# Collusion or competition?<br>Evaluating the firm behaviors in the instant noodles market*

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June 2024

**Abstract**

This study investigates the pricing behaviors of instant noodle manufacturers in South Korea during the 2010s. We find strong evidence against the suspicion by the Korea Fair Trade Commission (KFTC) that firms in this industry have colluded in price-fixing. Contrary to these suspicions, it appears they have been subjected to *de facto* price controls by the government; the observed markups are significantly lower than those calculated under a scenario of Nash–Bertrand competition, setting aside any collusion. Our counterfactual analysis suggests that profits would have been much higher (by 50 percent on average) than observed if the firms had engaged in the 'follow-the-leader' pricing strategy as claimed by the regulatory authority. These findings align with the ruling of the Supreme Court of Korea in 2015, which overturned the KFTC's imposition of fines (approximately 120 million US dollars) on the four major instant noodle producers in 2012.

**Keywords: Follow-the-leader pricing, Discrete choice demand, Collusion, Instant noodles**

**JEL Classification Numbers: D12, D22, L40, L66**

*We are grateful to seminar and workshop participants at SKKU, Yonsei University, Korea University, and the Korea-America Economic Association. Financial support from Dr. Delia Koo Faculty Endowment Award granted by the Asian Studies Center of Michigan State University is gratefully acknowledged.

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# 1 Introduction

Over the past few decades, Korean ramen (instant noodles) manufacturers have been suspected by authorities and media of possible collusion both domestically and internationally. In March 2012, the Korea Fair Trade Commission (KFTC) fined the four largest domestic ramen manufacturers - Nongshim, Samyang, Ottogi, and Paldo (then Korea Yakult) - 135.4 billion South Korean won (KRW), approximately 120 million US dollars, for sharing information and colluding to fix prices during the 2000s.[1] The KFTC cited 'follow-the-leader' pricing behavior as evidence of price-fixing. Furthermore, in September 2013, certified classes of direct and indirect instant noodle buyers in the U.S. filed a class-action lawsuit, accusing the four manufacturers of fixing prices between 2001 and 2010. After years of legal battles, the ramen makers were cleared of the charges; the Supreme Court of Korea overturned the KFTC's ruling in December 2015, and a federal jury in San Francisco rejected the antitrust price-fixing claims in December 2019. However, the KFTC still suspects collusion among the ramen manufacturers. For instance, when the four firms responded to the cost increases in the aftermath of the COVID-19 pandemic in 2021 by raising ramen prices, the KFTC carefully monitored the situation for any possibility of collusion.[2]

This study aims to find any empirical evidence of price-fixing behavior by South Korean ramen manufacturers in the domestic market. For the empirical analysis, we utilize monthly sales and advertising information for the 25 best-selling instant noodle products between January 2010 and December 2019, acquired from NielsenIQ and Nielsen Media. We first estimate the demand for instant noodles by adopting the random coefficient nested logit (RCNL) framework. The estimation results reveal strong substitutability among products within the same category (either pouch or cup) and heterogeneity in the marginal utility of income across consumers.

We then use the estimated demand parameters to calculate markups under each of the following three firm behavior scenarios: (i) single-product firm competition, (ii) Nash-Bertrand competition, and (iii) partial price-coordination. Under the first scenario, a firm does not internalize the substitutability between its products when setting prices, whereas it does under the second scenario. The third scenario assumes that a firm also partially internalizes the substitutability between its

[1] Throughout the paper, we use the average exchange rate during the sample period (January 2010 to December 2019), which is 1,120 KRW to 1 USD.

[2] Here is a link to a news article on this issue: `https://biz.chosun.com/policy/policy_sub/2021/08/23/KIRN7WF375HFPHFMPM6JE6APTM/`.

own products and those owned by its rivals. We find that the implied markups under the first scenario are closest in magnitude to the observed gross margins for the industry (20–25 percent) during the sample period. Markups derived under scenarios of Bertrand competition, as well as price-coordination, tend to be much higher, with median values exceeding 40 percent.

The above finding by no means implies that each ramen manufacturer behaved exactly as a single-product firm would. It rather suggests that they could not compete *à la* Nash–Bertrand, putting aside the possibility of collusion. While this may seem counter-intuitive at first glance, the finding aligns with the fact that ramen prices have been practically under government control in South Korea for the past few decades. In fact, ramen manufacturers have often been unable to fully adjust their prices in response to increases in raw material prices or labor costs, because the government has frequently enforced their cooperation in stabilizing food prices during periods of surge.[3] Consequently, firms might not have set optimal prices for their products, resulting in margins that are lower than those at the profit-maximizing level.

Having rejected the possibility of collusion among instant noodle manufacturers, we further investigate the prices that firms might have set had they engaged in the 'follow-the-leader' pricing, as suggested by the KFTC. To do this, we develop an empirical framework to calculate equilibrium prices in a two-stage Stackelberg price game with differentiated products. In the first stage of the game, Nongshim, the market leader with a sales share of over 50 percent during the sample period, sets the prices for its products. After observing the leader's prices, the three followers - Ottogi, Samyang, and Paldo - simultaneously choose their prices in the second stage. We solve the game backward and derive the first-order conditions for both the leader and the followers. To the best of our knowledge, our paper is the first in the literature to develop a Stackelberg leadership model in the context of a differentiated products market and discrete choice.

Focusing on the 11 best-selling products, we find that prices might have been much higher than observed had the firms actually competed *à la* Nash-Bertrand or adopted Stackelberg leadership in the absence of government intervention. The leader, Nongshim, would have charged prices 15–40 percent higher under Nash-Bertrand competition and 20–90 percent higher under price leadership than the observed prices. The price gap between the actual and counterfactual prices tends to

[3]In Section 2, we provide anecdotal evidence of *de facto* ramen price control by the government, which was also explicitly mentioned in the ruling of the Supreme Court of Korea.

be smaller for the followers, ranging from 1–25 percent under Nash-Bertrand competition to 3–50 percent under price leadership. Therefore, Nongshim was the most negatively affected by the government intervention in terms of margin reduction.

Comparing the annual profits and revenues of each firm under the three different firm behavior scenarios, we find that, under Nash-Bertrand competition, Nongshim's annual profit would have increased by 20 percent. Additionally, Ottogi, Samyang, and Paldo would also have seen higher profits compared to those under government regulation. If the firms had adopted Stackelberg leadership, Nongshim's profit would have further risen to 320 billion KRW (a 4.3 percent increase from the profit under Nash-Bertrand competition), while the followers would have seen profit increases ranging from 23 percent to 39 percent. Overall, annual profits from the 11 best-selling products would have been 50 percent higher without government regulation.

Our findings suggest that merely observing sequential price increases by firms, especially amid rising raw material prices and labor costs, is insufficient to conclude collusion. Instead, the regulatory authority should carefully examine the market structure and firm behaviors, and evaluate whether the firms' pricing behaviors are consistent with competitive equilibrium.

The rest of the paper is organized as follows: In the next section, we provide an overview of the related literature and outline the contribution of our study. In Section 3, we offer a detailed description of the South Korean instant noodles market, the antitrust cases against the four ramen manufacturers in South Korea and the U.S., and the data used in our analysis. After estimating the demand for instant noodles using the RCNL framework in Section 4, we evaluate firm behaviors in the market in Section 5. Also in this section, we introduce a two-stage Stackelberg price game and derive counterfactual prices and profits under price leadership. We conclude in Section 6.

## 2 Related literature

The Nash-Bertrand model has been the workhorse supply model for analyzing differentiated product markets. For instance, Nevo (2001) investigated whether firms in the U.S. ready-to-eat cereal industry colluded on pricing between the late '80s and early '90s. He identified three sources of the price-cost margin: product differentiation, multi-product pricing, and collusion, and empirically showed that the first two sources explain most of the seemingly high margins in the industry. In doing so, he considered three different ownership structures—namely, single-product firm, multi-product firm, and monopoly—in the Nash-Bertrand model. Nevo (2000) and Peters (2006) examined merger effects in the U.S. ready-to-eat cereal and U.S. airline industries, respectively, by adjusting the ownership structure accordingly. We extend the literature by introducing an empirical framework for a two-stage Stackelberg price game with differentiated products.

Several papers have considered potential collusion among firms by assuming or estimating conduct parameters.[4] Ciliberto and Williams (2014) defined the degree of collusion as a function of the level of multi-market contact between firms and estimated the conduct parameters along with demand and cost parameters. Björnerstedt and Verboven (2016) analyzed a merger in the Swedish painkiller industry and compared the simulated price increases with the actual price increases after the merger, allowing for the possibility of partial price coordination among firms by introducing a coordination parameter (ranging between 0 and 1). Miller and Weinberg (2017), studying the effects of the MillerCoors joint venture, estimated the size of the conduct parameter and showed that the MillerCoors joint venture facilitated collusion between the joint venture and its closest competitor, Anheuser-Busch. Similar to these previous works, we explore evidence of (partial) price coordination among South Korean instant noodle manufacturers, whom the regulatory authority has continuously suspected of collusion. We provide empirical evidence supporting the 2015 Supreme Court ruling, which overturned the KFTC's imposition of fines on the four major instant noodle producers in 2012.

Our work is also connected to empirical studies of price leadership. Most of these studies are descriptive and document evidence of price leadership in various industries, including retail gasoline (Lewis, 2012; Byrne and De Roos, 2019), vitamins (Marshall, Marx, and Raiff, 2008), retail pharmacies (Chilet, 2018), and supermarkets (Seaton and Waterson, 2013; Kim, Lan, and Dobson, 2021). Exceptionally, Rojas (2008) compared price-cost margins for various pricing models—Nash-Bertrand, Stackelberg leadership, and collusion—using estimates from a linear model of the Almost Ideal Demand System (Deaton and Muellbauer 1980). Our work differs from his in two important

[4] Alternatively, Hu, Xiao, and Zhou (2014) estimated the marginal cost function under various ownership structures and tested whether Chinese car manufacturers colluded using Rivers and Vuong (2002)'s non-nested hypothesis test methodology. Non-structural approaches have also been used to examine firm behaviors. For instance, Ciliberto, Watkins, and Williams (2019) proposed two tests that detect collusion using only price information; the first test, based on Athey, Bagwell, and Sanchirico (2004)'s prediction that prices of colluding firms are unresponsive to firm-specific shocks, examines price variation in a market over time. Their second test, drawing from the insight of Werden and Froeb (1994), examines the price gap between a pair of products in a market.

directions. First, we use the discrete choice model of differentiated products to estimate demand, allowing for unobserved product attributes, random coefficients, and correlation across product groups. Second, we derive the counterfactual prices (and thus, the price-cost margins) directly from the assumed supply-side models with differentiated products. Miller, Sheu, and Weinberg (2021) developed an infinitely repeated two-stage model of price leadership; in the first stage of each period, the leader makes non-binding announcements regarding supermarkups, and all firms set prices simultaneously in the second stage. Unlike their work (and similar to Rojas (2008)), we consider a Stackelberg leadership model in which the leader sets prices first, followed by other firms.

# 3 Background information and data

### Instant Noodles Market

Since their introduction in the 1960s, instant noodles have soared in popularity across South Korea due to their convenience and low price. In 2020, instant noodle consumption accounted for 3.3 percent of the daily caloric intake, ranking as the fifth primary energy source in the country.[5] According to the World Instant Noodles Association, South Korea was the eighth largest instant noodles market in the world in 2020. Additionally, the country had the highest level of per capita instant noodle consumption, with 79.7 packages, or equivalently, 6.6 packages per month on average, when considering both retail sales and consumption at restaurants.

In South Korea, ramen is considered a staple item in the daily lives of the working class, youth, and elderly, almost akin to a main dish. As such, the government has often enforced ramen manufacturers' cooperation in stabilizing food prices during price surges.[6] Consequently, the industry has been under *de facto* price controls by the government for the past few decades. To present anecdotal evidence of such price control, we compare price changes for four processed food categories that are similar in nature to one another - instant noodles, bread, biscuits, and snacks - between 1985 and 2019. According to Figure B1 in Appendix B, the price of instant noodles

[5] https://knhanes.kdca.go.kr/knhanes/sub04/sub04_04_01.do

[6] In 2010 and 2023, manufacturers were forced to decrease their product prices as food prices soared in the aftermath of the 2007–2008 global economic crisis and the COVID-19 pandemic, respectively. See the following news articles for more detail: https://www.thinkfood.co.kr/news/articleView.html?idxno=37023, https://www.chosun.com/economy/market_trend/2023/06/27/N7GYVS36ARH7HKGETVPCTFH33Y/

Table 1: Retail instant noodles market in 2019

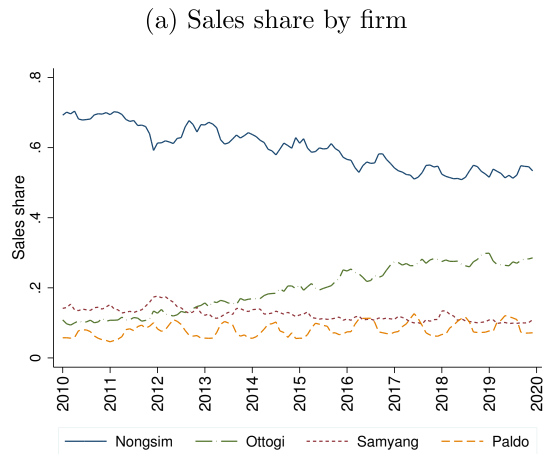
| | Sales revenue | | Sales volume | |
|---|---|---|---|---|
| | in Mil. KRW | % | in 1,000 | % |
| *By firm* | | | | |
| Nongshim | 1,091,653 | 51.4 | 1,380,040 | 51.2 |
| Ottogi | 492,311 | 23.2 | 717,224 | 26.6 |
| Samyang | 234,735 | 11.1 | 265,268 | 9.8 |
| Paldo | 204,089 | 9.6 | 241,115 | 9.0 |
| Others | 100,827 | 4.7 | 90,219 | 3.3 |
| *By package type* | | | | |
| Pouch | 1,299,243 | 61.2 | 1,843,215 | 68.4 |
| Cup | 824,372 | 38.8 | 850,651 | 31.6 |
| Total | 2,123,615 | | 2,693,866 | |

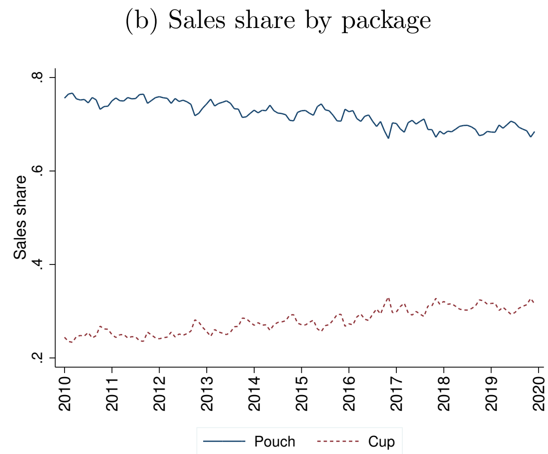
Note: Sales volume is the number of packages sold. Source: NielsenIQ.

had risen by a factor of three over the period, while the other three categories experienced a much higher (at least 450 percent) price increase. This observation suggests that reflecting increases in raw material prices or labor costs in pricing has been more challenging for ramen manufacturers.

The South Korean instant noodles market is characterized as a quadropoly, with the four largest manufacturers accounting for over 95 percent of the industry's sales. Table 1 shows that total retail sales revenue and volume were 2.1 trillion KRW (approximately 1.9 billion US dollars) and 2.7 billion packages, respectively, in 2019, with Nongshim, the market leader, claiming more than 50 percent of the share. Sales from each follower - Ottogi, Samyang, and Paldo - accounted for approximately 23 percent, 11 percent, and 10 percent, respectively, of the total sales that year. While the industry is highly concentrated, with an HHI over 3,000, we observe interesting industry dynamics. Notably, Ottogi nearly tripled its sales over the course of the 2010s. According to the left panel of Figure 1, the firm accounted for merely around 10 percent of the industry sales in the early 2010s, competing with Samyang and Paldo for second place. By the end of 2019, its sales share had reached 28 percent, primarily at the expense of Nongshim's sales. This observation, along with the *de facto* price regulation, may serve as anecdotal evidence against the KFTC's persistent suspicions of collusion among instant noodle manufacturers.

Figure 1: Industry dynamics




Note: The left panel plots the sales share trends of the four major ramen manufacturers, while the right panel shows the sales share trends of the two package types. Source: NielsenIQ.

Instant noodles are sold in two types of packaging: pouch/packet and cup/bowl, with a brand often being offered in both forms. Pouches are more popular among consumers, outselling cup noodles by one billion units in 2019, as shown in Table 1. However, the latter have gained more popularity in the last decade; according to the right panel of Figure 1, the sales share of cup noodles increased by 7 pp during the 2010s, rising from 25 percent in 2010 to 32 percent in 2019.

## Accusation of collusion

Table 2 presents the timeline of major events regarding the accusation of collusion against the four ramen manufacturers. In March 2012, the KFTC imposed a correction order to prohibit collusion and information exchange among the four producers, as well as fining them a total of approximately 130 billion KRW (120 million US dollars).[7] According to the KFTC, the four firms jointly raised prices on six different occasions during the 2000s (May–July 2001, October 2002–January 2003, December 2003–April 2004, December 2004–April 2005, March–September 2007, and February–April 2008). More specifically, the price increases were conducted sequentially; Nongshim, the market leader, took action first, followed by the other three firms. Furthermore, as an effort to strengthen the collusion's integrity, the four firms regularly held meetings, such as the 'Instant Noodles Council', and shared information on both price and non-price factors (e.g., sales,

[7] The KFTC's press release is available at `http://www.ftc.go.kr/www/selectReportUserView.do?key=10&rpttype=1&report_data_no=4693`.

Table 2: Timeline of major events

| Year/Month | Event |
|---|---|
| 2012 | |
| Mar | The KFTC announced price-fixing among four ramen manufacturers. |
| Jul | The KFTC decided to impose fines to the firms for collusion. |
| Aug | Nongshim, Ottogi, and Paldo filed an administrative lawsuit with the Seoul High Court. |
| 2013 | |
| Jul | The Plaza Company requested approval for a class-action lawsuit in the Federal Court of California. |
| Nov–Dec | The three firms (Nongshim, Ottogi, and Paldo) lost the lawsuit to cancel the fines at the Seoul High Court. |
| 2015–2016 | |
| Dec–Jan | The three firms won the lawsuit at the Supreme Court to cancel the fines. |
| 2018 | |
| Dec | The United States District Court for the Northern District of California ruled in favor of Nongshim and Ottogi. |

Note: The table presents the timeline of major events regarding the accusation of collusion against the four ramen manufacturers.

promotions, and new product launches).

Samyang voluntarily reported collusion as soon as the KFTC began its investigation into the issue and was exempted from a fine of 12 billion KRW (10.7 million US dollars), thanks to the KFTC's leniency program.[8] In contrast, Nongshim, Ottogi, and Paldo filed administrative litigation against the fine. The three firms claimed that they were not involved in price-fixing and made pricing decisions independently, based on the prices of flour and oil, the primary ingredients of instant noodles. The firms also argued that the information they allegedly shared was not confidential but was, in fact, publicly available. On November 2013, the Seoul High Court ruled against the firms, stating that the timing and size of the price increases signified a prior agreement. However, this verdict was overturned by the Supreme Court of Korea in December 2015, which stated that the price of instant noodle products had always been under the pressure of cost increases and was practically under government control. Thus, other companies following Nongshim in raising prices is reasonable and cannot be considered collusion.[9]

[8]According to an industry source, the firm had been struggling so much with performance failure that facing the fine would have risked closure.

[9]This Supreme Court ruling is available at https://www.scourt.go.kr/supreme/news/NewsViewAction2.work?seqnum=5081&gubun=4&searchOption=&searchWord=.

Meanwhile, using this collusion case in South Korea as a pretext, in July 2013, the Plaza Company, a Koreatown market in the U.S., filed a class-action lawsuit against the four firms, alleging price-fixing for their export products. Later, two class actions brought by direct and indirect purchasers were consolidated into the U.S. District Court for the Northern District of California (In re: Korean Ramen Antitrust Litigation, Case No. 3:13-cv-04115). In December 2018, the jury concluded that the plaintiffs failed to prove that the ramen makers had colluded to increase prices and ended the case.[10]

### Data

In this study, we define a product as a combination of a brand and package type. The product-level data analyzed in this study were acquired from two sources: sales data from NielsenIQ and advertising data from Nielsen Media. The first dataset contains monthly sales and prices for each product offered by the four major producers across six geographical areas (as defined by the firm) from January 2010 to December 2019.[11] Among the products, we focus on the 25 best-selling products from 19 brands, comprising 13 pouches and 12 cups. 14 products are owned by Nongshim, six by Ottogi, three by Samyang, and the remaining two by Paldo. Table B1 in Appendix B shows that the proportion of their combined sales in the total sales of the four major producers has remained stable at around 75 percent during the sample period. The second dataset provides monthly advertising expenditures for each of the aforementioned 19 brands.

We define a market as an area and time (year-month) combination, resulting in 720 markets (six areas $\times$ 120 year-months) in the sample. In the next two sections, we conduct empirical analyses based on the assumption that the market size is 10 times the population size of the market.[12] This assumption is equivalent to presuming that the potential market involves 10 instant noodle packages consumed per capita per month. We calculate the market share by dividing the sales volume by the market size and obtain real prices by adjusting nominal prices for inflation using the CPI excluding food and energy (the base year is 2020).

The sample consists of 16,692 product-market level observations. Table 3 presents descriptive

[10] A detailed description of this trial is available at `https://www.nera.com/content/nera/us/en/about/press-releases/2019/korean-ramen-makers-prevail-in-rare-antitrust-class-action-trial.html`.

[11] Figure B2 in Appendix B presents the division of South Korea into these six areas.

[12] Empirical results (available from the authors upon request) are robust to variations in market sizes.

Table 3: Descriptive statistics

| | Package type | | | |
|---|---|---|---|---|
| | Pouch | | Cup | |
| Variable | Avg. | Std. Dev. | Avg. | Std. Dev. |
| Sales revenue | 1,270.25 | 1,422.99 | 604.11 | 492.21 |
| Number of packages sold | 1,739.49 | 2,035.46 | 661.13 | 578.45 |
| Market share (%) | 2.10 | 2.10 | 0.80 | 0.55 |
| Price | 816.26 | 183.46 | 958.91 | 158.23 |
| Advertising expenditure | 165.74 | 377.27 | 112.58 | 328.41 |
| Market-level product count | | | | |
| All | 137.90 | 28.96 | 135.45 | 28.39 |
| Same group | 75.75 | 13.65 | 59.87 | 15.17 |
| Same group, rival firms | 55.15 | 10.50 | 43.78 | 10.97 |

Note: Sales revenue and advertising expenditures are in million KRW, while price is in KRW. Also, the number of packages sold are in 1,000 units.

statistics for the key variables, separated by the two package types. The average market share is 2.1 percent for pouches and 0.8 percent for cup noodles. Additionally, the market share of the outside option - which includes consumption of excluded products, consumption at restaurants, and no consumption of instant noodles - averages 67 percent in the sample. On average, a cup noodle is 17.5 percent more expensive than a pouch product, mainly due to higher packaging costs; styrofoam or plastic cups are more costly to produce than foil pouches.

## 4 Instant noodles demand

### Model

Similar to Grigolon and Verboven (2014) and Miller and Weinberg (2017), we specify the indirect utility of consumer $i$ for product $j$ in market $m$, which is a combination of region $r$ and time $t$, as follows:

$$u_{ijm} = \alpha_i p_{jm} + \beta adv_{jt} + \xi_j + \xi_r + \xi_t + \triangle\xi_{jm} + \bar{\varepsilon}_{ijm}, \tag{1}$$

where $p$ and $adv$ are the price and (brand-level) advertising expenditures, respectively. The marginal utility of net income is consumer-specific:

$$\alpha_i = \alpha + \sigma v_i,$$

where $v_i$ follows standard normal distribution. Product, area, and time fixed effects, $\xi_j$, $\xi_r$, and $\xi_t$, are included in the model to control for both observed and unobserved product attributes, heterogeneity in consumer tastes across geographical areas, and time-varying demand shocks for instant noodles. The error term $\Delta\xi_{jm}$ captures the remaining product-specific demand shocks.

The random taste parameter $\bar{\varepsilon}_{ijm}$ follows the nested logit distributional assumptions:

$$\bar{\varepsilon}_{ijm} = \zeta_{igm} + (1-\rho)\varepsilon_{ijm},$$

where $\varepsilon_{ijm}$ is i.i.d. and follows extreme value distribution. Then, as is well known (McFadden, 1978; Cardell, 1997), there exists a unique distribution of $\zeta_{igm}$ relying on the nesting parameter $\rho$ such that $\bar{\varepsilon}_{ijm}$ is extreme value. Under the nested logit framework, the size of $\rho \in [0,1)$ indicates the level of the within-group preference correlation. As it converges to zero, less and less additional preference correlation exists across products within the same group, whereas the size of $\rho$ close to one indicates a strong within-group preference correlation.

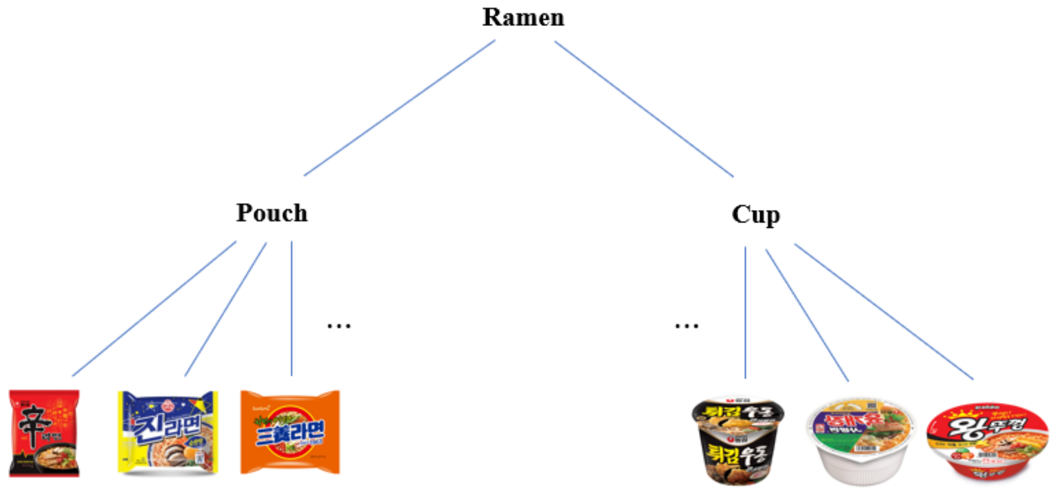
In this study, we categorize the ramen products into two groups based on their package types (pouch and cup), as Figure 2 graphically illustrates. Pouches are not portable and usually consumed at home, as they require cooking in a separate pot. In contrast, due to their self-contained nature, cup noodles are rather portable and suitable for on-the-go consumption. Given the clear difference between pouches and cup noodles in terms of portability and cooking method, we believe that this classification is the most reasonable and that the within-group substitutability is much higher than that across groups.

The utility for the outside option is normalized as $u_{iom} = \bar{\varepsilon}_{iom}$. Then, the probability that consumer $i$ selects product $j$ in market $m$, denoted as $s_{ijm}$, can be derived as follows:

$$s_{ijm} = \underbrace{\frac{\exp\left(I_{igm}\right)}{\exp\left(I_{im}\right)}}_{s_{ig}} \underbrace{\frac{\exp\left(\frac{\delta_{jm}+\sigma p_{jm} v_i}{1-\rho}\right)}{\exp\left(\frac{I_{igm}}{1-\rho}\right)}}_{s_{ij|g}}, \tag{2}$$

where the first and second terms, $s_{ig}$ and $s_{ij|g}$, on the right-hand side of the equation represent the consumer's probability of choosing group $g$ and probability of selecting product $j$ within the group, respectively. The terms $I_{igm}$ and $I_{im}$, commonly referred to as the inclusive values of choices, are

Figure 2: Product categorization




defined as

$$I_{igm} = (1-\rho)\ln \sum_{k=1}^{J_{gm}} \exp\left(\frac{\delta_{km} + \sigma p_{km} v_i}{1-\rho}\right), \quad I_{im} = \ln\left(1 + \sum_{g=1}^{2} \exp(I_{igm})\right)$$

and $\delta_{jm}$ is the mean utility of product $j$:

$$\begin{aligned} \delta_{jm} &= \alpha p_{jm} + \beta adv_{jt} + \xi_j + \xi_r + \xi_t + \triangle\xi_{jm} \\ &= \mathbf{x}_{jm}\theta_1 + \triangle\xi_{jm}, \end{aligned}$$

where vector $\theta_1$ contains linear utility parameters including the three fixed effects.

Integrating individual consumer's choice probability in (2) with respect to $v$ lets us predict product $j$'s market share:

$$s_{jm}\left(\delta_m, p_m; \theta_2\right) = \int s_{ijm} dF(v), \tag{3}$$

where vector $\theta_2$ contains the two nonlinear utility parameters, $\theta_2 = (\rho, \sigma)$, and $F(v_i)$ is the CDF of the standard normal distribution. Then, we can obtain the implied error term $\triangle\xi_{jm}$ by equating the predicted and observed market shares, and construct the following moment condition:

$$E[\triangle\xi_{jm}(\theta)|Z_{jm}] = 0,$$

where $\theta = (\theta_1, \theta_2)$ and $Z_{jm}$ is the set of instruments.

Since the price and its interaction with unobserved consumer characteristics, denoted by $v$, are endogenous, exogenous instruments are required. Additionally, estimating the nesting parameter necessitates the use of exogenous variables that correlate with market shares. Following prior studies such as Berry, Levinsohn, and Pakes (1995), Bresnahan, Stern, and Trajtenberg (1997), and Brenkers and Verboven (2006), we consider several product counts as instrumental variables: the total number of products available in the market, the number of products owned by competitors, the number of products sharing the same package type as the focal product, and the number of competitor-owned products with the same packaging as the focal product. These product counts influence market shares and markups but are unlikely to be affected by the current demand shock $\Delta\xi_{jm}$, as firms typically make decisions about product launches and discontinuations in advance. We also use a product's average price in other geographical areas and the wheat price multiplied by the product size as additional instruments. These capture observed and unobserved cost shocks that affect marginal costs.[13]

### Estimation results

If we assume that both nonlinear utility parameters, $\rho$ and $\sigma$, are zero, then the demand model collapses to a logit model. Allowing only the nesting parameter $\rho$ to take a non-zero value, we transition to a one-level nested logit (NL) model. We first estimate these restricted versions of the demand model using the sample data described in the previous section and re-estimate them after aggregating the monthly data to quarter levels. Estimation results show that the price and advertising coefficients, $\alpha$ and $\beta$, are statistically significant and exhibit the anticipated signs.[14] Moreover, the nesting parameter in the NL model indicates strong substitutability among products within the same group.

We use optimal instruments, $E\left[\frac{\partial \Delta\xi_{jm(\theta)}}{\partial \theta} \mid Z_{jm}\right]$, to estimate the RCNL models. Approximations of these optimal instruments, inspired by the approaches of Amemiya (1977) and Chamberlain

[13] A product's average price in other geographical areas, reflecting common cost shocks, is not correlated with the demand shock $\Delta\xi_{jm}$ unless cross-sectional correlations among the demand shocks exist (Gandhi and Nevo, 2021). After controlling for a set of fixed effects and advertising expenditures, we believe such cross-sectional correlations are unlikely (Nevo, 2000, 2001).

[14] $F$-statistics for the weak identification test are sufficiently large ($> 50$) to reject the null hypothesis of weak IVs. Additionally, the overidentification test fails to reject the validity of instruments at the 5% significance level in all specifications.

Table 4: Demand estimation results

| | Logit | | NL | | RCNL | |
|---|---|---|---|---|---|---|
| Utility parameter | Monthly | Quarterly | Monthly | Quarterly | Monthly | Quarterly |
| $\alpha$ | -2.301 | -1.732 | -0.310 | -0.231 | -0.828 | -1.203 |
| | (0.128) | (0.216) | (0.036) | (0.090) | (0.153) | (0.325) |
| $\beta$ | 0.205 | 0.127 | 0.027 | 0.036 | 0.030 | 0.020 |
| | (0.012) | (0.013) | (0.003) | (0.007) | (0.005) | (0.005) |
| $\rho$ | | | 0.908 | 0.754 | 0.891 | 0.886 |
| | | | (0.015) | (0.053) | (0.021) | (0.035) |
| $\sigma$ | | | | | 0.569 | 0.846 |
| | | | | | (0.107) | (0.217) |
| Fixed effects | | | | | | |
| Product | Yes | Yes | Yes | Yes | Yes | Yes |
| Area | Yes | Yes | Yes | Yes | Yes | Yes |
| Time | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 16,692 | 5,610 | 16,692 | 5,610 | 16,692 | 5,610 |

Note: The table presents the Logit (in the first two columns), Nested Logit (in the next two columns) and Random-coefficient Nested Logit (in the last two columns) demand estimates. Each demand model is estimated twice, using month-level and quarter-level sub-samples. The average price of the focal product in other areas, the wheat price multiplied by product size, and product counts in the market are used as instrumental variables. Robust standard errors (clustered by market for the Logit and Nested Logit models) are in parentheses.

(1987), significantly improve the precision and econometric efficacy of the estimator, particularly in terms of nonlinear parameters (Reynaert and Verboven, 2014; Conlon and Gortmaker, 2020; Berry and Haile, 2021).[15] Estimation results presented in the last two columns of Table 4 are consistent with those of the logit and NL models; while price and ad spending have opposing effects on consumer utility, consumers treat products within the same group as closer substitutes. Furthermore, the parameter $\sigma$ is significantly different from zero, implying heterogeneity in the marginal utility of income across consumers.

The own- and cross-price elasticities of demand are formulated as

$$e_j = \frac{p_j}{s_j} \int \alpha_i s_{ij} \left( \frac{1}{1-\rho} - \frac{\rho}{1-\rho} s_{ij|g} - s_{ij} \right) dF(v_i)$$
$$e_{jk} = -\frac{p_k}{s_j} \int \alpha_i s_{ij} \left( \frac{\rho}{1-\rho} s_{ik|g} D_{jk} + s_{ik} \right) dF(v_i),$$

where the binary variable $D_{jk}$ equals one if products $j$ and $k$ are in the same group. Using the

[15] Additionally, we approximate the integration in (3) using a Gaussian quadrature rule with nine nodes.

Table 5: Summary of the price elasticities

| Package type | Own-price elasticity | Cross-price elasticity | |
|---|---|---|---|
| | | Same group | Different group |
| | Logit | | |
| Pouch | -1.843 | 0.034 | 0.017 |
| Cup | -2.190 | 0.017 | 0.035 |
| **All** | -2.019 | 0.025 | 0.026 |
| | Nested Logit | | |
| Pouch | -2.561 | 0.197 | 0.002 |
| Cup | -3.003 | 0.241 | 0.005 |
| **All** | -2.785 | 0.219 | 0.003 |
| | Random Coefficient Nested Logit | | |
| Pouch | -2.902 | 0.234 | 0.002 |
| Cup | -3.860 | 0.310 | 0.006 |
| **All** | -3.388 | 0.273 | 0.004 |

Note: The table presents the empirical means of the own- and cross-price elasticities during the sample period, computed using the estimated Logit, Nested Logit, and RCNL demand parameters.

estimated Logit, NL, and RCNL demand parameters from the monthly observations, we calculate the elasticities for each observation and report their empirical means in Table 5. While cup noodles tend to have larger own-price elasticities than pouches across all specifications, the RCNL model generates larger own-price elasticities ($-3.4$ on average) compared to the two restricted models ($-2.8$ and $-2$ on average). Within-group cross-price elasticities are significantly higher than those between products in different groups under NL and RCNL, reflecting the large size of the nesting parameter ($\rho > 0.75$).

## 5 Firm behaviors

In this section, we use the RCNL demand parameters estimated in the previous section to infer markups under various scenarios of firm behavior. By comparing these with the observed markups, we draw conclusions about whether the four major instant noodle producers colluded. Additionally, we estimate the prices that would have been set had the firms adopted Stackelberg leadership.

### Observed versus predicted markups

The variable profit of a multi-product company $c$, $\Pi_c$, in a given market is

$$\Pi_c(p) = \sum_{j \in \mathcal{F}_c} (p_j - mc_j) s_j(p) \mathcal{M},$$

where $\mathcal{F}_c$ is the set of products owned by the company, $mc_j$ is the constant marginal cost of product $j$, and $\mathcal{M}$ is the market size. The profit-maximizing prices for the company satisfy the following first-order conditions:

$$s_j(p) + \sum_{r \in \mathcal{F}_c} (p_r - mc_r) \frac{\partial s_r(p)}{\partial p_j} = 0, \ \forall j \in \mathcal{F}_c \tag{4}$$

so that market equilibrium prices solve the following equation:

$$s(p) + (\Omega \circ \nabla_p s)(p - mc) = 0, \tag{5}$$

where $s(p)$, $p$, and $mc$ are vectors of the market shares, prices, and marginal costs of the products in the market, respectively. $\Omega$ is the ownership matrix, that is, $\Omega(j,k)$ equals one if products $j$ and $k$ are owned by the same firm and zero otherwise. $\nabla_p s \equiv \frac{\partial s}{\partial p'}$ is the Jacobian matrix, and the operator $\circ$ denotes the Hadamard product, that is, element-by-element multiplication.

Similar to Nevo (2001) and Björnerstedt and Verboven (2016), we consider three scenarios of firm behavior: (i) single-product firm competition (Scenario 1), (ii) multi-product firm competition (Scenario 2), and (iii) partial price-coordination (Scenario 3). Under the first scenario, a firm sets the price for each product considering only its own sales effects, ignoring interactions with other products it owns. Under the second scenario, a firm maximizes its profits by considering the substitutability among its products when setting prices. Under the third scenario, a firm also considers, albeit partially, the substitutability between its products and those owned by competitors. As an illustration, suppose there are two firms, each owning two products. The ownership matrices under each scenario, $\Omega^1$, $\Omega^2$, and $\Omega^3$, are given by:

$$\Omega^1 = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}, \ \Omega^2 = \begin{bmatrix} 1 & 1 & 0 & 0 \\ 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \end{bmatrix}, \ \Omega^3 = \begin{bmatrix} 1 & 1 & \phi & \phi \\ 1 & 1 & \phi & \phi \\ \phi & \phi & 1 & 1 \\ \phi & \phi & 1 & 1 \end{bmatrix},$$

where the conduct parameter $\phi \in [0,1]$ indicates the degree of collusion; $\phi$ equals zero under multi-product firm competition and one under full collusion.

From the first-order condition (5), the marginal cost vector, $mc^i$, and Lerner index (markup) for product $j$, $L_j^i$, under firm behavior scenario $i \in \{1,2,3\}$ can be derived as:

$$mc^i = p + \left(\Omega^i \circ \nabla_p s\right)^{-1} s(p), \quad L_j^i = (p_j - mc_j^i)/p_j, \ \forall j.$$

Using the RCNL demand estimates from the monthly observations and setting 0.3 as the value of the conduct parameter $\phi$, we back out the implied marginal costs and markups for each of the 16,692 observations in the sample.

Table 6 presents the summary statistics of the markups recovered under the three firm behavior scenarios.[16] The average and median of the implied markups under the first scenario, which involves no price coordination even across products of the same firm, are below 25 percent. Markups recovered under the baseline scenario of multi-product firm competition are substantially higher; the average and median markups are 46 percent and 50 percent, respectively. Implied markups under the scenario of partial collusion are even higher. Their average and median values are around 60 percent when the conduct parameter $\phi$ is 0.3, and rise above 100 percent under stronger price-coordination and full collusion ($\phi > 0.7$), which is unrealistic.[17]

Regarding the observed markups, Table B2 in Appendix B presents aggregate estimates of the production cost for the "Noodle, Macaroni, and Similar Food Manufacturing" sector (KSIC C10730) in South Korea for the years 2005, 2010, 2015, and 2020.[18] Given that products in this sector are

[16]The summary excludes 462 outliers, which constitute 2.8 percent of the 16,692 markups.

[17]Figure B3 in Appendix B graphically presents the average and median of implied markups under different degrees of price-coordination.

[18]These cost figures are derived from Mining and manufacturing Surveys available at `https://kosis.kr/common/meta_onedepth.jsp?vwcd=MT_ZTITLE&listid=L_5`.

Table 6: Summary of the recovered markups

| Package type | Mean | 10th | 50th | 90th |
|---|---|---|---|---|
| | | Scenario 1 | | |
| Pouch | 0.311 | 0.207 | 0.279 | 0.520 |
| Cup | 0.178 | 0.170 | 0.223 | 0.319 |
| **All** | 0.244 | 0.179 | 0.245 | 0.376 |
| | | Scenario 2 | | |
| Pouch | 0.486 | 0.213 | 0.494 | 0.835 |
| Cup | 0.435 | 0.193 | 0.503 | 0.792 |
| **All** | 0.460 | 0.207 | 0.498 | 0.806 |
| | | Scenario 3 ($\phi = 0.3$) | | |
| Pouch | 0.603 | 0.385 | 0.598 | 0.927 |
| Cup | 0.568 | 0.408 | 0.616 | 0.897 |
| **All** | 0.586 | 0.393 | 0.607 | 0.906 |

Note: The table presents descriptive statistics of the markups recovered under three different firm behaviors: (i) single-product firm competition, (ii) multi-product firm competition, and (iii) partial collusion with $\phi = 0.3$.

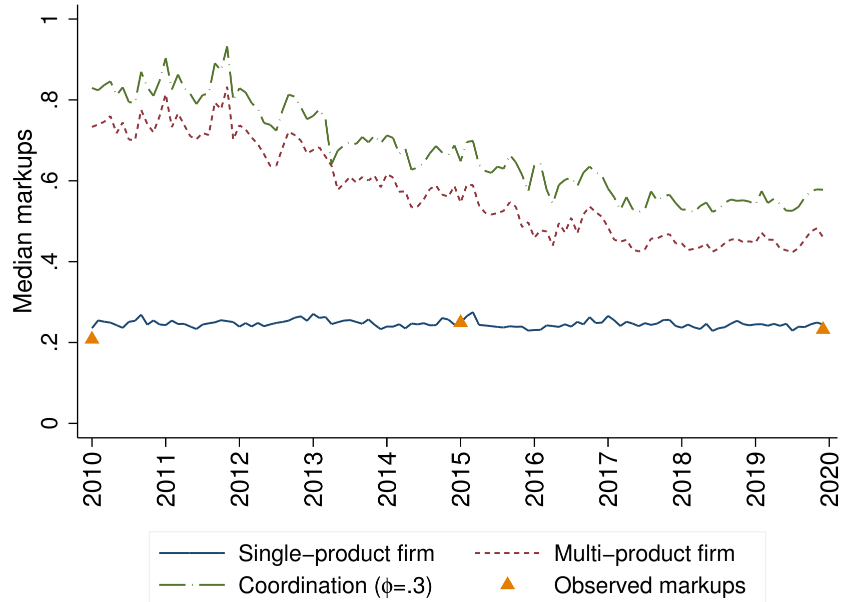
predominantly instant noodles,[19] we treat these estimates as the observed costs for instant noodles production. Additionally, according to an industry source, the retail margin for instant noodles is not less than 20 percent.[20] Using the above information, we calculate the gross margins for the industry, finding that they (20–25 percent) align closely with the markups recovered under the single-product firm competition scenario.

In Figure 3, we plot the median markup trends under the three firm behavior scenarios. Similar to the observed industry-level gross margin, the median markup under the single-product firm competition scenario remains fairly stable in the low 20 percent range over the sample period. In contrast, the medians of the markups recovered under the other two scenarios exceed 40 percent during the sample period. These observations indicate that there was no collusion during the sample period in the 2010s. Moreover, given the observed markup of 25 percent in 2005, along with the declining markup trend under the partial collusion scenario during the sample period, it is also

[19]For instance, in 2009, the shipment value for instant noodles was 1.8 billion KRW, accounting for 75 percent of the total sector's shipment value of 2.4 billion KRW (Source: "Processed Food Industry Survey: Instant Noodles", Korea Agro-Fisheries Trade Corp., 2009).

[20]For instance, the margin has consistently been 25 percent or higher for convenience stores, which are the primary retail channel for instant noodle sales in the country; the proportion of sales through convenience stores has been 25 percent or higher.

Figure 3: Observed vs recovered markups




Note: The figure presents median markup trends under the three firm behavior scenarios: (i) single-product firm competition, (ii) multi-product firm competition, and (iii) partial price coordination ($\phi = .3$), as well as presenting the observed gross margins for the industry in 2010, 2015 and 2020.

unlikely that the firms engaged in collusion during the 2000s, contrary to the claims made by the KFTC.

At first glance, the finding that the observed markups are lower than those recovered under the baseline multi-product firm competition scenario, let alone any collusion scenario, is counter-intuitive, suggesting that firms in the industry are not maximizing their own profits. This finding, however, is not surprising given that the industry has been under *de facto* government price controls for the past few decades. As described in Section 2, ramen manufacturers have been explicitly pressured to not raise or even to cut prices. As a result, they might not have been able to set optimal prices for their products, leading to margins substantially lower than those that would maximize profits.

### Counterfactual analysis: 'follow-the-leader' pricing

Based on the analysis so far, we reject the claim that the four instant noodle firms engaged in any colluding or price-coordinating behaviors in the 2010s. We now aim to answer the following question: What prices might the firms have set had they engaged in the 'follow-the-leader' pricing, as suspected by the KFTC? To address this, we consider a two-stage Stackelberg price game with differentiated products. In this model, the leader (Nongshim) sets the prices for its products in the first stage, while the three followers (Ottogi, Samyang, and Paldo) simultaneously choose their prices in the second stage.

We solve the game backward. In the second stage, a follower $f$ determines the optimal prices for its products by solving the following first-order conditions:

$$s_k(p) + \sum_{h \in \mathcal{F}_f} (p_h - mc_h) \frac{\partial s_h(p)}{\partial p_k} = 0, \quad \forall k \in \mathcal{F}_f \tag{6}$$

which are essentially the same as those of the baseline Nash-Bertrand model in (4) except that the follower's profit-maximizing prices, $p_f$, depend on the leader's prices, $p_\ell$, set in the preceding stage.

In the first stage, the leader maximizes its profit, $\Pi_\ell$, defined as

$$\Pi_\ell(p_\ell, p_f(p_\ell)) = \sum_{r \in \mathcal{F}_\ell} (p_r - mc_r) s_r(p_\ell, p_f(p_\ell)) \mathcal{M}$$

by setting prices $p_\ell$ that satisfy the following first-order conditions:

$$s_j(p) + \sum_{r \in \mathcal{F}_\ell} (p_r - mc_r) \underbrace{\left( \frac{\partial s_r(p)}{\partial p_j}\Big|_{\text{direct}} + \sum_{k \notin \mathcal{F}_\ell} \frac{\partial s_r(p)}{\partial p_k} \frac{\partial p_k}{\partial p_j} \right)}_{\partial s_r / \partial p_j} = 0, \ \forall j \in \mathcal{F}_\ell. \tag{7}$$

The intuition behind the leader's profit-maximization strategy is straightforward. When deciding on the price for product $j$, the leader considers its effects on the product's margin, the sales of its own products, and the followers' prices, which in turn influence the sales of the leader's products. This last effect is unique to the leader. Details on how to compute the derivative of the market share with respect to price, $\partial s_r / \partial p_j$, under our RCNL framework are provided in Appendix A.

First-order conditions for the leader and followers, (6) and (7), can be combined to form the following equation:

$$s(p) + (\Omega \circ \nabla_p s)(p - mc) + \begin{pmatrix} \nabla_{p_\ell} p_f \; \nabla_{p_f} s_\ell \; (p_\ell - mc_\ell) \\ 0 \end{pmatrix} = 0. \tag{8}$$

In the equation, $\nabla_{p_\ell} p_f \equiv \frac{\partial p_f}{\partial p'_\ell}$ and $\nabla_{p_f} s_\ell \equiv \frac{\partial s_\ell}{\partial p'_f}$ are the Jacobian matrices of dimensions $J_\ell \times J_f$ and $J_f \times J_\ell$ respectively, where $J_\ell$ and $J_f$ represent the number of products owned by the leader and the followers. The solution to this equation, $(p_\ell, p_f)$, determines the subgame perfect equilibrium.

To ease the computational burden, we focus on the 11 best-selling instant noodle products: seven owned by the leader and four by the three followers. According to Table B1 in Appendix B, their combined sales share exceeded 50 percent in the 2010s, although it showed a declining trend. We estimate the demand model using month-level and quarter-level sub-samples (comprising 7,920 and 2,640 observations of the 11 products, respectively) and report the results in Table B3 in Appendix B. The results again show that consumers perceive products of the same package type as close substitutes and those of different package types as weak substitutes. To derive the counterfactual prices under Stackelberg leadership, we use the RCNL demand estimates, especially from the quarter-level sub-sample, in consideration of the time lag between the leader's and followers' pricing decisions. Predicting the prices also requires knowledge of the actual marginal costs, which are not observed. Instead, we use the marginal costs recovered under the single-product firm competition scenario, $mc^1$. We take this approach not because each firm in this industry behaved exactly as a single-product firm, but because it generates margins that are closest to those observed under government regulation.

Table 7 presents the average observed and counterfactual prices for each product. Two points are noteworthy. First, counterfactual prices are higher than the observed prices. For instance, Nongshim would have charged 16 to 38 percent higher prices had the firms competed à la Nash-Bertrand in the absence of government intervention. While the prices of products owned by the followers would also have been higher, the gaps between their actual and counterfactual prices are smaller than those for Nongshim products. This finding indicates that the multi-product firm effect is largest for Nongshim, as the firm owns seven out of the 11 products. Consequently, the markup of Nongshim products was most negatively affected by the government intervention, while the markup adjustments for the followers were relatively minor. Second, as expected, Stackelberg's

Table 7: Observed and counterfactual prices

| Firm and sales ranking | Observed KRW (A) | Nash-Bertrand KRW (B) | B/A | Stackelberg KRW (C) | C/A |
|---|---|---|---|---|---|
| Nongshim | | | | | |
| 1 | 721.9 | 924.8 | 1.28 | 1,005.7 | 1.39 |
| 2 | 838.2 | 974.4 | 1.16 | 1,031.9 | 1.23 |
| 3 | 635.3 | 852.9 | 1.34 | 944.7 | 1.49 |
| 4 | 780.6 | 989.3 | 1.27 | 1,048.9 | 1.34 |
| 6 | 920.4 | 1,221.8 | 1.33 | 1,472.3 | 1.60 |
| 8 | 801.1 | 1,105.7 | 1.38 | 1,517.8 | 1.89 |
| 10 | 919.9 | 1,239.8 | 1.35 | 1,511.6 | 1.64 |
| Ottogi | | | | | |
| 5 | 595.2 | 617.7 | 1.04 | 629.2 | 1.06 |
| 11 | 695.8 | 789.8 | 1.14 | 908.9 | 1.31 |
| Samyang | | | | | |
| 7 | 658.1 | 667.5 | 1.01 | 677.5 | 1.03 |
| Paldo | | | | | |
| 9 | 1,026.4 | 1,280.6 | 1.25 | 1,503.4 | 1.46 |

Note: The table presents the average observed and counterfactual prices (in KRW) for each of the 11 best-selling products. Marginal costs recovered under the single-product firm scenario are used to predict the equilibrium prices for the Nash-Bertrand and Stackelberg games.

equilibrium prices are even higher than the competitive Nash-Bertrand prices. More specifically, the four firms would have charged prices 3 to 89 percent higher than the observed prices had they adopted Stackelberg leadership.

Finally, we compute each company's counterfactual revenue and variable profit in a given market under each scenario of the Nash-Bertrand and Stackelberg games as:

$$\widehat{R}_c = \sum_{j \in \mathcal{F}_c} p_j s_j(p)\mathcal{M}, \quad \widehat{\Pi}_c = \sum_{j \in \mathcal{F}_c} (p_j - mc_j^1) s_j(p)\mathcal{M},$$

where $p$ is vector of the equilibrium prices under a given firm behavior scenario, and $mc_j^1$ is product $j$'s constant marginal cost recovered under the single-product firm scenario. We aggregate revenues and profits across the six areas and the 12 months of each year to obtain the company's annual revenue and profit. For comparison, we also compute the counterfactual profits under the

Table 8: Revenues and profits under the three firm-behavior scenarios

| Firm behaviors | Manufacturer: Nongshim | Ottogi | Samyang | Paldo | Total |
|---|---|---|---|---|---|
| | *Revenues* | | | | |
| A. Regulated | 886,659 | 139,136 | 51,338 | 95,584 | 1,172,716 |
| B. Nash-Bertrand | 738,791 | 231,957 | 55,167 | 164,046 | 1,189,960 |
| B-A | -147,868 | 92,821 | 3,828 | 68,463 | 17,244 |
| C. Stackelberg | 662,494 | 281,469 | 59,338 | 193,522 | 1,196,822 |
| C-B | -76,297 | 49,512 | 4,172 | 29,475 | 6,862 |
| | *Variable profits* | | | | |
| A. Regulated | 245,741 | 29,759 | 21,736 | 19,576 | 316,811 |
| B. Nash-Bertrand | 307,022 | 60,923 | 29,209 | 35,665 | 432,819 |
| B-A | 61,281 | 31,164 | 7,473 | 16,090 | 116,008 |
| C. Stackelberg | 320,238 | 84,870 | 35,982 | 44,676 | 485,767 |
| C-B | 13,217 | 23,947 | 6,773 | 9,011 | 52,948 |

Note: The table presents the average annual variable profits and revenues (in million KRW) of each firm under the scenarios of single-product firm competition, Nash-Bertrand game, and Stackelberg leadership during the sample period. The analysis considers the 11 top-selling products. Revenues under the single-product firm scenario presented in the first row are the observed revenues.

single-product firm scenario (which we regard as the observed firm behavior under the government regulation).[21]

Table 8 compares the average annual profits and revenues of each firm under the three firm behavior scenarios. While resulting in lower revenue, Nash-Bertrand competition would have led to a 25 percent increase in Nongshim's annual variable profit, from 246 billion KRW to 307 billion KRW (equivalently, from 220 million USD to 274 million USD). As for Ottogi, Samyang, and Paldo, both revenue and variable profit under the Nash-Bertrand competition are higher than those under the government regulation. Adopting Stackelberg leadership would have further increased the market leader's average annual profits to 320 billion KRW (a 4.3 percent increase from the profit under the Nash-Bertrand competition), while the three followers would have gained additional annual profits of 24 billion KRW (a 39 percent increase), 6.8 billion KRW (a 23 percent increase), and 9 billion KRW (a 25 percent increase), respectively. Consequently, the annual profit from the 11 best-selling products would have been more than 50 percent (169 billion KRW or equivalently 150 million US

[21] By construction, revenues under this scenario are the observed revenues.

dollars) higher had firms been engaged in Stackelberg leadership in the absence of government regulation.

## 6 Conclusion

In this study, we evaluate the pricing behaviors of South Korean instant noodle manufacturers, whom the regulatory authority has continuously suspected of collusion. Utilizing instant noodles sales and advertising data acquired from NielsenIQ and Nielsen Media, we first estimate the demand for instant noodles. We employ a random coefficient nested logit framework to explore product substitutability and income effects. Then, we back out markups under three different firm behavior scenarios. Comparing the observed and recovered price-cost margins reveals that it is highly unlikely that the four major instant noodle producers had been engaged in any colluding or price-coordinating behaviors during the sample period. On the contrary, they might have hardly exerted any market power from their dominating market shares to coordinate prices, even across their own products. This finding indicates that governmental price interventions have been severe in this industry.

After providing evidence against the KFTC's suspicions of price-fixing collusion, we investigate the prices that firms might have set had they been engaged in the 'follow-the-leader' pricing, as claimed by the authority. To do so, we develop an empirical framework based on a two-stage Stackelberg price game with differentiated products and compute the equilibrium prices. We find that prices of the 11 best-selling products might have been substantially higher, particularly for Nongshim, the market leader. Moreover, variable profits from the 11 products would have been 50 percent higher if the firms had adopted Stackelberg leadership. All in all, our empirical findings in this study support the ruling of the Supreme Court in 2015, which overturned the KFTC's imposition of fines (approximately 120 million US dollars) on the four major instant noodle producers in 2012.

Our study is subject to several limitations and caveats. First, since we do not observe actual margins, we instead use the gross price-(average variable) cost margins calculated from the aggregate observations of production costs. Although the accounting estimates of the margins can be problematic (Fisher and McGowan, 1983; Nevo, 2001), the gap between them and price-cost margins predicted under the collusion scenario is too large to be attributed to measurement errors. Second, in our counterfactual analysis, we use marginal costs predicted under the single-product firm scenario to simulate the equilibrium prices for both the Nash-Bertrand and Stackelberg games. Again, this is because we do not observe actual marginal costs. Finally, according to industry practitioners, South Korean instant noodles manufacturers have expanded into foreign markets and increased product variety in response to the *de facto* price control by the government. As a result, the export of instant noodles tripled during the sample period (from 157 million US dollars in 2010 to 467 million US dollars in 2019), while domestic grocery sales of ramen remained almost unchanged, hovering around two trillion KRW (approximately 1.8 billion US dollars). Additionally, Figure B4 in Appendix B shows that each firm aggressively launched new brands since the mid-2010s, increasing the total product count by almost 70 percent (from 123 to 206) during the 2010s. While beyond the scope of this paper, considering firm decisions on product offerings and exports, as well as prices, would provide a fuller picture of how firms behave and respond to government interference in this industry.

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# Appendix

## Appendix A: Derivatives of the market share with respect to price

We start with the standard case where there is no price leadership, and then extend the analysis to the case where there is a price leader and other producers are price followers.

### No price leadership

Assume a market $m$ with $J_m$ alternatives. Under our random coefficient nested logit framework, the probability that consumer $i$ in the market selects alternative $r$, $s_{irm}$, can be derived as

$$s_{irm} = \frac{\exp\left(\frac{\alpha_i p_{rm} + \mathbf{x}_{rm}\lambda}{1-\rho}\right)}{\exp\left(\frac{I_{igm}}{1-\rho}\right)} \frac{\exp(I_{igm})}{\exp(I_{im})},$$

where vector $\mathbf{x}_{rm}$ includes product attributes and the error term (the demand shock). The inclusive values $I_{igm}$ and $I_{im}$ are defined as

$$I_{igm} = (1-\rho)\ln\sum_{k=1}^{J_{gm}} \exp\left(\frac{\alpha_i p_k + \mathbf{x}_k\lambda}{1-\rho}\right), \quad I_{im} = \ln\left(1 + \sum_{g=1}^{G} \exp(I_{igm})\right),$$

where $G$ denotes the number of nested product groups. Henceforth, we will suppress the market index $m$ for ease of notation.

Following the standard approach, taking the derivative of $s_{ir}$ with respect to $p_j$ yields

$$\frac{\partial s_{ir}}{\partial p_j} = \alpha_i s_{ir}\left(\frac{1}{1-\rho}D_{r=j} - \frac{\rho}{1-\rho}s_{ij|g}D_{r,j\in g} - s_{ij}\right), \tag{A1}$$

where $s_{ij|g}$ is consumer $i$'s probability of selecting alternative $j$ once the alternative's group is chosen. The dummy variable $D_{r=j}$ equals one if $r = j$, and the dummy variable $D_{r,j\in g}$ equals one if both alternatives belong to the same group $g \in \{1, 2, \ldots, G\}$. In matrix notation, the derivatives are

$$\nabla_p s_i = \begin{bmatrix} \frac{\partial s_{i1}}{\partial p_1} & \frac{\partial s_{i2}}{\partial p_1} & \cdots & \frac{\partial s_{iJ}}{\partial p_1} \\ \frac{\partial s_{i1}}{\partial p_2} & \frac{\partial s_{i2}}{\partial p_2} & \cdots & \frac{\partial s_{iJ}}{\partial p_2} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{\partial s_{i1}}{\partial p_J} & \frac{\partial s_{i2}}{\partial p_J} & \cdots & \frac{\partial s_{iJ}}{\partial p_J} \end{bmatrix}$$

$$= \begin{bmatrix} \alpha_i s_{i1}\left(\frac{1}{1-\rho} - \frac{\rho}{1-\rho}s_{i1|g} - s_{i1}\right) & \alpha_i s_{i2}\left(-\frac{\rho}{1-\rho}s_{i1|g}D_{2,1\in g} - s_{i1}\right) & \cdots & \alpha_i s_{iJ}\left(-\frac{\rho}{1-\rho}s_{i1|g}D_{J,1\in g} - s_{i1}\right) \\ \alpha_i s_{i1}\left(-\frac{\rho}{1-\rho}s_{i2|g}D_{1,2\in g} - s_{i2}\right) & \alpha_i s_{i2}\left(\frac{1}{1-\rho} - \frac{\rho}{1-\rho}s_{i2|g} - s_{i2}\right) & \cdots & \alpha_i s_{iJ}\left(-\frac{\rho}{1-\rho}s_{i2|g}D_{J,2\in g} - s_{i2}\right) \\ \vdots & \vdots & \ddots & \vdots \\ \alpha_i s_{i1}\left(-\frac{\rho}{1-\rho}s_{iJ|g}D_{1,J\in g} - s_{iJ}\right) & \alpha_i s_{i2}\left(-\frac{\rho}{1-\rho}s_{iJ|g}D_{2,J\in g} - s_{iJ}\right) & \cdots & \alpha_i s_{iJ}\left(\frac{1}{1-\rho} - \frac{\rho}{1-\rho}s_{iJ|g} - s_{iJ}\right) \end{bmatrix}$$

Then, for the random coefficients model, the $J \times J$ Jacobian matrix $\nabla_p s \equiv \frac{\partial s}{\partial p'}$ is approximated by

$$\nabla_p s = \frac{1}{ns} \sum_i S_i(p), \tag{A2}$$

where $ns$ denotes the number of draws from a standard normal distribution.

**Price leadership**

Now consider a two-stage Stackelberg price game where the leader moves first and decides how much to charge for its products in the first stage, and then followers set prices simultaneously in the second stage.

The derivative of the individual choice probability with respect to the price of a follower's product follows the equation given by (A1). This holds because followers take the leader's prices as given when setting their own prices. On the other hand, the derivatives for the leader's products require modification. For products $j$ and $r$ owned by the leader, that is, $r, j \in \mathcal{F}_\ell$, the derivative $\frac{\partial s_{ir}}{\partial p_j}$ takes the form:

$$\begin{aligned}
\frac{\partial s_{ir}}{\partial p_j} &= \alpha_i s_{ir} \left( \frac{1}{1-\rho} D_{r=j} - \frac{\rho}{1-\rho} s_{ij|g} D_{r,j\in g} - s_{ij} \right) + \sum_{k \notin \mathcal{F}_\ell} \frac{\partial s_{ir}}{\partial p_k} \frac{\partial p_k}{\partial p_j} \\
&= \alpha_i s_{ir} \left( \frac{1}{1-\rho} D_{r=j} - \frac{\rho}{1-\rho} s_{ij|g} D_{r,j\in g} - s_{ij} \right) \\
&+ \sum_{k \notin \mathcal{F}_\ell} \alpha_i s_{ir} \left( \frac{1}{1-\rho} D_{r=k} - \frac{\rho}{1-\rho} s_{ik|g} D_{r,k\in g} - s_{ik} \right) \frac{\partial p_k}{\partial p_j}
\end{aligned} \tag{A3}$$

where the additional term $\sum_{k \notin \mathcal{F}_\ell} \frac{\partial s_{ir}}{\partial p_k} \frac{\partial p_k}{\partial p_j}$ in the first line of (A3) reflects the fact that the followers set their prices after the leader makes its pricing decision, thereby allowing the leader to influence the followers' pricing.

To derive the gradient $\frac{\partial p_k}{\partial p_j}$ for the price of the leader's product $j$ and the price of a follower's product $k$, we assume that the equilibrium pricing function of a follower's product is smooth with respect to the leader's product prices. Under this assumption, we compute the gradient from the total derivative of the follower's first-order condition as follows.[22]

Without loss of generality, let $j = 1, \cdots, J_1$ and $k = J_1 + 1, \cdots, J$ represent products owned by the leader and followers, respectively. Then, for a follower $f$'s product $k$, the first-order condition is

$$F_k(p_1, \ldots, p_J) \equiv s_k + \sum_{h \in \mathcal{F}_f} (p_h - mc_h) \frac{\partial s_h}{\partial p_k} = 0$$

where $s_k$ and $s_h$ denote the aggregate shares, and $\frac{\partial s_h}{\partial p_k}$ is approximated by (A2).

[22] The differentiability assumption and the approach utilizing the total derivative are similar to those taken in Villas-Boas (2007) and Fan (2013) in different contexts. They assumed that the equilibrium pricing function is smooth with respect to other observed (endogenously chosen) characteristics. To use this approach, we need to rule out the possibility of corner solutions, which we believe are unlikely to occur for optimal prices.

We then construct a system of equations from the total derivatives of the first-order conditions of the followers' products $k = J_1 + 1, \ldots, J$ as

$$\begin{aligned}
\frac{\partial F_{J_1+1}(p_1,\ldots,p_J)}{\partial p_j} + \sum_{k=J_1+1}^{J} \frac{\partial F_{J_1+1}(p_1,\ldots,p_J)}{\partial p_k}\frac{\partial p_k}{\partial p_j} = 0 \\
\frac{\partial F_{J_1+2}(p_1,\ldots,p_J)}{\partial p_j} + \sum_{k=J_1+1}^{J} \frac{\partial F_{J_1+2}(p_1,\ldots,p_J)}{\partial p_k}\frac{\partial p_k}{\partial p_j} = 0 \\
\vdots \\
\frac{\partial F_{J}(p_1,\ldots,p_J)}{\partial p_j} + \sum_{k=J_1+1}^{J} \frac{\partial F_{J}(p_1,\ldots,p_J)}{\partial p_k}\frac{\partial p_k}{\partial p_j} = 0
\end{aligned} \tag{A4}$$

for each product $j$ of the leader. We construct this system of equations under the assumption that the pricing functions $p_{J_1+1}(\cdot), \ldots, p_J(\cdot)$ are smooth with respect to $p_1, \ldots, p_{J_1}$.

Since the above system (A4) has exactly $J - J_1$ equations for the $J - J_1$ gradients $\frac{\partial p_{J_1+1}}{\partial p_j}, \ldots, \frac{\partial p_J}{\partial p_j}$ for each product $j$ of the leader, it can be rewritten as:

$$\begin{pmatrix} \frac{\partial p_{J_1+1}}{\partial p_j} \\ \frac{\partial p_{J_1+2}}{\partial p_j} \\ \vdots \\ \frac{\partial p_J}{\partial p_j} \end{pmatrix} = - \begin{pmatrix} \frac{\partial F_{J_1+1}(p_1,\ldots,p_J)}{\partial p_{J_1+1}} & \cdots & \frac{\partial F_{J_1+1}(p_1,\ldots,p_J)}{\partial p_J} \\ \frac{\partial F_{J_1+2}(p_1,\ldots,p_J)}{\partial p_{J_1+1}} & \cdots & \frac{\partial F_{J_1+2}(p_1,\ldots,p_J)}{\partial p_J} \\ \vdots & \ddots & \vdots \\ \frac{\partial F_J(p_1,\ldots,p_J)}{\partial p_{J_1+1}} & \cdots & \frac{\partial F_J(p_1,\ldots,p_J)}{\partial p_J} \end{pmatrix}^{-1} \begin{pmatrix} \frac{\partial F_{J_1+1}(p_1,\ldots,p_J)}{\partial p_j} \\ \frac{\partial F_{J_1+2}(p_1,\ldots,p_J)}{\partial p_j} \\ \vdots \\ \frac{\partial F_J(p_1,\ldots,p_J)}{\partial p_j}. \end{pmatrix} \tag{A5}$$

from which we obtain all gradients $\left\{\frac{\partial p_k}{\partial p_j}\right\}$ for $j = 1, \ldots, J_1$ and $k = J_1 + 1, \ldots, J$.

We approximate $\frac{\partial F_k(p_1,\ldots,p_J)}{\partial p_j}$ for $j = 1, \ldots, J$ and $k = J_1 + 1, \ldots, J$ in (A5) using a simulator. Note that at the individual-level

$$\begin{aligned}
\frac{\partial F_{ik}(p_1,\ldots,p_J)}{\partial p_k} &= \frac{\partial}{\partial p_k}\left\{ s_{ik} + \sum_{h\in\mathcal{F}_f}(p_h - mc_h)\frac{\partial s_{ih}}{\partial p_k}\right\} \\
&= \frac{\partial s_{ik}}{\partial p_k} + \frac{\partial s_{ik}}{\partial p_k} + \sum_{h\in\mathcal{F}_f}(p_h - mc_h)\frac{\partial^2 s_{ih}}{\partial p_k \partial p_k}
\end{aligned}$$

and

$$\begin{aligned}
\frac{\partial F_{ik}(p_1,\ldots,p_J)}{\partial p_j} &= \frac{\partial}{\partial p_j}\left\{ s_{ik} + \sum_{h\in\mathcal{F}_f}(p_h - mc_h)\frac{\partial s_{ih}}{\partial p_k}\right\} \\
&= \frac{\partial s_{ik}}{\partial p_j} + \sum_{h\in\mathcal{F}_f}(p_h - mc_h)\frac{\partial^2 s_{ih}}{\partial p_j \partial p_k} \text{ for } j \neq k
\end{aligned}$$

where

$$
\begin{aligned}
\frac{\partial^2 s_{ih}}{\partial p_k \partial p_k} &= \frac{\partial}{\partial p_k}\left(\frac{\partial s_{ih}}{\partial p_k}\right) = \frac{\partial}{\partial p_k}\left\{\alpha_i s_{ih}\left(\frac{1}{1-\rho}D_{h=k} - \frac{\rho}{1-\rho}s_{ik|g}D_{h,k\in g} - s_{ik}\right)\right\} \\
&= \alpha_i \frac{\partial s_{ih}}{\partial p_k}\left(\frac{1}{1-\rho}D_{h=k} - \frac{\rho}{1-\rho}s_{ik|g}D_{h,k\in g} - s_{ik}\right) \\
&+ \alpha_i s_{ih}\left(-\frac{\rho}{1-\rho}\frac{\partial s_{ik|g}}{\partial p_k}D_{h,k\in g} - \frac{\partial s_{ik}}{\partial p_k}\right) \\
&= \alpha_i \frac{\partial s_{ih}}{\partial p_k}\left(\frac{1}{1-\rho}D_{h=k} - \frac{\rho}{1-\rho}s_{ik|g}D_{h,k\in g} - s_{ik}\right) \\
&+ \alpha_i s_{ih}\left(-\alpha_i\frac{\rho}{(1-\rho)^2}s_{ik|g}(1-s_{ik|g})D_{h,k\in g} - \frac{\partial s_{ik}}{\partial p_k}\right)
\end{aligned}
$$

and

$$
\begin{aligned}
\frac{\partial^2 s_{ih}}{\partial p_j \partial p_k} &= \frac{\partial}{\partial p_j}\left(\frac{\partial s_{ih}}{\partial p_k}\right) = \frac{\partial}{\partial p_j}\left\{\alpha_i s_{ih}\left(\frac{1}{1-\rho}D_{h=k} - \frac{\rho}{1-\rho}s_{ik|g}D_{h,k\in g} - s_{ik}\right)\right\} \\
&= \alpha_i \frac{\partial s_{ih}}{\partial p_j}\left(\frac{1}{1-\rho}D_{h=k} - \frac{\rho}{1-\rho}s_{ik|g}D_{h,k\in g} - s_{ik}\right) \\
&+ \alpha_i s_{ih}\left(-\frac{\rho}{1-\rho}\frac{\partial s_{ik|g}}{\partial p_j}D_{h,k\in g} - \frac{\partial s_{ik}}{\partial p_j}\right) \\
&= \alpha_i \frac{\partial s_{ih}}{\partial p_j}\left(\frac{1}{1-\rho}D_{h=k} - \frac{\rho}{1-\rho}s_{ik|g}D_{h,k\in g} - s_{ik}\right) \\
&+ \alpha_i s_{ih}\left(\alpha_i\frac{\rho}{(1-\rho)^2}s_{ik|g}s_{ij|g}D_{j,h,k\in g} - \frac{\partial s_{ik}}{\partial p_j}\right) \text{ for } j \neq k.
\end{aligned}
$$

where $\frac{\partial s_{ih}}{\partial p_k}$, $\frac{\partial s_{ik}}{\partial p_k}$, $\frac{\partial s_{ih}}{\partial p_j}$, and $\frac{\partial s_{ik}}{\partial p_j}$ are given by (A1).

Finally, for products $j$ and $r$ owned by the leader, that is, $r, j \in \mathcal{F}_\ell$, the derivative $\frac{\partial s_r}{\partial p_j}$ is approximated using the derivatives in (A3) and a simulator.

## Appendix B: Additional tables and figures

Table B1: Product sales by year

| Year | Top 11 | % | Top 25 | % | All |
|---|---|---|---|---|---|
| | | | *Sales revenue* | | |
| 2010 | 1,141 | 66.3 | 1,362 | 79.1 | 1,722 |
| 2011 | 1,133 | 63.0 | 1,356 | 75.4 | 1,798 |
| 2012 | 1,125 | 59.9 | 1,370 | 72.9 | 1,879 |
| 2013 | 1,182 | 62.8 | 1,499 | 79.6 | 1,883 |
| 2014 | 1,097 | 59.4 | 1,468 | 79.5 | 1,847 |
| 2015 | 1,011 | 53.7 | 1,464 | 77.8 | 1,881 |
| 2016 | 957 | 47.8 | 1,437 | 71.7 | 2,003 |
| 2017 | 1,055 | 52.9 | 1,477 | 74.0 | 1,995 |
| 2018 | 1,094 | 53.6 | 1,544 | 75.6 | 2,042 |
| 2019 | 1,109 | 54.8 | 1,544 | 76.4 | 2,023 |
| | | | *Sales volume* | | |
| 2010 | 1,744 | 69.6 | 2,021 | 80.7 | 2,505 |
| 2011 | 1,751 | 66.9 | 2,030 | 77.6 | 2,615 |
| 2012 | 1,650 | 63.4 | 1,945 | 74.7 | 2,604 |
| 2013 | 1,702 | 65.8 | 2,072 | 80.2 | 2,585 |
| 2014 | 1,595 | 62.9 | 2,024 | 79.8 | 2,537 |
| 2015 | 1,471 | 59.1 | 1,955 | 78.5 | 2,489 |
| 2016 | 1,409 | 55.9 | 1,901 | 75.4 | 2,521 |
| 2017 | 1,490 | 58.3 | 1,946 | 76.1 | 2,556 |
| 2018 | 1,529 | 59.0 | 2,006 | 77.4 | 2,592 |
| 2019 | 1,543 | 59.3 | 2,008 | 77.1 | 2,604 |

Note: The table displays the annual combined sales revenues (in billion KRW) and sales volumes (in 1000 unit) for products analyzed in this study, along with their proportions in the total sales revenues and volumes of the four major producers. Source: NielsenIQ.

Table B2: Observed production costs

| Item | 2005 | | | 2010 | | | 2015 | | | 2020 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M$ | % | % of retail sales | M$ | % | % of retail sales | M$ | % | % of retail sales | M$ | % | % of retail sales |
| Value of Shipments | 1,828 | 100.0 | 80.0 | 2,046 | 100.0 | 80.0 | 2,573 | 100.0 | 80.0 | 2,712 | 100.0 | 80.0 |
| Materials | 1,109 | 60.7 | 48.5 | 1,290 | 63.0 | 50.4 | 1,486 | 57.8 | 46.2 | 1,538 | 56.7 | 45.4 |
| Energy | 12 | 0.7 | 0.5 | 49 | 2.4 | 1.9 | 61 | 2.4 | 1.9 | 71 | 2.6 | 2.1 |
| Labor | 128 | 7.0 | 5.6 | 175 | 8.5 | 6.8 | 223 | 8.7 | 6.9 | 315 | 11.6 | 9.3 |
| Gross Margin | | 31.7 | 25.3 | | 26.0 | 20.8 | | 31.2 | 24.9 | | 29.0 | 23.2 |

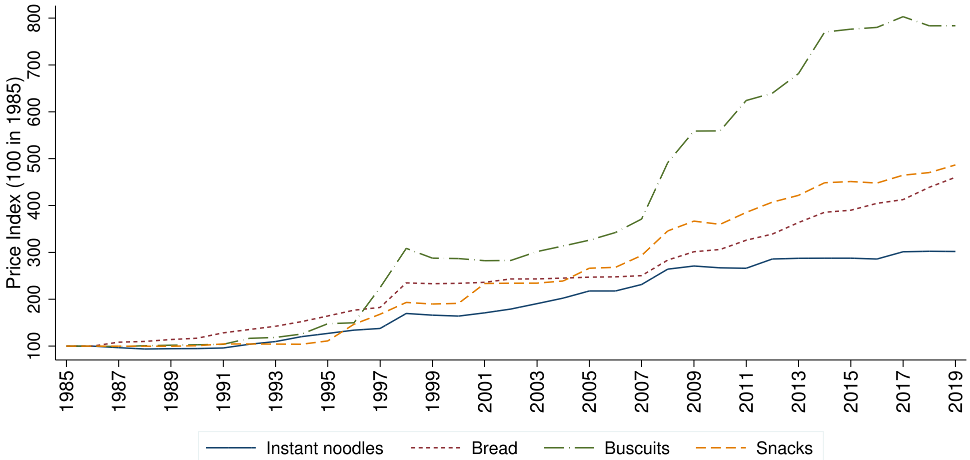
Note: The table presents value of shipments, costs, and gross margins for the “Noodle, Macaroni, and Similar Food Manufacturing” sector. Average exchange rates (1,024.13 KRW/USD in 2005, 1,156.06 KRW/USD in 2010, 1,132.10 KRW/USD in 2015, and 1,180.11 KRW/USD in 2020) are applied to obtain the dollar values. Source: 2005, 2010, 2015, and 2020 Mining and Manufacturing Surveys, Korean Statistical Information Service (KOSIS).

Table B3: Demand estimation results from the sub-sample

| | Logit | | NL | | RCNL | |
|---|---|---|---|---|---|---|
| Utility parameter | Monthly | Quarterly | Monthly | Quarterly | Monthly | Quarterly |
| $\alpha$ | -4.583 | -5.144 | -0.615 | -0.769 | -1.748 | -1.932 |
| | (0.169) | (0.276) | (0.127) | (0.166) | (0.330) | (0.858) |
| $\beta$ | 0.074 | 0.065 | 0.012 | 0.014 | 0.020 | 0.017 |
| | (0.010) | (0.010) | (0.002) | (0.002) | (0.004) | (0.004) |
| $\rho$ | | | 0.955 | 0.905 | 0.814 | 0.813 |
| | | | (0.029) | (0.028) | (0.025) | (0.051) |
| $\sigma$ | | | | | 1.106 | 1.123 |
| | | | | | (0.196) | (0.526) |
| Fixed effects | | | | | | |
| Product | Yes | Yes | Yes | Yes | Yes | Yes |
| Area | Yes | Yes | Yes | Yes | Yes | Yes |
| Time | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 7,920 | 2,640 | 7,920 | 2,640 | 7,920 | 2,640 |

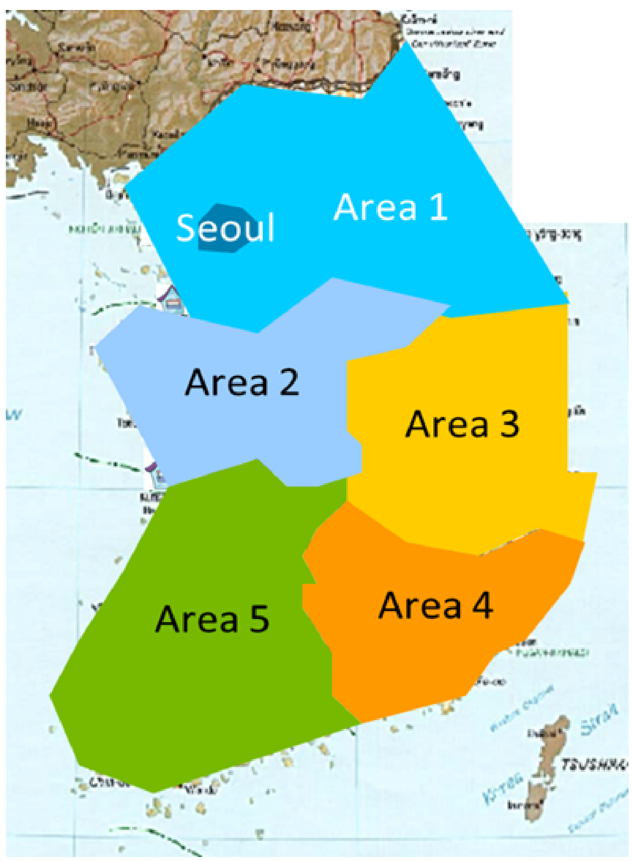
Note: The table presents the Logit (in the first two columns), Nested Logit (in the next two columns) and Random-coefficient Nested Logit (in the last two columns) demand estimates. Each demand model is estimated twice, using month-level and quarter-level sub-samples. The average price of the focal product in other areas, the wheat price multiplied by product size, and product counts in the market are used as instrumental variables. Robust standard errors (clustered by market for the Logit and Nested Logit models) are in parentheses.

Figure B1: Processed food price trends: 1985–2019




Note: The figure plots the price trends for instant noodles, bread, biscuits, and snacks between 1985 and 2019. Source: KOSIS.

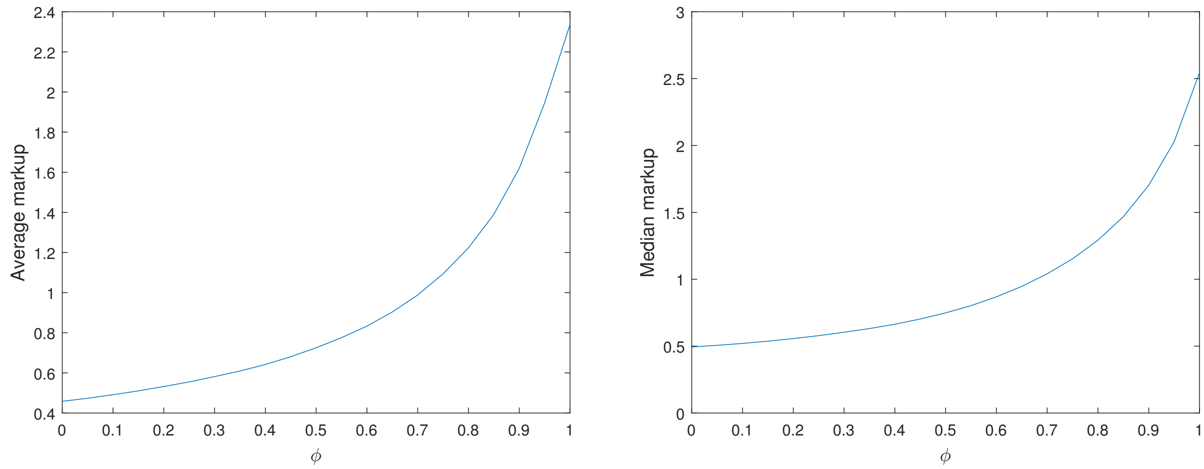
Figure B2: Geographical areas




Note: The figure shows the six geographical areas of South Korea classified by NielsenIQ.

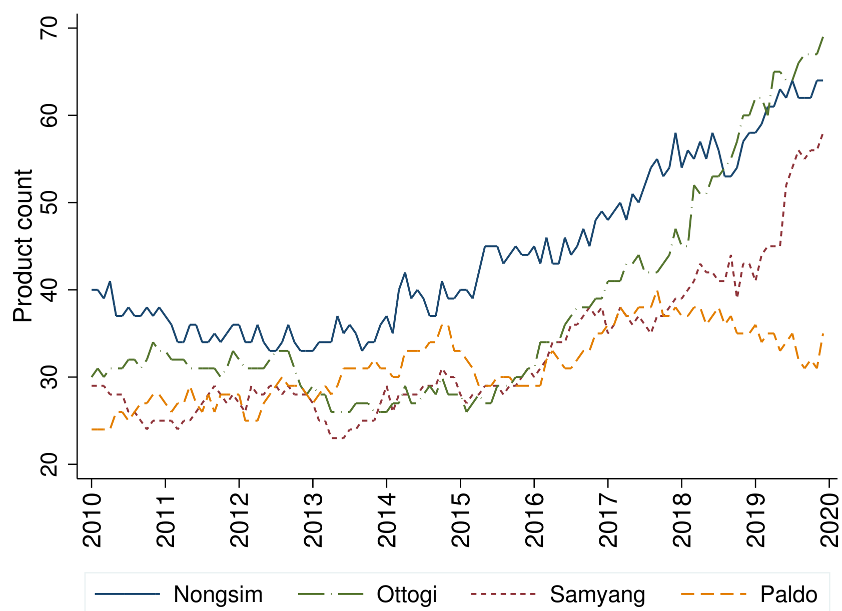
Figure B3: Markups under price coordination

(a) Average markups (b) Median markups




Note: The figure presents average and median markups recovered under different degrees of price-coordination among the four firms ($\phi \in [0, 1]$).

Figure B4: Product variety trends




Note: The figure presents the number of products sold by each of the four firms during the 2010s. Source: KOSIS and AT Food Information Statistic System.