circuit Court commented that[3]

> ...product price lists and parallel price-increase announcements — 'presumably established an artificially inflated baseline' for negotiations.

Adding to these cases is a recent event that took place in Chile's wholesale fresh-egg market. Egg producers used to publish their list prices on a weekly basis—on each Monday—in the country's main newspaper. For reasons unknown to us, this publication was suddenly interrupted in October of 2018.[4] After the cease of publication, suppliers continued communicating

[1] Commission of the European Communities, 14.09.2005, Case COMP/38337/E1/PO/Thread, 112, 159-60.

[2] *Reserve Supply v. Owens-Corning Fiberglas* 971 F. 2d 37 (7th Cir., 1992), para 62.

[3] *In Re: Urethane Antitrust Litigation,* No. 13-3215 (10th Cir., 2014), p. 7.

[4] Around the same time, this newspaper also interrupted the publication of (wholesale) list prices concerning many other products, including cattle, fruits, vegetables, fertilizers, etc. Our empirical analysis focuses on the egg market primarily because of data availability, but it would be useful to carry out similar analysis for these

their list prices but asynchronously and in a more decentralized and "opaque" way, using the internet, emails and phone calls. It was not uncommon for different buyers to get different quotes with list prices. Using detailed transaction-level data from two of its largest suppliers, in Section 2 we explore the effect that the cease of publication could have had on the wholesale market.[5] We find strong effects on both list and effectively-paid (i.e., transaction) prices; list prices fell by about 15%.

Motivated by this event and the cases, our goal in this paper is to contribute to our understanding of whether, how and to what extent simultaneous and public announcements of list prices—to which we will often refer as *public* list prices—could help suppliers to sustain supracompetitive prices. We start our analysis in Section 3 with an irrelevant result consistent with the above first and second quotes: public list prices play no role.

In formulating our theory we build on Horn and Wolinsky's (1988) model of bilateral negotiations and extend it to consider list-price announcements and negotiations over two-part tariffs that may suffer from contractual frictions *à la* Calzolari et al (2020). Contractual frictions help explain why sometimes we see parties bargaining just over linear prices, as in our motivating evidence but also elsewhere (e.g., Crawford and Yurukoglu, 2012; Noton and Elberg, 2018). In this setting, and regardless of the level of contractual frictions, list prices do not emerge in equilibrium; if they do, they are payoff irrelevant. For list prices to play some role, suppliers would need to set them low enough for buyers to prefer to buy at such prices than to bargain with suppliers. In equilibrium suppliers never want to announce list prices that low, whether they compete or attempt to collude.

This irrelevant result is in contrast to recent work by Harrington and Ye (2019) and Harrington (2022).[6] The reason is that these works rely on elements that are absent from our theory. In Harrington and Ye (2019) suppliers use list prices to coordinate on high-cost signals before buyers invite them to "negotiate," that is, to participate in their procurement auctions. In our setting suppliers and buyers negotiate bilaterally under complete information, so costless messages are never informative.[7]

In Harrington (2022), on the other hand, offering discounts carries a disutility to the sales agents offering them. In other words, list price announcements are no longer cheap talk, unlike in Harrington and Ye (2019). As a result, list prices serves to "inflate the baseline" for negotiations, much consistent with the third quote above. We abstract from such "organizational" costs, partly because we see discounts to vary widely—in absolute and percentage terms—across

other markets. Note also that no case has been opened by the Competition Authority on any of these markets as of this writing.

[5]We are grateful to these two companies for giving access to their data. However, this authorization does not implicate them in anything expressed in this paper.

[6]There are also works looking at the effect of list-price announcements and discount offers directed at final consumers (e.g., Raskovich, 2007; Gill and Thanassoulis, 2016). We come back to their connection to our theory below.

[7]Lubensky (2017) is another setting of incomplete information and where final consumers must search for better prices. Announcements of list prices are again informative in that they affect the direction of this search.

buyers and overtime, including in our motivating evidence.[8]

Collusion on prices can still emerge in our bargaining setting and in the absence of list prices but it does require two elements: transfers and communication to buyers about suppliers' intention to collude. Communication is needed because suppliers invite buyers to accept terms that depart from the expected negotiation outcome, that is, from the Nash bargaining solution (Nash, 1950; Binmore et al., 1986; Collard-Wexler et al., 2019). Thus, in their attempt to collude suppliers must leave buyers with at least the Nash-bargaining-solution payoff. This participation constraint is also present in the hub-and-spoke cartels of Garrod et al (2021), where suppliers and buyers also engage in bilateral negotiations. Because of buyers' participation constraint, when suppliers agree to increase wholesale prices they necessarily must compensate buyers with lower fixed fees.[9] But when contractual frictions are important—and parties bargain over linear prices only—there are no fixed fees suppliers can draw upon. In this case, collusion on prices is just not possible.[10]

This no-collusion result is an important piece of our theory because in none of the cases there is a mention to transfers nor they appear in our motivating evidence. There is however a key element present in the cases (see the first quote) and in our motivating evidence that we have omitted so far, which is the presence of "small" buyers that for most part pay list prices. Some of these small buyers may still get some discounts, but they rather respond to a price-discrimination motive than to bargaining. What ultimately distinguish small from large buyers in our theory is that the former are price takers and the latter are not. In addition, and this is particularly true in our motivating evidence, large and small buyers compete for final consumers in the downstream market, giving rise to a *multibuyer contact* effect.[11,12]

This multibuyer contact effect is similar in spirit to the multimarket contact effect of Bernheim and Whinston (1990) but is actually quite different. It is similar because market/buyer-type A allows to also monopolize market/buyer-type B. In Bernheim and Whinston (1990) suppliers can sustain collusion in market A with slack, some of which is used to sustain collusion in market B, that otherwise would not be possible. Here, suppliers can in principle agree to charge collusive list prices to small (type A) buyers—as in any retail market with price-taking consumers. And since this allows suppliers to negotiate better terms (i.e., higher wholesale prices) with large (type B) buyers, in an attempt to also monopolize type B buyers, suppliers

[8] In fact, before the cease of publication large buyers (e.g., supermarkets) were able to negotiate discounts off list prices of about 19%, whereas after the cease of publications these discounts dropped to about 11%.

[9] This resistance to price increases is well documented. See, for example, the discussions in Marshall and Marx (2012, chs. 2 and 6), Marshall et al (2008) and the European Commission's decision on the *Vitamins* case: Case COMP/E-1/37.512 - Vitamins, Comm'n Decision (Nov 21, 2001), para 325.

[10] In Garrod et al (2021) the participation constraint does not pose a problem to the cartel. Suppliers and buyers negotiate linear terms but have an additional instrument to transfer rents, which is the level at which parties agree to maintain the retail price. As far as we know, this RPM option falls outside the above cases and our motivating evidence.

[11] That small and large retailers compete in downstream markets is well documented; see, for example, Thomassen et al (2017).

[12] Note that our theory extends equally well to a situation where final consumers have not only the option to buy from large (and possibly small) intermediaries but also directly from suppliers. Increasing evidence of this hybrid sales model can be found in European Commission (2017) and Oliver-Wyman (2018).

agree on list prices above what they would have otherwise agreed if type-B buyers did not exist. This extra increase in list prices is the workings of the multibuyer contact effect.[13]

Note that because prices effectively paid by large buyers are determined in bilateral negotiations with suppliers, any additional increase in list prices is not passed through one-to-one to such prices, but only a fraction of it (it also adds to this incomplete pass-through the fact that large buyers are less aggressive than small buyers in the downstream market). As a result of this incomplete pass-through, any termination of collusion would predict not only a drop in both prices—list and negotiated prices—but also a drop in the gap between the two. In other words, we should also see an important reduction in discounts off list prices. Interestingly enough, our motivating evidence tells us exactly that: with the cease of publication of list prices in the local newspaper all prices fell, but list prices fell a lot more.

Does our theory support a collusive explanation for the role that simultaneous and public announcements of list prices may have played in the evolution of wholesale fresh-egg market, and possibly in the evolution of other markets? It certainly does. But at the same time, and on equal footing, it supports a non-collusive, competitive explanation, which is that public list prices would have allowed suppliers to unilaterally negotiate better terms with their large buyers. This is the workings of the *commitment* effect.

By publicly communicating in advance—before bargaining with large buyers—the price to be charged small buyers, suppliers solve a commitment problem, akin to that in Hart and Tirole (1990), which is the temptation to offer better deals to small buyers after setting terms with large buyers. As a result, all prices are higher than when all prices are determined simultaneously. We often use the term *private* list prices to refer to prices posted simultaneously with negotiated prices (as in our motivating evidence after the cease of publication of list prices).

Note that our theory is not prepared to distinguish the collusive explanation from the competitive one: both predict a fall in prices and in discounts as we move from public to private list prices.[14] The reason is that what distinguishes one from the other is a matter of magnitude since there is multibuyer contact in both cases. When suppliers exhibit little patience, the collusive equilibrium converges to the competitive equilibrium. One may say that in this case the multibuyer contact effect reduces to the commitment effect. As suppliers become more patient, the multibuyer contact effect grows larger, allowing suppliers to sustain higher prices, for both small and large buyers. Whatever the explanation, our theory unambiguously predicts that public announcements of list prices would lead to supracompetitive prices.

A similar anticompetitive outcome is found in models of retail markets with discounts going to final consumers. Raskovich (2007), for example, assumes that a fraction of consumers are given the opportunity to bargain with suppliers for discounts off the list prices. When that fraction is big enough, the game accepts two equilibria in list prices, marginal cost pricing and

[13] It is interesting to notice that large buyers also benefit from collusion. In the absence of transfers, suppliers have no choice but to share some of the profits coming from higher retail prices with large buyers.

[14] In the Extensions we also explore a third possibility: that collusion did not completely end with the cease of publication but rather turned into a less ambitious agreement. This possibility is also consistent with our motivating evidence.

monopoly pricing; otherwise the former is the unique equilibrium. What explains his result is that suppliers posting higher list prices have worse outside options and so are more attractive to bargaining consumers. Closer to ours is Gill and Thanassoulis (2016) who assume that a fraction of consumers are offered discounts that they receive with some probability (these would be our large buyers; although ours all bargain with suppliers, so they are not "discount takers"). They find that the potential to offer discounts dampens competitive pressure in the market, thus raising all prices.

The rest of the paper is organized as follows. Our motivating evidence is presented in Section 2. The baseline model with the irrelevant result is in Section 3. We add small buyers who pay public list prices in Section 4. In Section 5 we consider the alternative timing of private list prices, when all prices are determined simultaneously. At the end of the section we contrast the collusive and competitive predictions of our theory to the motivating evidence. The extension to the possibility of collusion with private list prices is in Section 6. We conclude in Section 7. Proofs and other auxiliary results are relegated to the online Appendix.

2 Motivating evidence

Our theory is motivated, at least partly, by recent developments in Chile's wholesale fresh-egg market. Egg producers used to publish their list prices on a weekly basis—on each Monday—in the country's main newspaper. This publication was suddenly interrupted in October of 2018.[15] After the cease of publication, suppliers continued communicating their list prices but in a more decentralized and "opaque" way, using the internet, emails and phone calls. It was not uncommon for different buyers to get different quotes with list prices.

The event we exploit here is that before the cease of publication, list prices were publicly and readily available in a single place, where they were posted simultaneously, while afterward they became more dispersedly and asynchronously informed. For our purposes here, we will refer as *public* list prices to those posted before the interruption of publication in the local newspaper and as *private* list prices to those posted after the interruption.

We want to explore whether the cease of publication had any effect not only on list prices posted by suppliers but also on prices that resulted from bilateral negotiations between suppliers and buyers. If anything, one could argue that the cease of publication could have increased search costs of those small, price-taking buyers who pay list prices. If so, as the search literature suggests (e.g., Varian 1980),[16] the cease of publication could have resulted in higher list prices. We find otherwise.

We can identify two type of buyers in our sample. An important fraction of buyers comprises

[15] Leaving aside explanations for this interruption, what is clear is that the interruption caught suppliers by surprise.

[16] Although less relevant for our motivating evidence, an increase in search costs may sometimes lead to lower prices. In a multiproduct setting, with firms carrying different set of products, an increase in search costs may also affect merger/product choice decisions toward more symmetric configurations, leading to fiercer competition in prices (see, e.g., Rhodes and Zhou 2019, Fabra and Montero 2021).

small grocery stores that for most part pay list prices, before and after the cease of publication. The remaining fraction corresponds to large buyers (e.g., supermarkets, retail chains) who engage in bilateral negotiations with suppliers. We want to compare wholesale prices paid by these different type of buyers before and after the cease of publication. We focus on the most popular fresh-egg category, white large eggs, for which we have detailed transaction-level data from two of its largest suppliers.[17] Together these two suppliers account for roughly 16% of sales during our sample period, which runs from December of 2016 to August 2020. Identification of its effect over wholesale prices comes from the assumption that the cease of publication was an unexpected event for both suppliers and buyers. It seems a reasonable assumption based on a series of conversations with industry personnel.

We estimate the following "before-and-after" model:

$$w_{ilt} = \alpha + \gamma Post_t + \beta Large_i + \phi Large_i \times Post_t + \mu' X_{ilt} + \delta' Y_t + \varepsilon_{ilt} \tag{1}$$

where w_{itl} is the unit price paid by buyer i located in municipality l on day t,[18] $Post_t$ is an indicator that takes the value of one for days after the cease of publication, and $Large_i$ is an indicator that takes the value of one if buyer i qualifies as large, i.e., as a supermarket or retail chain. Therefore, the omitted category of buyers is small buyers. We also add a set of controls. Vector X includes controls common to all specifications: day of the week fixed effects, supplier fixed effects and municipality fixed effects. Vector Y, in contrast, includes controls that differ by specification. In the baseline specification, it includes only month-year fixed effects, while in an alternative specification it includes year fixed effects, month of the year fixed effects, and a proxy for costs of production (the corn wholesale price index provided by the National Bureau of Statistics, which is of monthly frequency). We estimate (1) for two windows of data around the cease of publication, one and two-year windows before and after the event.

If the cease of publication had any effects on list prices (i.e., prices paid by small buyers), this should be captured by the coefficient of $Post$, γ. Similarly, if it had any effect on the prices paid by large buyers, this should be captured by sum of the coefficients of $Post$ and $Large \times Post$, $\gamma + \phi$. In addition, any discount off list prices received by large buyers before the cease of publication should be captured by a negative coefficient of $Large$, β, and after the cease of publication by a negative sum of the coefficients of $Large$ and $Post \times Large$, $\beta + \phi$.

Table 1 reports the results of our estimation of (1). Results are consistent across specifications and windows of estimation. The coefficient of $Large$ is negative and statistically significant, confirming that discounts off list prices are common among large buyers. Given that the average list price observed in our sample is 92 pesos (13 U.S. cents), we are talking of discounts in the range of 20% before the cease of publication. The table also shows that the coefficient of $Post$ is always negative and statistically significant, meaning that list prices fell with the cease of publication, by about 15%. Meanwhile, the coefficient of $Post \times Large$

[17] White large eggs account for 40% of the fresh-egg market. Other categories include white extra-large, white medium, white small, and colour in different sizes.

[18] Prices that fall outside the 2nd and 98th percentiles are discarded.

is positive, statistically significant and smaller than that of *Post* in all specifications. This means that prices paid by large buyers fell as well with the cease of publication, but not as much as list prices. The F-tests at the bottom of the table indicate that these falls in prices were statistically different from zero. In all cases we reject the null of no fall in prices paid by large buyers. Ultimately, these tests imply that the gap between prices paid by small and large buyers have reduced after the cease of publication.

Table 1: Impact of the Cease of Publication of List Prices on Transaction Prices

	(1)	(2)	(3)	(4)
Large	-18.114***	-23.580***	-18.172***	-23.894***
	(2.322)	(3.200)	(2.325)	(3.052)
Post	-11.678***	-13.905***	-13.142***	-13.560***
	(3.489)	(3.475)	(3.505)	(3.413)
$Post \times Large$	8.691***	10.894***	8.520**	11.317***
	(3.279)	(3.207)	(3.506)	(3.207)
Corn Price Index			0.167***	0.391***
			(0.024)	(0.048)
Constant	108.224***	113.327***	92.440***	75.350***
	(2.045)	(2.952)	(3.478)	(6.135)
Observations	200566	108723	200566	108723
F-tests, p-values				
$\gamma + \phi = 0$	0.000	0.000	0.000	0.000

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: Dependent variable is effective prices charged by two suppliers for the most popular fresh-egg category in the market (truncated at the 2nd and 98th percentiles). Columns (1) and (2) show estimates of the baseline specification of (1) for two symmetric windows around the week of the cease of publication (third week of October of 2018): 22 months before and after that week and 12 months before and after that week. Columns (3) and (4) show the same but for the alternative specification (year and month-of-the-year fixed effects, and the corn price index). All models include fixed effects by day of the week, supplier and municipality. Standard errors, which are clustered at the municipality level, are shown in parentheses. The bottom of the table shows the results of the F-tests mentioned in the text.

In preparation for our theory, several results in Table 1 deserve further discussion. It is clear that the weekly publication of list prices in the local newspaper had helped suppliers to charge higher prices to small buyers, those with no bargaining power that for most part pay list prices. One explanation is a collusive one: the "transparency" of posting list prices on a single place and at the same time would have facilitated the monitoring of compliance with a supposed collusive agreement.[19]

But even if this collusive explanation turns out to be correct, it does not automatically

[19]Price transparency and its implications for competition has been studied in other industries; for example, retail gasoline (Luco, 2019) and supermarkets (Atir and Ragid, 2022). Transparency was also mentioned by UK's Office of Fair Trading as a softening-competition factor in its competition study of the cement market (OFT, 2011).

explain the evolution of prices paid by large buyers. Take for instance the numbers of column (1) in the table. Given an average list price for the entire period of our sample of 92 pesos, the coefficient of $Post$ would suggest that list prices fell from an average of 97.8 pesos before the cease of publication to an average of 86.2 pesos afterwards. According to the coefficients of $Large$ and $Post \times Large$, the discounts received by supermarkets before the cease of publications were 18.1 pesos on average, or 18.5% off list prices. With the cease of publication, these discounts dropped dramatically, to 9.4 pesos, or 10.9%. Despite prices paid by supermarkets also dropped with the cease of publication, from 79.7 to 76.8 pesos on average, it remains unclear how to explain such drop.

Two explanations come to mind. One can be found in the thesis advanced, for example, by the Tenth Circuit Court in the polyurethane price-fixing case that higher list prices serve to establish an "artificially inflated baseline for negotiations" with large buyers (see third quote in the Introduction). This thesis presumes that discounts are some "exogenously" given percentage of list prices, which our motivating evidence clearly fails to support. Discounts, when measured as a percentage of list prices, suffered a major drop with the cease of publication.

Another explanation, in the spirit of Bernheim and Whinston (1990), could be a "multi-market contact" one. Even if prices paid by large buyers are set independently of list prices, the cease of publication could have not only terminated any collusion in the small-buyer market but also in the large-buyer market because the latter would no longer be sustainable in a stand-alone fashion. An important assumption in this multimarket contact thesis, however, is that collusion in the larger-buyer market (as well as in the small-buyer market) is always sustainable in a stand-alone fashion for a sufficiently large discount factor. Since the latter is not supported by our theory,[20] this alternative thesis does not fit well our motivating evidence either. Besides, this thesis makes no prediction as to whether there should be a drop in prices paid by large buyers at all, let alone, whether that drop, if any, is expected to be larger or smaller than the drop in list prices.

Our theory advances a related but different multimarket contact effect than that of Bernheim and Whinston (1990), one that is based on the fact that small and large buyers compete in the retail market for final consumers.[21] We refer to it as a "multibuyer contact" effect. Because of this multibuyer competition in the retail market, any increase in prices paid by small buyers allows suppliers to negotiate better terms (i.e., higher wholesale prices) with large buyers. Aware of this multibuyer contact, any attempt by suppliers to collude on list prices has collusive spillover effects over the prices paid by large buyers as well. Important for explaining our motivating evidence, this multibuyer contact thesis makes two clear predictions. If the cease of publication ended any collusion in list prices, we should observe (i) a drop in both list prices and prices paid by large buyers, and (ii) a drop in discounts (i.e., in the gap between the two

[20] The reason is that any collusion with regard to large buyers fails when suppliers have only linear prices at their disposal, which may happen in the presence of contractual frictions. For more see Proposition 2.

[21] This competition certainly extends beyond the market for fresh eggs. Thomassen et al (2017) offer a detail analysis of how supermarkets adjust their pricing strategies to the presence of smaller stores carrying a reduced number of products (e.g., butchers, bakers, greengrocers, etc).

prices).

As these predictions fit well our motivating evidence, one is tempted to embrace a collusive explanation for the evolution of prices in the wholesale egg-fresh market. Our theory, however, also advances an alternative, non-collusive explanation that is also consistent with the evolution of such prices, in particular, with predictions (i) and (ii). This alternative, competitive explanation is also based on the fact that small and large buyers compete in the retail market but exploits a different channel, a commitment channel *à la* Hart and Tirole (1990). The publication of list prices in the local newspaper could have provided suppliers with a vehicle to *unilaterally* commit to higher prices charged to small buyers, and thus to obtain better terms (i.e., higher wholesale price) from large buyers. A supplier has all the incentives to build and maintain a reputation of not secretly offering lower prices to small buyers after posting list prices and setting terms with large buyers.[22]

A final note is that our theory is not prepared to distinguish between these two explanations. The reason is that what distinguishes the collusive from the competitive explanation is a matter of magnitude. When suppliers exhibit little patience, the collusive equilibrium converges to the competitive equilibrium. One may say that in this case the multibuyer contact effect reduces to the commitment effect. As suppliers become more patient, the multibuyer contact effect grows larger, allowing suppliers to sustain higher prices, for both small and large buyers. But predictions (i) and (ii) remain valid for any level of collusion, so the two effects remain qualitatively alike.

3 A model of irrelevant list prices

We start our analysis with a model where list prices play no role, whether suppliers compete or collude. Throughout the paper we adopt simple functional forms to keep the model tractable. We think this is without much loss of generality because our goal is to simply document the presence of new forces that may help explain our motivating evidence, and possibly evidence from other similar cases. In that regard, our theory is not intended to provide a definite explanation of the evidence just presented.

Following Horn and Wolinsky (1988) consider a set up with two upstream suppliers, U_1 and U_2, and two (large) downstream buyers or distributors, D_1 and D_2. Products are homogeneous. Cost of production is normalized to zero. Distributors compete a la Cournot in the downstream or retail market, but there is no direct upstream competition among suppliers, only indirectly through the retail market. Each buyer negotiate with a different supplier the terms under which trade takes place under equal bargaining weights.[23]

[22]Some elements of a contract between a large buyer and a supplier (e.g., delivery and packing conditions) may not be subject to frequent changes as wholesale prices are, which in our sample change on a weekly basis.

[23]The case of different barganing weights is in the online appendix. Nevertheless, support for equal bargaing weights, i.e., $\beta_i = \beta_{-i} = 1/2$, can be found in Binmore et al's (1986) model of sequential bargaining with exogenous risk of breakdown. In that model, party i assigns a constant probability $1 - \exp(-\lambda_i \Delta)$ that the bargaining process will breakdown between two barganing periods, with Δ being the time elapsed between

Parties D_i and U_i negotiate two-part tariff contracts: a wholesale unit price w_i per each unit ordered and a transfer T_i from D_i to U_i upon contract acceptance. We let negotiations to be subject to contractual frictions that may preclude wholesale prices to drop all the way to marginal cost (or even below).[24] Following Calzolari et al (2020), we capture these contractual frictions in a reduced-form way. We assume that transferring rents from distributors to suppliers by means of fixed fees creates deadweight losses: the supplier only gets $(1-\kappa)T_i$, with $\kappa \in [0,1]$. These losses extend in a similar way when transferring rents from suppliers to retailers by means of slotting allowances.

The timing of the game is as follows. In the first stage suppliers simultaneously post list prices l_i and l_j. In the second stage D_i has the option to skip negotiations and buy at the posted list price l_i or engage in negotiations with U_i. If D_i opts for the latter she forgoes the option to ever buy at the posted list price. Alternatively, one can view l_i as the initial offer made by U_i in his negotiation with D_i. We will see that in equilibrium D_i always rejects this offer and continues negotiating. Finally, in the third stage, and after observing the terms of trade that governed the relationships between distributors and suppliers, distributors simultaneously set quantities q_1 and q_2. The downstream (inverse) demand is

$$p = a - q_1 - q_2$$

This three-stage game is repeated indefinitely.

3.1 Competitive equilibrium

To find the equilibrium of the one-shot game, let us proceed by backward induction. Consider first the case in which list prices are high enough that distributors decide to negotiate with their respective suppliers at the second stage. If in that stage negotiating parties agreed to wholesale prices w_i and w_j, then the Cournot outcome in stage three is characterized by D_i's equilibrium output

$$q_i(w_i, w_j) = (a - 2w_i + w_j)/3 \tag{2}$$

and clearing price

$$p(w_i, w_j) = (a + w_i + w_j)/3 \tag{3}$$

In turn, D_i's profit gross of any fixed fees is given by

$$\pi_{D_i} = (p(w_i, w_j) - w_i)q_i(w_i, w_j) = q_i^2(w_i, w_j)$$

In the second stage, D_i and U_i bargain over the two-part tariff (w_i, T_i) contract while

bargaining periods. In that model, party i's bargaining weight converges to $\beta_i = \lambda_i/(\lambda_i + \lambda_{-i})$ as $\Delta \to 0$, so when parties share a common belief about the probability of breakdown, $\beta_i = \beta_{-i}$.

[24] Departure from marginal-cost pricing is not only supported in practice (see, e.g., Crawford and Yurukoglu, 2012, and Noton and Elberg, 2018) but also in theory. It endogenously arises when bilateral negotiations are subject to moral hazard (Rey and Tirole, 1986; Bernheim and Whinston, 1998) or adverse selection (Calzolari and Denicolo, 2015).

forming some expectation about the contract (w_j, T_j) that D_j and U_j will sign and anticipating the corresponding Cournot outcome (2) and (3) that would follow from such contracts. If D_i and U_i close a deal, their on-path payoffs are

$$\hat{\pi}_{D_i} = \pi_{D_i}(w_i, w_j) - T_i$$

and

$$\hat{\pi}_{U_i} = w_i q_i(w_i, w_j) + (1-\kappa)T_i$$

respectively, whereas if they do not, their off-path payoffs become $\bar{\pi}_{D_i} = \bar{\pi}_{U_i} = 0$. Note that we are using an upper hat (resp. an upper bar) to denote on-path (resp. off-path) payoffs. Although we do not expect parties to fail to reach an agreement in equilibrium, off-path payoffs determine their outside options, and hence, the surplus they expect to obtain from a successful negotiation.

We adopt the Nash bargaining solution as the outcome of the bargaining process. The solution is a pair of contracts (w_i^*, T_i^*) and (w_j^*, T_j^*) such that (w_i^*, T_i^*) is the Nash solution to the bargaining problem between D_i and U_i, given that both expect (w_j^*, T_j^*) to be agreed upon between D_j and U_j. Thus, the Nash solution w_i^* and T_i^* is found by solving

$$\max_{w_i, T_i} (\hat{\pi}_{U_i}(w_i, w_j, T_i) - \bar{\pi}_{U_i})(\hat{\pi}_{D_i}(w_i, w_j, T_i) - \bar{\pi}_{D_i})$$

for $w_j = w_j^*$ and $T_j = T_j^*$.

Proposition 1 *If $\kappa \geq 1/2$, then the one-shot game exhibits an equilibrium with $w_1^* = w_2^* = a/7$ and $T_1^* = T_2^* = 0$; otherwise*

$$w_1^* = w_2^* = w^* = \frac{4\kappa - 1}{4\kappa + 5} a$$

and

$$T_1^* = T_2^* = T^* = \frac{3 - 6\kappa}{25 - 16\kappa^3 - 24\kappa^2 + 15\kappa} a^2 > 0$$

Proof. See the Appendix. ■

Wholesale prices are increasing in contractual frictions (κ) while transfers are decreasing. At some point, when $\kappa = 1/2$, it becomes too costly for parties to use transfers to split the surplus generated by the vertical relationship. At that point, and consistent with what we observe in some wholesale markets (e.g., Noton and Elberg, 2018; Garrod et al., 2021, p. 30), they rely exclusively on linear pricing. In contrast, when contractual frictions are very low suppliers are ready to sell even below cost and ask for a large transfer in return. Each pair agrees to this below-cost pricing in an effort to gain a Stackelberg position in the retail market against the other pair. As a result, they end up pricing too aggressively in the wholesale market.[25] In a way, contractual frictions allow parties to commit to a softer competition.

[25] Note that retail prices are nevertheless above cost, equal to $p = a/5$ when $\kappa = 0$.

We finally move to the first stage of the game, when suppliers announce list prices. So far we have considered announcements that were payoff irrelevant, i.e., neglected by distributors. Do suppliers have incentives to announce list prices that may eventually be accepted by distributors before their negotiations? This possibility can be ruled out almost by definition in a world of high contractual frictions, where parties negotiate linear prices. To formally see it, suppose that instead of announcing a high list price, U_1 announces l_1 with the hope that D_1 will take it at the beginning of their negotiation. Since this deviation will be observed by U_2 and D_2 before they initiate theirs, their negotiated response in anticipation to D_1 accepting l_1 is to agree on the wholesale price

$$w_2(l_1) = (a + l_1)/8 \tag{4}$$

Anticipating this response, U_1's best deviation would be to leave D_1 indifferent between accepting l_1 and continue negotiating with him. Given this acceptance restriction, the best deviation for U_1 would be to announce $l_1 = a/7$, to which U_2 and D_2 would respond with $w_2 = a/7$, as seen from (4).

According to Proposition 1, this deviation reports no benefit to U_i, showing that announcements of list prices at stage one make no difference to the terms agreed on the wholesale market, and hence, to retail prices. This irrelevance of list prices extends to the case of lower contractual frictions (see the Appendix) and also when suppliers attempt to collude, as we will see next.

3.2 Collusive equilibrium

Since suppliers and buyers interact repeatedly in the market, less competitive outcomes may emerge in equilibrium. Our focus here is on less competitive outcomes in the wholesale market, while maintaining the assumption that retailers compete in the retail market.

As a benchmark, ask what would be the best collusive arrangement that suppliers could agree upon if they face no contractual frictions, have all the bargaining power and are sufficiently patient (i.e., have a discount factor sufficiently close to the unity). The retail price that maximizes the profit of the supply chain or the entire industry is $p^m = a/2$, so the best suppliers can do in such a case is to approach their respective retailers with take-it-or-leave-it offers that implement p^m and leave them with the industry profit, that is, with $w_1 = w_2 = w^m = a/4$ and $T_1 = T_2 = T^m = a^2/16$. A threat to return to the one-shot equilibrium of Proposition 1 should suffice to prevent suppliers from deviating of these collusive offers.

Even if suppliers were sufficiently patient, there are nevertheless two elements in our set up that may prevent suppliers from implementing the industry profit-maximizing outcome. One is that contract terms are not set unilaterally by suppliers but negotiated with buyers. And the other is that negotiations often suffer from contractual frictions of some sort. It is evident that the negotiation of terms put a limit as to how much suppliers can profit from collusion.

To start, they must share with buyers some of the collusive gains. No buyer would accept an offer that leaves her worse off than in the one-shot equilibrium, which is the natural outcome if the offer is rejected and collusion fails. Thus, a first requirement in any collusive agreement is

to satisfy every buyer's participation constraint. This requirement certainly reduces suppliers' gain from collusion but it does not, in itself, impede them from implementing the industry profit-maximizing outcome. Suppliers would just need to ask for a lower transfer in their offers, say, lower than T^m.[26] What impedes the implementation of the industry profit-maximizing outcome is the presence of contractual frictions. Since there is no other vehicle to transfer rents than direct transfers, suppliers would have to move away from the industry profit-maximizing outcome in an effort to reduce these transfers. The relevant question then is by how much. Could it be enough so as to eliminate any possible collusion? Does the announcement of list prices make any difference?

The rest of the section is devoted to answer these questions. Leaving aside sustainability issues, suppliers' collusive problem is to maximize their collective payoff subject to buyers' participation constraint (and their own). There are two cases to consider depending on the direction of transfers. Given the symmetry of the problem, the problem when transfers go from distributors to suppliers ($T \geq 0$) is given by

$$\max_{w,T} wq(w,w) + (1-\kappa)T$$

subject to $\pi_D(w,w) - T \geq \pi_D(w^*,w^*) - T^*$ and $wq(w,w) + (1-\kappa)T \geq w^*q(w^*,w^*) + (1-\kappa)T^*$, where $\pi_D(w,w) = (a - 2q(w,w) - w)q(w,w)$ and $q(w,w)$ is given by (2). On the other hand, when transfers go from suppliers to distributors ($T < 0$) the problem changes to

$$\max_{w,T} wq(w,w) + T$$

subject to $\pi_D(w,w) - (1-\kappa)T \geq \pi_D(w^*,w^*) - T^*$ and $wq(w,w) + T \geq w^*q(w^*,w^*) + (1-\kappa)T^*$.

The solution to the suppliers' collusive problem, denoted by the terms w^c and T^c, is summarized in the next proposition.

Proposition 2 *Suppose that suppliers are sufficiently patient. If $\kappa \geq 1/2$, then the solution to suppliers' collusive problem is the one-shot equilibrium, $w^c = w^* = a/7$ and $T^c = T^* = 0$; otherwise*

$$w^c = \left(1 - \frac{3}{5+4\kappa}\sqrt{\frac{1+2\kappa}{1-\kappa}}\right) a > w^*$$

and $T^c = 0$ if $\kappa \in [\kappa_0, 1/2)$, where $\kappa_0 \approx 1/5$ solves the cubic $8\kappa^3 + 20\kappa^2 + 11\kappa - 3 = 0$, or

$$w^c = \frac{1+2\kappa}{2(2+\kappa)} a > w^*$$

and

$$T^c = \frac{3\left(3 - 8\kappa^3 - 20\kappa^2 - 11\kappa\right)}{4\left(1-\kappa\right)\left(4\kappa^2 + 13\kappa + 10\right)^2} a^2 > 0$$

[26] The transfer may turn into a slotting allowance (i.e., a negative transfer) if we let buyers enjoy a larger bargaining power.

if $\kappa \in [0, \kappa_0)$.

Proof. See the Appendix. ■

There are several results to highlight in the proposition. The first is that list prices play no role in suppliers' attempt to collude. This is a corollary of Proposition 1, in that buyers' participation constraint does not depend on list prices, and the need of transfers.

The second result is that collusion can only emerge for low levels of contractual frictions, when $\kappa < 1/2$. To understand why, it helps to explain how suppliers accommodate their collusive agreement as contractual frictions raise. For low levels of frictions, when $\kappa \in [0, \kappa_0)$, suppliers elevate industry profits and simultaneously satisfy buyers' participation constraint by adjusting both terms in their offers, w and T. Increasing w^c above w^* yields industry profits in excess of those under competition. But this increase leaves buyers strictly worse off—their payoffs gross of fixed fees are decreasing in wholesale prices—which suppliers solve by lowering T^c below T^* accordingly. This adjustment proceeds until $\kappa = \kappa_0$, when $T^c = 0$.

Above κ_0 suppliers have a choice. One is to compensate buyers with slotting allowances, i.e., negative fixed fees. The other is to keep $T^c = 0$ and increase w^c above w^* just enough to keep buyers' participation constraint in balance (recall that $T^* > 0$ for all $\kappa < 1/2$, so there is still some collusive profits to be made in this range). It turns out that suppliers never resort to slotting allowances to compensate buyers; it is too costly in the presence of contractual frictions. As stated in the proposition, they simply exempt buyers from the payment of any fixed fee as compensation for any increase in wholesale prices. But at $\kappa = 1/2$, when $T^* = 0$, this exemption is no longer available to compensate buyers. At this point, suppliers find themselves with just one instrument to accomplish two conflicting goals, increasing industry profit and sharing enough of it with buyers. This is just no possible with one instrument.

It is not clear to us what other instruments suppliers can use in our context. More generally, one may think of retail price maintenance (RPM) contracts, like the ones studied by Garrod et al. (2021) in the context of hub-and-spoke cartels. In their setting, suppliers and buyers negotiate linear terms but have an additional instrument to transfer rents, which is the level at which parties agree to maintain the retail price. We have abstracted from this possibility here, partly because is absent in many of the markets we are interested in, let alone, in the market we have used as motivation for our theory.[27]

Proposition 2 identifies two conditions for the formation of a collusive agreement, even if suppliers are sufficiently patient. One is that suppliers need of buyers' consent to go ahead with the agreement, that is, they need to make sure that every buyer's participation constraint is satisfied. This condition points to some level of communication that needs to take place between buyers and suppliers, which the latter may want to avoid or that is simply not feasible.

The second condition is the presence of transfers as part of the agreement. Furthermore, the proposition suggests that we should see these transfers go up in case of a collusion breakdown. We do not see any of these transfers, or changes in them for that matter, in the data of the

[27] Besides, in none of the cases listed in the Introduction there is mention to RPM contracts.

fresh-egg market. The fact that we do not see them in our data does not mean they do not exist. Some of the terms agreed upon suppliers and (large) buyers are established on an annual basis. These terms, which may include transfers of some sort, would not be captured in our data, which only contains the result of weekly negotiations over wholesale prices. This way to organize wholesale transactions—where general terms are negotiated once a year while the rest, most importantly unit prices, are negotiated on a more frequent basis—is quite common in markets subject to frequent changes in production costs. The fresh-egg market is just one example.

These conditions pose the question as to whether we can ever observe a collusive agreement in wholesale prices where suppliers disregard buyers' participation constraint and have no access to transfers.[28] Absent of our analysis this far is the presence of small, price-taking buyers who do pay list prices. As we show next, their presence not only alters suppliers' collusion possibilities but also their non-collusive ones. For the rest of the analysis we will focus on values of κ large enough that in equilibrium parties rely exclusively on linear contracts, whether they compete or collude (in the Appendix we document the thresholds that ensure that). Likewise, we will focus on collusive agreements where suppliers pay no attention to large buyers' participation constraint, possibly because they do not want to communicate with them. We come back to these considerations in the Extensions.

4 Public list prices

We now extend our model to the presence of small buyers who pay list prices. The rest of the model remains the same, most importantly, that suppliers post their list prices at stage one, that is, before they negotiate with large buyers at stage two. This timing is intended to capture the situation of the fresh-egg market before the cease of publication of list prices in the local newspaper; more generally, a situation where list prices are readily available and posted simultaneously in a single place. We refer to these prices as *public* list prices. In terms of our model, what formally distinguish *public* from *private* list prices is that the former are posted before suppliers and larger buyers negotiate their terms and the latter are posted simultaneously as these terms are negotiated. According to this distinction, *public* list prices could have provided suppliers with some form of commitment to exploit a first-mover advantage over large buyers, something that could have been lost with the cease of publication.

In extending the model, we consider a fringe of small buyers following the structure of Horn and Wolinsky (1988) that we have used so far. In addition to the large buyer, each supplier $i = 1, 2$ faces his own fringe of price-taking buyers that pay the list price l_i. We adopt a linear supply function for each fringe. At stage three, fringe retailers buying from supplier i are ready

[28] One can imagine a "partial" collusive scheme in which suppliers only attempt to collude on wholesale prices but not on the rest of the terms agreed on their contracts (including transfers), which are revised much less frequently. There are many examples of these partial or semi-collusive arrangements. See, for example, Harrington (2017).

to sell a total of

$$q_i^F = \gamma(p - l_i) \tag{5}$$

units in the retail market in anticipation of a retail price p and given their wholesale unit-cost l_i.[29] We assume that $\gamma > 0$ is a constant not too large so in equilibrium small and large buyers always share the retail market (otherwise suppliers would only sell through the large buyers).[30]

Since the retail price now is given by

$$p = a - \sum_{i=1,2} q_i - \sum_{i=1,2} q_i^F$$

we can use (5) to derive what would be the large buyers' residual demand given the list prices announced by suppliers at stage one,

$$p(q_i, q_j) = \frac{1}{1+2\gamma}\left(\tilde{a} - q_i - q_j\right)$$

where

$$\tilde{a} = a + \gamma(l_i + l_j)$$

This residual demand is obviously increasing in list prices but ultimately decreasing in the fringe presence.[31] As a result, list prices will play a role now, whether suppliers compete or collude.

4.1 Competitive equilibrium with public list prices

Suppose that l_1 and l_2 are such that large buyers prefer to bargain with suppliers than to buy at those prices. Proceeding as in the previous section, given wholesale prices paid by small and large buyers, l_i and w_i, respectively, the Cournot outcome in stage three is characterized by D_i's equilibrium output

$$q_i(w_i, w_j) = (1+2\gamma)(\tilde{a}/(1+2\gamma) - 2w_i + w_j)/3 \tag{6}$$

and clearing price

$$p(w_i, w_j) = (\tilde{a}/(1+2\gamma) + w_i + w_j)/3. \tag{7}$$

[29] Formally, the action of each fringe member is whether to order a unit of product to be sold in the retail market, which happens when the clearing price p is anticipated to be equal o larger than its marginal cost.

[30] We model small buyers as a continuum of agents mainly for simplicity. What ultimately distinguishes small from large buyers is not their size per se but their ability to negotiate the prices effectively paid. This includes an understanding of the total surplus involved in the negotiation and how it may be split among the negotiating parties. Large buyers have account managers dedicated to these negotiations. Small buyers—very much like final consumers in the retail market—lack of such ability; they accept or reject whatever offer is presented to them. These offers may include small discounts off the list price, but they should be interpreted as "tokens of appreciation" not as negotiated discounts. They could even respond to a price-discrimination motive tailor-made by suppliers. In fact, if we let fringe buyers to vary by size, suppliers could second-degree price discriminate them according to their sale orders and nothing would change in our analysis. The data in our motivating evidence confirms prices effectively paid by small buyers to be slightly dispersed around list prices.

[31] Given that in equilibrium $p > l_i$ for the fringe to sell a strictly positive amount, it is immediate that $\partial p/\partial\gamma < 0$.

Note that as $\gamma \to 0$, these expressions converge to (2) and (3), respectively. In turn, D_i's profit gross of any fixed fees is given by

$$\pi_{D_i}(w_i, w_j) = (p(w_i, w_j) - w_i)q_i(w_i, w_j) = q_i^2(w_i, w_j)/(1 + 2\gamma)$$

The second stage, when D_i and U_i bargain, is also similar to what we saw in the previous section except for two aspects. One is that high contractual frictions have lead parties to bargain just over the wholesale price w_i. Given this and the fringe supply (5), we have that parties' on-path payoffs are now given by

$$\hat{\pi}_{D_i} = \pi_{D_i}(w_i, w_j) \tag{8}$$

and

$$\hat{\pi}_{U_i} = w_i q_i(w_i, w_j) + l_i\gamma(p - l_i) \tag{9}$$

respectively.

The second aspect is already evident from looking at (9). In case of a negotiation breakdown, D_i's off-path payoff continues to be zero, $\bar{\pi}_{D_i} = 0$, but U_i's does not. Now it is strictly positive, equal to

$$\bar{\pi}_{U_i} = l_i\gamma(\bar{p} - l_i)$$

where

$$\bar{p} = a - q_i^F - q_j^F - q_j = (\tilde{a}/(1 + 2\gamma) + w_j)/2 \tag{10}$$

is the prevailing off-path price, which is obviously higher than the on-path price (7).

If D_i and U_i expect w_j be the wholesale price agreed upon between D_j and U_j, then their Nash bargaining solution as a function of w_j is

$$w_i^*(w_j) = \frac{a + (1 + 2\gamma)w_j + \gamma(4l_i + l_j)}{8(1 + 2\gamma)}$$

which together with $w_j^*(w_i)$ leads to

$$w_i^*(l_i, l_j) = \frac{3a + \gamma(11l_i + l_j)}{21(1 + 2\gamma)} \tag{11}$$

for $i = 1, 2$.

It turns out that higher list prices allow suppliers to negotiate better (i.e., higher) terms with large buyers. This is mainly explained by U_i's outside option to sell through the fringe in case of a negotiation breakdown. To see it, notice that an increase in l_i (and in l_j) augments both $\hat{\pi}_{U_i}$ and $\hat{\pi}_{D_i}$. As dictated by the maximization of the Nash product

$$(\hat{\pi}_{U_i} - \bar{\pi}_{U_i})(\hat{\pi}_{D_i} - \bar{\pi}_{D_i}),$$

while an increase in $\hat{\pi}_{U_i}$ calls for a decrease in w_i, as a way to share some of this extra profit with D_i, and increase in $\hat{\pi}_{D_i}$ calls for the exact opposite, an increase in w_i, and for the exact same reason. The latter effect dominates because the increase in $\hat{\pi}_{U_i}$ is partly muted by the outside option $\bar{\pi}_{U_i}$ being strictly positive.

As we move to the first stage of the game, suppliers simultaneously post list prices l_i and l_j while anticipating their consequences in the subsequent stages. Thus, if U_i expects U_j to post l_j, then he anticipates a payoff of

$$\hat{\pi}_{U_i}(l_i, l_j) = w_i^*(\cdot) q_i(w_i^*(\cdot), w_j^*(\cdot)) + l_i \gamma (p(w_i^*(\cdot), w_j^*(\cdot)) - l_i) \tag{12}$$

from posting l_i, where $w_i^*(\cdot) \equiv w_i^*(l_i, l_j)$ is given by (11) and $p(w_i^*(\cdot), w_j^*(\cdot))$ is given by (7). Solving for the best response $l_i^*(l_j) = \arg\max_{l_i} \hat{\pi}_{U_i}(l_i, l_j)$ and imposing symmetry we arrive at the following proposition.

Proposition 3 *When contractual frictions κ are sufficiently large, the one-shot game with public list prices exhibits an equilibrium in which suppliers post list prices*

$$l_1^* = l_2^* \equiv l^* = \frac{43}{147 + 149\gamma} a$$

at stage one, and then negotiate wholesale prices

$$w_1^* = w_2^* \equiv w^* = \frac{21 + 52\gamma}{(1 + 2\gamma)(147 + 149\gamma)} a < l^*$$

with large buyers at stage two.

Proof. The proof in the Appendix is devoted to establish: (i) the critical level of contractual frictions that eliminates transfers in equilibrium, which is a function of gamma, and (ii) that U_i does not have incentives to deviate from l_i^* to induce D_i to also take the list price and skip negotiations. ■

To get some intuition as to how list prices are determined in equilibrium note that a supplier has two sources of profits. As captured by the first and second terms in (12), these profits come from large and small buyers, respectively. An increase in list prices always help U_i to increase his profits from the large buyer, i.e., $\partial[w_i^*(\cdot) q_i(w_i^*(\cdot), w_j^*(\cdot))]/\partial l_i > 0$ for all l_i. There are two reasons for this. As shown in (11), one is that a higher list price allows U_i to commit to negotiate better terms with D_i. And as seen from

$$q_i(w_i^*(\cdot), w_j^*(\cdot)) = (6a + \gamma(l_i + 8l_j))/21,$$

the other is that higher list prices leave more residual demand to the large buyers, boosting their sales despite their higher wholesale costs. This boost in sales also benefits U_i.

An increase in list prices also helps U_i to increase his profit from small buyers when their

levels are low, that is,

$$\frac{\partial}{\partial l_i}\left(l_i\gamma(p(l_i,l_j)-l_i)\right)=\frac{\gamma}{7(1+2\gamma)}\left(3a-2(7+10\gamma)l_i+4\gamma l_j\right)>0 \tag{13}$$

when l_i is sufficiently small, and where $p(l_i,l_j)=p(w_i^*(\cdot),w_j^*(\cdot))$. Thus, for low levels of l_i, U_i faces no trade-off from increasing l_i. As l_i gets larger, above the level that takes the right-hand side of (13) to zero, U_i starts destroying profits from small buyers to increase those from the large buyer. The list price in the proposition is the solution to that trade-off.

Consistent with our motivating evidence, the solution to that trade-off confirms that large buyers do indeed negotiate discounts off list prices, which here amount to $w^*/l^*=(21+52\gamma)/43(1+2\gamma)$, i.e., to 50% or more. Note that nowhere in our formulation we have restricted large buyers to pay no more than list prices, although is a natural restriction to impose. Discounts emerge endogenously, as part of the equilibrium.

There are two reasons for that. One is that selling through the fringe of buyers introduces too much competition in the downstream market. In fact, if for the sake of the explanation we let small buyers be equally efficient than the large buyers, i.e., if $\gamma\to\infty$, then suppliers would restrain themselves from selling to the small buyers; otherwise, and according to the proposition, they would be selling at cost to both small and large buyers. Thus, in equilibrium suppliers maintain l_i above w_i in an effort to prevent small buyers from becoming too competitive. This "softening competition" effect arises even if suppliers had all the bargaining power when negotiating with large buyers.[32]

The second reason of why $l^*>w^*$ is the "commitment" effect already detected in (11), which arises when suppliers must bargain with large buyers the terms in their contracts. Increasing list prices—the prices paid by small buyers—allows suppliers to negotiate better terms with large buyers.

This "commitment" effect introduces another consideration into the one-shot equilibrium of Proposition 3, which is a supplier's temptation to revise his list price once the negotiation with the large buyer is over or during the negotiation for that matter. Either way, the temptation is to revise the list price downward, which any small buyer would be happy to accept. A sufficiently patient supplier, however, has (unilateral) incentives to resist such temptation, regardless of what his rival supplier does. The equilibrium in Proposition 3 assumes that both suppliers commit to what they post at stage one, which seems reasonable when prices are posted on a frequent (e.g., weekly) basis.

4.2 Collusive equilibrium with public list prices

Imagine now an agreement among suppliers to collude on list prices, while staying away from any communication with buyers. Unlike the agreement in Proposition 2, this is an agreement

[32] It is not difficult to show that when suppliers approach large buyers with take-it-or-leave-it (linear) offers we still have that $w^*/l^*=(15+29\gamma)/16(1+2\gamma)<1$.

in which suppliers do not need to pay attention to buyers' participation constraint. If they seek to maximize their joint payoff

$$\hat{\pi}_{U_1}(l_1, l_2) + \hat{\pi}_{U_2}(l_2, l_1)$$

where $\hat{\pi}_{U_i}(l_i, l_j)$ is given by (12), their best course of action, provided they can sustain it, is the following.

Proposition 4 *Suppose that suppliers are sufficiently patient. The best collusive agreement on public list prices is for suppliers to post*

$$l_1 = l_2 \equiv l^c = \frac{19}{49 + 27\gamma} a > l^*$$

at stage one and then negotiate wholesale prices

$$w_1 = w_2 \equiv w^c = \frac{49 + 122\gamma}{7(1 + 2\gamma)(49 + 27\gamma)} a > w^*$$

which large buyers at stage two. Relative to the one-shot competitive equilibrium characterized in Proposition 3, this collusive agreement (i) reduces the sales of small buyers, (ii) increases the sales of large buyers, (iii) reduces total sales, and (iv) increases the profits of both suppliers and large buyers.

A few things are worth highlighting in the proposition. One is that discounts off list prices remain under the collusive agreement; if anything, they get larger, i.e., $w^c/l^c < w^*/l^*$. The other is that as $\gamma \to 0$, the collusive agreement reduces to the one-shot equilibrium of Proposition 1 (and 2), which is when list prices become irrelevant. It is the presence of the small buyers ($\gamma > 0$) what allows suppliers to coordinate on charging higher prices to both small and large buyers. This "multibuyer" contact effect is reminiscent of the multimarket contact effect of Bernheim and Whinston (1990), but is actually very different. It is not as if suppliers transfer collusive discipline from the "small-buyer market" to the "large-buyer" market. Rather, colluding with respect to one group of buyers has spillover effects over a second group through the downstream market.

These spillovers explain the opposing implications of the agreement over small and large buyers. While the former see their sales reduced the later see them enlarged, and with that, their profits. In their attempt to soften competition in the retail market, suppliers' only choice is to increase the wholesale price paid by small buyers. The resulting contraction of small buyers necessarily reports extra benefits to large buyers, part of which are shared with suppliers during their negotiations *via* higher wholesale prices.

Propositions 3 and 4 have presented us with two potential explanations to describe the fresh-egg market before the cease of publication of list prices in the local newspaper, a competitive and a collusive one. Essentially, the equilibria in both propositions predict that large buyers pay less than small buyers for each unit of product. Qualitatively speaking, not much else

separate the two equilibria so far.[33] What we want to explore next is whether the cease of the publication may shed further light on to which of these two equilibria is more plausible.

5 From public to private list prices

With the cease of publication in the local newspaper, suppliers had to resort to alternative means to communicate their list prices to potential buyers, particularly, small ones. To avoid confusion, we refer to them as *private* list prices to emphasize that are they no longer so readily available. But in reality, we could dispense with any reference to list prices altogether, and simply refer to them as prices paid by small buyers. This is so, because in terms of our model we are merging stages one and two into a single stage: suppliers now approach all buyers, large and small, simultaneously. The only difference is that small buyers take whatever offer is presented to them (all small buyers receive the same offer since there is no means to discriminate across them; they all order one unit of the product at best) whereas large buyers engage in bilateral negotiations.

Approaching all buyers simultaneously brings another question, that of the feasibility of collusion. One of the potential explanations for the evidence presented in Section 2 is that public list prices would have helped suppliers to better monitor a possible collusive agreement. If so, the explanation goes, forcing suppliers to move to private list prices would have caused their agreement to end, or alternatively, to turn into a softer (i.e., more competitive) one. Either post-publication path would be consistent with the evidence of the fall in prices paid by both large and small buyers. Here we take the first path—that collusion ended—and leave the alternative path for the next section (Extensions).

The rest of the section is organized as follows. We first characterize the competitive equilibrium with private list prices, again under the assumption that contractual frictions κ are sufficiently large so transfer do not emerge in equilibrium. We will continue denoting these list prices by l_i and l_j. Using this equilibrium as the post-publication benchmark, we then discuss which of the two explanations advanced by our motivating evidence gathers more support to explain the role of public list prices, the collusive explanation (Proposition 4) or the competitive one (Proposition 3).

5.1 Competitive equilibrium with private list prices

Since U_i now approaches D_i at the same time as he approaches the small buyers, during their negotiation not only U_i and D_i must form (correct) expectations of the prices l_j and w_j at which U_j would sell his products, but also D_i must form correct expectations of the the price l_i that U_i would charge small buyers. The equilibrium concept we adopt to find the outcome of this multibuyer bargaining problem is Nash-in-Nash (Horn and Wolinsky 1990, Collard-Wexler

[33] In that regard there is a difference with the competitive and collusive equilibria in Propositions 1 and 2, respectively, in that the latter required of transfers.

et al 2019).

The Nash-in-Nash solution is the set of price agreements w_i^s, l_i^s, w_j^s and l_j^s such that w_i^s is the Nash solution to the bargaining problem between U_i and D_i given that both anticipate correctly that the other prices will be l_i^s, w_j^s and l_j^s (we use superscripts "s" to indicate that a supplier bargains simultaneously with several buyers). Similarly, l_i^s is the Nash solution to the bargaining problem between U_i and each of his small buyers given that both anticipate correctly that the other prices will be w_i^s, w_j^s and l_j^s. The only difference with settings where the Nash-in-Nash concept has been used is that here many negotiations, those of U_i and each of the many small buyers, have one of the parties, here U_i, with all the bargaining power. This implies that l_i^s can be readily obtained from U_i's best response to the other prices, that is

$$l_i^s = \arg\max_{l_i}\{\hat{\pi}_{U_i}(w_i^s, l_i, w_j^s, l_j^s) = w_i^s q_i(w_i^s, l_i, w_j^s, l_j^s) + l_i\gamma(p(w_i^s, l_i, w_j^s, l_j^s) - l_i)\} \tag{14}$$

where $q_i(\cdot)$ and $p(\cdot)$ we are given by (6) and (7), respectively.

To obtain w_i^s, we maximize the Nash product (recall that $\bar{\pi}_{D_i} = 0$)

$$w_i^s = \arg\max_{w_i}(\hat{\pi}_{U_i}(w_i, l_i^s, w_j^s, l_j^s) - \bar{\pi}_{U_i}(l_i^s, w_j^s, l_j^s))\hat{\pi}_{D_i}(w_i, l_i^s, w_j^s, l_j^s) \tag{15}$$

where $\bar{\pi}_{U_i} = l_i^s\gamma(\bar{p}(l_i^s, w_j^s, l_j^s) - l_i^s)$ and $\bar{p}(\cdot)$ is given by (10). Expressions (14) and (15), for $i = 1, 2$, characterize the outcome of the one-shot game, which is summarized in the next proposition.

Proposition 5 *When contractual frictions κ are sufficiently large, the one-shot game with private list prices exhibits an equilibrium in which suppliers make take-it-or-leave-it (list price) offers*

$$l_1^s = l_2^s \equiv l^s = \frac{120 + 374\gamma + 283\gamma^2}{6(84 + 356\gamma + 491\gamma^2 + 221\gamma^3)}a$$

to small buyers and simultaneously negotiate wholesale prices

$$w_1^s = w_2^s \equiv w^s = \frac{(6 + 11\gamma)(12 + 44\gamma + 37\gamma^2)}{6(1 + 2\gamma)(84 + 356\gamma + 491\gamma^2 + 221\gamma^3)}a < l^s$$

with large buyers.

Proof. The proof in the Appendix is devoted to establish the critical level of contractual frictions that eliminates transfers in equilibrium. ■

Again the reason large buyers pay less than small buyers ($w^s < l^s$) is because is not in U_i's best interest to make small buyers too competitive in the downstream market; something that is understood by both, U_i and D_i, during their negotiation. Note also that as $\gamma \to 0$, $w^s \to a/7$, just as predicted by Proposition 1 for the case when there are no small buyers.

5.2 Explaining our motivating evidence

Our motivating evidence, summarized in Table 1, showed that wholesale prices paid by small and large buyers not only fell with the cease of the publication of list prices in the local newspaper, but also their difference did. In other words, discounts became less prevalent with the cease of publication. As the next proposition indicates, this evolution of prices and discounts is consistent with a collusive explanation in which the publication of list prices had helped suppliers to coordinate on prices.

Proposition 6 *Relative to the collusive equilibrium characterized in Proposition 4, the competitive equilibrium with private list prices characterized in Proposition 5 (i) reduces the prices paid by small buyers (i.e., $l^s < l^c$), (ii) reduces the prices paid by large buyers (i.e., $w^s < w^c$), (iii) reduces the discounts received by large buyers (i.e., $l^s - w^s < l^c - w^c$ and $w^s/l^s < w^c/l^c$), (iv) increases the sales of small buyers, (v) reduces the sales of large buyers, (vi) increases total sales, and (vii) reduces the profits of both suppliers and large buyers.*

However, as the next proposition indicates, the same evolution of prices is also consistent with a non-collusive explanation in which the publication of list prices had helped each supplier independently to negotiate better terms with his large buyers.

Proposition 7 *Relative to the competitive equilibrium with public list prices characterized in Proposition 3, the competitive equilibrium with private list prices characterized in Proposition 5 (i) reduces the prices paid by small buyers (i.e., $l^s < l^*$), (ii) reduces the prices paid by large buyers (i.e., $w^s < w^*$), (iii) reduces the discounts received by large buyers (i.e., $l^s - w^s < l^* - w^*$ and $w^s/l^s > w^c/l^c$), (iv) increases the sale of small buyers, (v) reduces de sale of large buyers, (vi) increases total sales, and (vii) reduces the profits of both suppliers and large buyers.*

As the two propositions are identical, it is clear that our theory is not prepared to distinguish, at least qualitatively, between the collusive and the non-collusive explanations. The reason is that what distinguishes one from the other is a matter of magnitude. When suppliers are not sufficiently patient, the collusive equilibrium reduces to the competitive equilibrium. One may say that in this case the multibuyer contact effect reduces just to the commitment effect. This effect allows suppliers to (unilaterally) charge higher prices to both small and large buyers, with discounts also going larger. As suppliers become more patient, the multibuyer contact effect grows larger, allowing suppliers to charge even higher prices to both type of buyers, with discounts going even larger.

6 Extension: Colluding with private list prices

Colluding with private list prices is not unthinkable but it does require of some communication between suppliers and large buyers. This in itself could be problematic for collusion to be sustained, let alone, implemented. In the collusive agreement of Proposition 4 this communication

was not necessary because large buyers were aware of the prices charged to the small buyers at the time of their negotiations. That is no longer the case here.

One can think of two types of communication, soft and hard. Under soft communication, suppliers would communicate to large buyers only the list price they intend to charge small buyers. Whereas under hard communication suppliers would not only communicate list prices but also make large buyers an offer that may depart from the Nash-bargaining solution that would ensue in anticipation to such list prices. In either case, suppliers need to make sure that (large) buyers' participation constraint is satisfied, as they did in Proposition 2.[34] Note that in Proposition 4 we did not pay attention to this constraint. It turned out that larger buyers also benefited from the agreement; but had they not, this would have not invalidated the agreement.

6.1 Soft communication

Any agreement under soft communication would share the same properties of the agreement in Proposition 4 with the only difference being the level of list prices that suppliers would be able to sustain in equilibrium. Sufficiently patient suppliers would in principle be able to sustain the same level of list prices in Proposition 4, l^c, while less patient suppliers would have to content themselves with lower levels, anything between l^c and the competitive level in Proposition 5, l^s. Since in any of these intermediate levels of collusion large buyers' participation constraints hold with slack,[35] one could in theory advance a third potential explanation for the evolution of prices in the wholesale fresh-egg market: the cease of publication of list prices did not end collusion altogether, it just forced suppliers to move to a less ambitious agreement that in addition had to be communicated to large buyers.

If one were to overlook the implications of communication with large buyers for the implementation and sustainability of a collusive agreement, support for this third explanation still requires that the agreement would be easier to sustain under public list prices than under private list prices. This is not entirely obvious. Suppose that punishment strategies involve reversion to the competitive equilibrium in either Proposition 3 or 5. It is clear from these propositions that moving from public to private list prices increases the severity of the punishments. However, moving from public to private list prices also increases the incentives to deviate from the agreement by postponing its detection from the second to the third stage. It can be shown (see the Appendix) that the latter effect dominates, so collusion would indeed be more difficult to sustain under private list prices.

6.2 Hard communication

With hard communication suppliers can in theory aim for an agreement that is more ambitious than that in Proposition 4. Provided it can be sustained, the most they can aim for is to post

[34] Given small buyers' lack of ability to negotiate discounts, suppliers need to pay no attention to their participation constraints by definition. See also footnote 29.

[35] Large buyers get more than what they get in Proposition 5, which would be the natural outcome if they "sabotage" suppliers' attempt to collude.

list prices

$$l_1^h = l_2^h \equiv l^h = \frac{a}{2}$$

and simultaneously approach large buyers with offers

$$w_1^h = w_2^h \equiv w^h = \frac{24 + 172\gamma + 354\gamma^2 + 221\gamma^3}{2(84 + 356\gamma + 491\gamma^2 + 221\gamma^3)} a < l^h$$

where superscripts "h" indicate hard communication.

Since large buyers' participation constraint holds with slack in the agreement of Proposition 4, the way suppliers improve upon such agreement here is by increasing the price paid by large buyers ($w^h > w^c$) until the participation constraint binds. And while doing that, suppliers also increase the price paid by small buyers ($l^h > l^c$). If for some reason suppliers fail to sustain such high prices, the way they would adjust their agreement is by lowering both prices and closing their gap, much in line with the predictions of Propositions 6 and 7. Furthermore, the pattern of adjustment is no different whether suppliers remain in the hard-communication mode or, as part of the adjustment, must switch to a soft-communication mode.

This adjustment of prices presents us with another, yet closely related, explanation of the evolution of prices in our motivating evidence, which is that the cease of publication of list prices could have prompted suppliers to water down their "hard-communication" agreement. Whether the publication of list prices could have indeed played such a role is something our theory cannot tell.

7 Conclusions

Our goal has been to contribute to a better understanding of whether, how and to what extent simultaneous and public announcements of list prices could help suppliers to sustain supracompetitive wholesale prices. Our interest in the topic has been motivated partly by antitrust cases but also by recent developments in Chile's wholesale fresh-egg market, where we have seen a significant drop in list and transaction (i.e., effectively paid) prices after its main suppliers had to stop publishing their list prices in the local newspaper.

Our theory provides two explanations for this drop in prices, a collusive and a non-collusive, competitive one. Whether one turns out to be more plausible than the other is less relevant for consumer welfare, as our theory unambiguously predicts that public announcements of list prices lead to supracompetitive prices. This suggests that terminating with the publication of list prices was a sensible decision to make.[36]

A totally different matter is the legal implications of finding more support for one explanation over the other. Unfortunately, our theory sheds little light on that regard. Both

[36] Some industry observers might argue that in the past the publication of list prices helped reduce search costs, particularly, of small buyers. Whether that is true today is hard to tell. The evidence presented in Section 2 tells us that if anything this procompetitive factor carries much less weight than the anticompetitive ones highlighted by our theory.

explanations are equally plausible, i.e., they share the same qualitative predictions in terms of changes in quantities, prices and profits. To distinguish between the two explanations surely requires of further empirical analysis, something that is beyond the scope of this paper.

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