Oligopolistic Competition, Price Rigidity, and Monetary Policy

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Motivations

- Firms' strategic pricing
  - one source of real rigidity: strategic complementarity
    - ★ behind low inflation in Japan
  - departing from monopolistic competition
- Heterogeneity exists
  - competitiveness and pricing
- Contributions
  - Facts: relationships between the competitive environment and price setting
  - Model: the effects of monetary policy

Empirical Contribution

- Relationships between the competitive environment and price setting
- Two sets of data
  - questionnaire survey of firms
  - scanner data from supermarkets
- Examine
  - relationship between aggregated competitive environment indices (HHI) and pricing behavior for each goods category
  - heterogeneous relationship between each firm's market share and pricing behavior within a goods category

Theoretical Contribution

- Duopolistic competition model with sticky prices
  - A macroeconomic extension of address model, as described by Hotelling (1929)
  - Dynamic strategic complementarity
  - Heterogeneous in competitiveness and Calvo-type price stickiness
- Examine the effects of monetary policy

Findings

- Price changes by firms with low market share tend to be
  - less frequent,
  - smaller in size, and
  - have smaller correlations with other firms' price changes.
- The real effect of monetary policy substantially increases
  - because of the dynamic strategic complementarity and
  - asymmetry in price stickiness.

Literature

- Empirical studies on relationships between firms' position and pricing behavior within a sector.
  - Opposite: Berman, Martin, and Mayer (2012) and Amit, Itskhoki, and Konings (2019)
  - Similar: Dias, Dias, and Neves (2004), Fabiani et al. (2006), Jonker, Folkertsma, and Blijenberg (2004)
  - IO: Berle and Means (1932), Stigler and Kindahl (1970), Domberger (1979), Carlton (1986), and Slade (1991)
  - Sector-level competitive environment: Bils and Klenow (2004), Gopinath and Itskhoki (2010) etc
- Macro models incorporating oligopolistic competition and price stickiness
  - Faia (2012), Mongey (2017), Wang and Werning (2020), Ueda (2021)
  - Asymmetry (but not price stickiness), opposite: Atkeson and Burstein (2008) and Wang and Werning (2020)

Empirical Investigations

Questionnaire Survey

- "Questionnaire Survey on Companys' Product Pricing," conducted by the University of Tokyo and Intage Inc.
- Targets: consumer-goods (food, beverages, daily necessities) manufacturing firms that are customers of Intage Inc. and have the top 15 market shares in their respective product categories.
- Specified a product category and asked to indicate a brand name with the largest sales value in the category.
- Mailed in February and asked to return it by March 2020.
- A person in corporate planning or product planning department was asked to answer.
- 176 firms in total

Table: Reasons for Low Price Increase Expectations (Q12)

	No of firms	1 Applicable well	2 Applicable	3 Not very applicable	4 Not at all
(1) Costs are not expected to increase much.	139	1.4	3.6	45.3	49.6
(2) Retailers oppose.	138	33.3	46.4	18.1	2.2
(3) Competitors are unlikely to raise their prices.	139	28.1	54.0	13.7	4.3
(4) Consumers are price sensitive.	139	26.6	54.7	18.0	0.7
(5) Cost-cutting measures can be taken.	139	1.4	11.5	51.8	35.3
(6) Productivity can be improved.	138	2.2	14.5	54.3	29.0
(7) Products can be downsized.	139	1.4	17.3	49.6	31.7
(8) Others	11	72.7	27.3	0.0	0.0

Notes: In the preceding question (Q11), we asked firms,"In five years' time, how do you expect the shipping price of this product to change compared to the current level?" Then, we asked the firms that answered "the increase will be less than 1 percent annually" "What is the reason why you expect that the level of shipping prices will not increase much compared to the current level, or will decrease?" Unit is percent except for the number of firms.

Table: Price Change in Response to Depreciation from December 2012

	(1) Frequency	(2) Size	(3) Frequency	(4) Size
Log(no. of competitors)	0.001	-0.114	-0.207	-1.739
	(0.064)	(0.630)	(0.131)	(1.804)
Market share	0.009*	0.104	0.017**	0.287**
	(0.005)	(0.063)	(0.007)	(0.094)
Constant	0.376	2.835	0.808	4.485
	(0.281)	(2.533)	(0.448)	(5.834)
N	49	49	21	21
Category fixed effect	no	no	yes	yes
No. of categories	–	–	9	9
R2	0.064	0.095	0.627	0.755
Within R2	0.064	0.095	0.322	0.519

Standard errors in parentheses

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

Notes: In Q19, we asked firms, "In response to the depreciation of yen between December 2012 and June 2015, did your firm actually raise the shipping price of this product?" Firms answered the frequency, size, and timing of price changes.

Scanner Data from Retailers

- Retailer-side point-of-sale (POS) scanner data collected by Nikkei Inc.
- March 1, 1988 to December 31, 2019
- Consist of processed food and daily necessities and classified into 218 product categories such as instant cup noodles, tofu, and shampoo.
- Each product and manufacturer (firm) are identified by the Japanese Article Number (JAN) code and the code provided by GS1 Japan.

Market-leading product/firm tends to change prices more frequently

- Identify regular price that is defined as the mode price for 42 days before and after the date
- Calculate the frequency of regular-price changes
- For each category j, run the regression (firm/product i, year y, price up or down X, market share s):

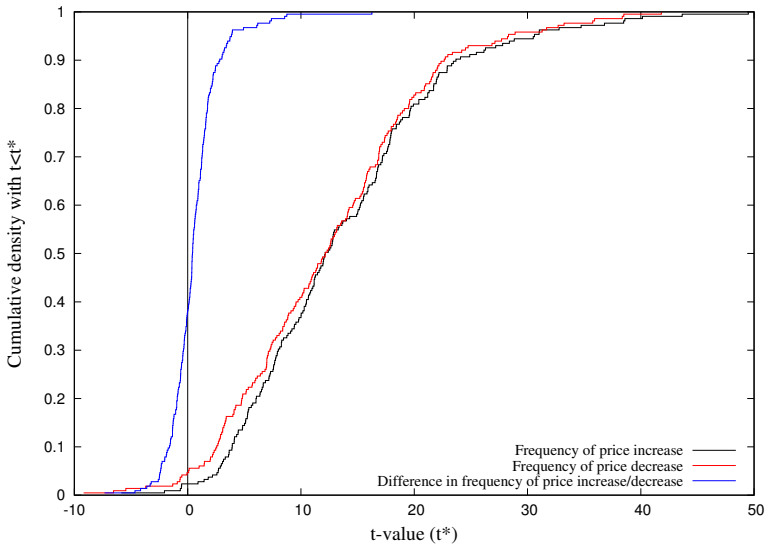
$$fr^X_{ijy} = \alpha \log s_{ijy} + \sum_{y=1}^{31} \beta_y d^{year}_y + \sum_{k=1}^{K-1} m_k d^{firm}_k + \epsilon_{ijy} \tag{1}$$

- Regression by pooling categories:

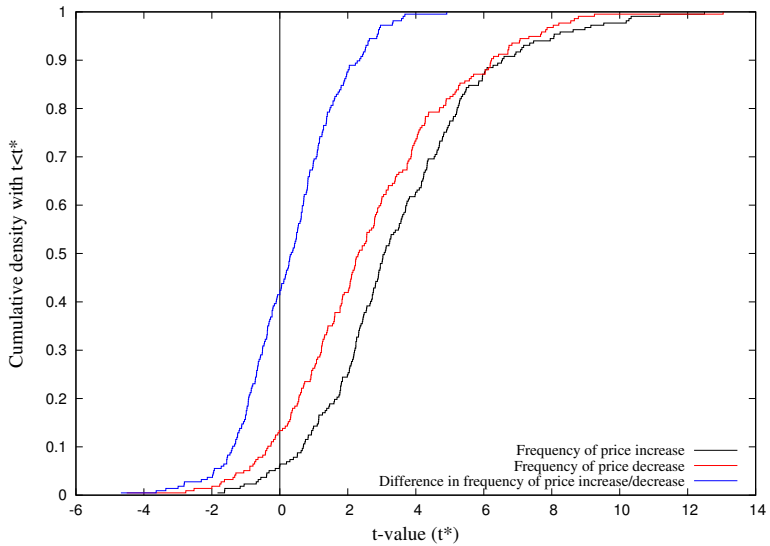
$$fr^X_{ijy} = \alpha \log s_{ijy} + \sum_{y=1}^{31} \beta_y d^{year}_y + \sum_{k=1}^{K-1} m_k d^{year}_k + \sum_{j=1}^{J-1} c_j d^{cat}_j + \gamma HHI_{jy} + \epsilon_{ijy}. \tag{2}$$

Figure: Cumulative Distribution of t-value for the Coefficient on Market Share

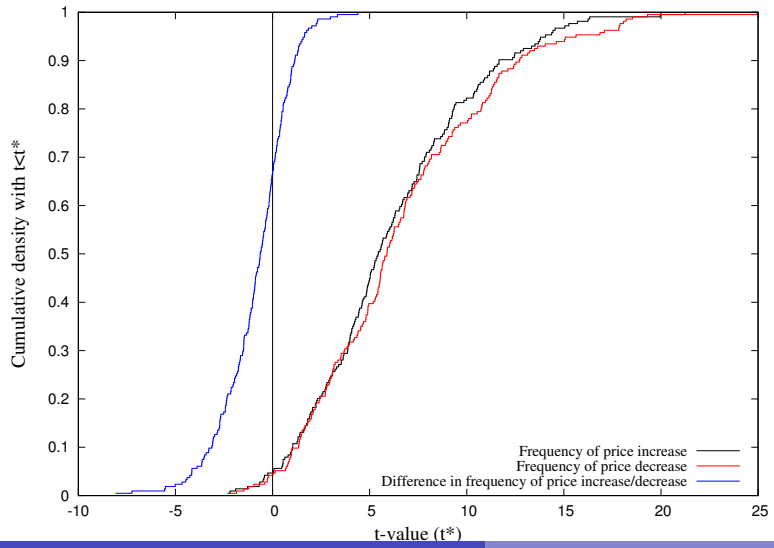
Product level



Firm level



(Top 100 products)



(Top 100 firms)

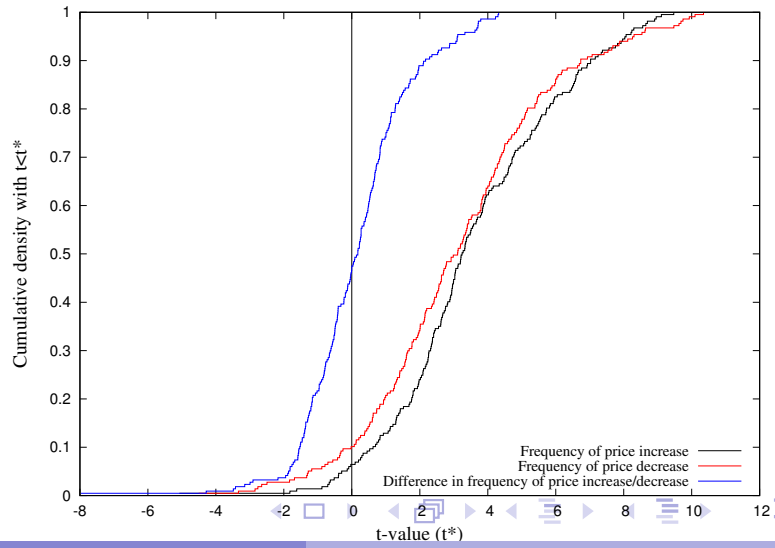


Table: Relationship between the Frequency of Regular-Price Changes and the Competitive Environment

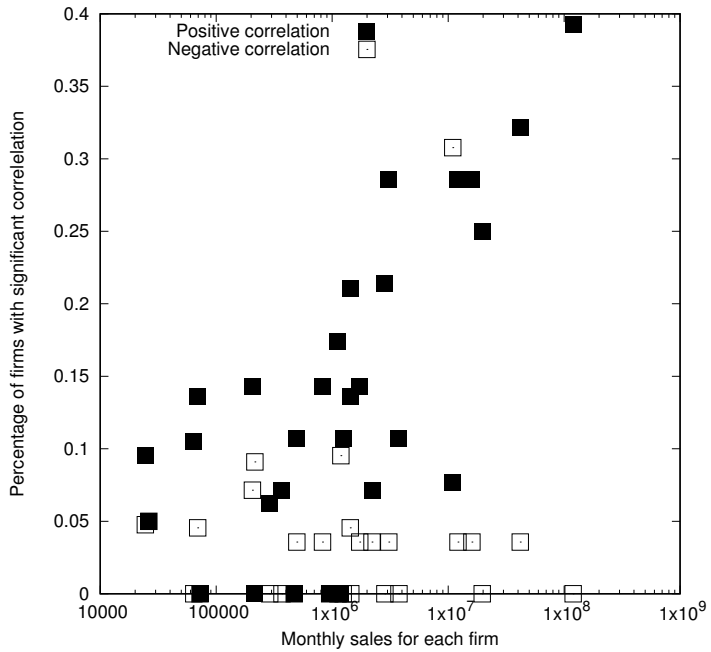
	Frequency of regular price changes:					
	Product level			Firm level		
	fr^+	fr^-	$fr^+ - fr^-$	fr^+	fr^-	$fr^+ - fr^-$
Market share	0.0004***	0.0004***	-0.00005***	0.0002***	0.0002***	0.000007**
	(73.55)	(83.41)	(-10.26)	(70.58)	(57.95)	(2.05)
HHI	0.0005	0.0008**	-0.0003	-0.0005***	-0.0005***	-0.000059
	(1.46)	(2.32)	(-0.94)	(-3.71)	(2.32)	(-0.39)
Observations	262,156	262,156	262,156	323,119	323,119	323,118

Notes: *p<0.1; **p<0.05; ***p<0.01. The values in the parenthesis are the t-values.
Dummies: period, firm, category
Use only data from the top 100 products/firms by (market share × sample period)

Market leader influences rivals' prices (strategic pricing)

- Calculate
  - Spearman's rank correlation for price changes between firm k and l in each product category j.
  - The fraction of firms with the significant correlation at the 5% level.
  - The mean monthly sales of firm k in category j.

Figure: Relationship between Sales and Price-Change Correlation with Other Firms (Instant Cup-Noodle Category)



Notes: The vertical axis represents the fraction of firms with the significant correlations for price changes between a pair of firms.

$$n_{jk}^{+} - n_{jk}^{-} = \alpha \log \overline{s}_{jk} + \sum_{j=1}^{J} c_j d_j + \epsilon_{jk}. \tag{3}$$

Table: Relationship between Sales and Price-Change Correlation with Other Firms

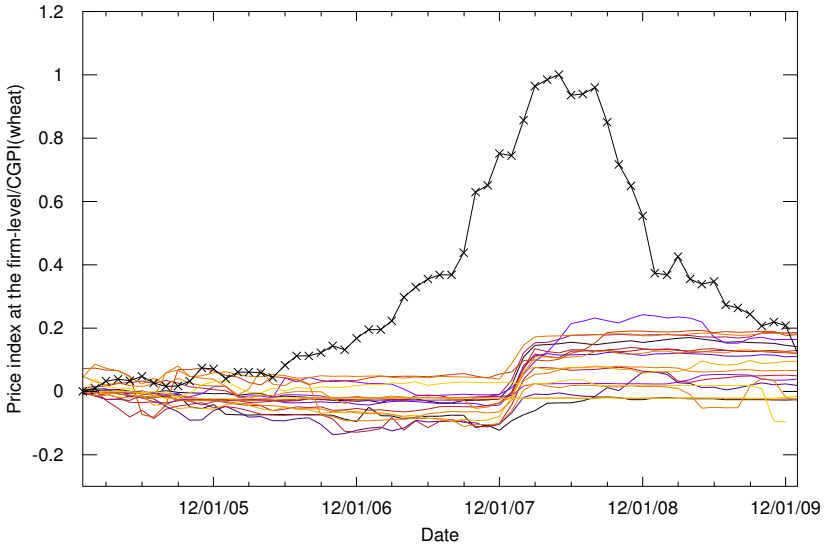
	Dependent variable:
	$n^{+} - n^{-}$
Market share	0.011***
	(34.41)
Observations	18,249
Dummy	category

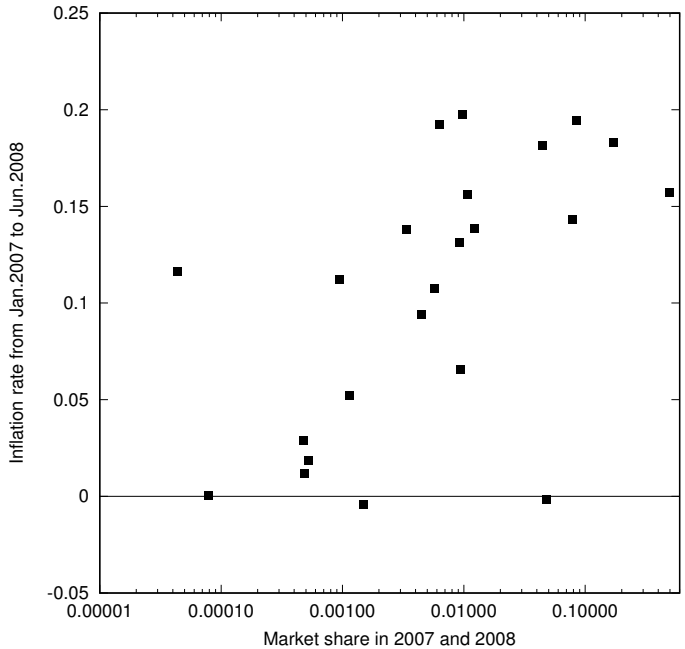
Notes: *p<0.1; **p<0.05; ***p<0.01. The value in the parenthesis is the t-value. For the dependent variable, n^{+} and n^{-} represent the fraction of firms with the significant positive and negative, respectively, Spearman's rank correlations for price changes between a pair of firms.

Price Responses to the Aggregate Shock

- Large firms tend to change its price more frequently and have a greater influence on rival firms' pricing than small firms.
- However, this result may not necessarily imply a difference in their reaction functions to costs.
  - It may arise if costs are idiosyncratic, for example, when costs for large firms are more volatile or change earlier than those for small firms.
- Thus, we investigate how firms' output prices change in response to aggregate shocks and how price responses depend on firms' market share.
  - First, we look at a particular product category, i.e., instant cup noodle, and an event around 2007.
  - Second, we extend the analysis to other product categories and events.

Figure: Changes in the Price Index for Each Cup-Noodle Manufacturer





Notes: In the left-hand panel, each line represent the changes in the price index for each instant cup noodle manufacturer, whereas the line with the cross represents the changes in the wheat price based on the CGPI. Prices changes from December 2004 are shown. The right-hand panel shows the scatter plot, where each dot represents an instant cup noodle manufactuer.

- Extend the previous analysis to other product categories and events.
- Identify category-level shocks and estimate how firms adjusted their prices to the shocks.
  - Calculate the category-level price index for product category j in month m.
  - Use observations from January 2007 to December 2019.
  - Statistically detect the periods of large price changes, $t's$, by the local outlier factor for each category.
  - Pool the set of $t's$.
  - Calculate the price adjustment for firm k in category j over the next twelve months and pool it in all the detected periods and categories.
  - Run the regression

$$\pi_{jkt} = \alpha \log s_{jkt} + \sum_{y=1}^{31} \beta_y d_y^{year} + \sum_{j=1}^{J-1} c_j d_j^{cat} + \gamma HHI_{jy} + \epsilon_{jkt}, \qquad (4)$$

Table: Relationship between Price Increase and the Competitive Environment

	Dependent variable:			
	π	*fr*	π	*fr*
	(1)	(2)	(3)	(4)
Market share	0.071^{**}	0.005^{***}	0.124^{***}	0.005^{***}
	(0.029)	(0.001)	(0.030)	(0.001)
HHI	0.084^{***}	-0.002^{***}	0.447	-0.027^{*}
	(0.015)	(0.001)	(0.462)	(0.016)
Constant	0.019^{***}	0.003^{***}		
	(0.004)	(0.0001)		
Observations	1741	1741	1741	1741
Dummy	No	No	period/category	period/category
Note:				*p<0.1; **p<0.05; ***p<0.01

Two Further Issues

- Changes in Input Prices (Tankan)
- Timing of Announcements on Price Changes
- Both strengthen our estimation results.
  - Large firms respond to shocks more quickly and strongly than small firms.

Table: Dates of Price Increases and Their Annoucements

Category	Date of Price Revision Announcement	Revison	Firm	Market share
Coffee	09-Dec-2004	01-Mar-2005	UCC	
	10-Feb-2005	01-Mar-2005	Key Coffee	
Mayonnaise	08-May-2007	01-Jun-2007	Kewpie	
	29-May-2007	03-Jul-2007	Ajinomoto	
Pasta	02-Aug-2007	01-Sep-2007	Nisshin Foods	
	14-Aug-2007	03-Sep-2007	NIPPN	
Pasta	01-Oct-2007	15-Nov-2007	Nisshin Foods	
	04-Oct-2007	20-Nov-2007	NIPPN	
	06-Oct-2007	20-Nov-2007	Showa Sangyo	
	22-Oct-2007	01-Dec-2007	Hagoromo Foods	
Instant noodle	06-Sep-2007	01-Jan-2008	Nisshin Foods	
	25-Sep-2007	01-Jan-2008	Myojo Foods	
	03-Oct-2007	01-Jan-2008	Toyo Suisan	
	11-Oct-2007	01-Jan-2008	Acecook	
	19-Oct-2007	01-Jan-2008	Maruka Foods	
Pasta	17-Jan-2008	01-Mar-2008	Nisshin Foods	
	24-Jan-2008	01-Mar-2008	NIPPN	
	24-Jan-2008	01-Mar-2008	Showa Sangyo	
	28-Jan-2008	01-Mar-2008	Hagoromo Foods	
Mayonnaise	23-May-2008	01-Aug-2008	Kewpie	
	20-May-2008	23-Jul-2008	Ajinomoto	
	26-Aug-2008	01-Oct-2008	Otafuku Foods	
Potato chips	08-Sep-2008	03-Nov-2008	Calbee	
	25-Sep-2008	17-Nov-2008	Koikeya	
Coffee	27-Dec-2010	01-Mar-2011	Key Coffee	
	25-Jan-2011	10-Mar-2011	UCC	
	08-Feb-2011	01-Apr-2011	Ajinomoto AGF	
Pasta	23-May-2011	01-Jul-2011	Nisshin Foods	
	26-May-2011	01-Jul-2011	Showa Sangyo	
	27-May-2011	01-Jul-2011	NIPPN	
Mayonnaise	08-May-2013	01-Jul-2013	Kewpie	
	20-May-2013	01-Aug-2013	Ajinomoto	
	22-May-2013	01-Jul-2013	Kenko Mayonnaise	
	30-May-2013	01-Aug-2013	SSK Foods	
Pasta	22-Oct-2014	05-Jan-2015	Nisshin Foods	
	30-Oct-2014	05-Jan-2015	NIPPN	
	12-Nov-2014	05-Jan-2015	Showa Sangyo	
	09-Jan-2015	02-Mar-2015	Hagoromo Foods	
Pasta	23-Apr-2015	01-Jul-2015	Nisshin Foods	
	30-Apr-2015	01-Jul-2015	Showa Sangyo	
	01-May-2015	01-Jul-2015	NIPPN	
Chocolate	14-May-2015	07-Jul-2015	Meiji	
	26-May-2015	14-Jul-2015	Morinaga	
	03-Jun-2015	14-Jul-2015	Lotte	
Potato chips	01-Mar-2019	21-May-2019	Calbee	
	06-Mar-2019	01-Jun-2019	Koikeya	
Instant noodle	05-Feb-2019	01-Jun-2019	Nisshin Foods	
	13-Feb-2019	01-Jun-2019	Myojo Foods	
	19-Feb-2019	01-Jun-2019	Toyo Suisan	
	27-Feb-2019	01-Jun-2019	Sanyo Foods	
	27-Feb-2019	01-Jun-2019	House Foods	
	28-Feb-2019	01-Jun-2019	Acecook	
	05-Mar-2019	01-Jun-2019	Maruka Foods	
Pasta	19-May-2021	01-Jul-2021	Nisshin Foods	
	26-May-2021	01-Jul-2021	Showa Sangyo	
	17-Jun-2021	01-Sep-2021	NIPPN	
	14-Jul-2021	01-Sep-2021	Hagoromo Foods	
Mayonnaise	26-Apr-2021	01-Jul-2021	Kewpie	
	28-Apr-2021	01-Jul-2021	Ajinomoto	
	19-May-2021	01-Aug-2021	SSK Foods	
Coffee	08-Jul-2021	01-Sep-2021	UCC	
	03-Aug-2021	01-Oct-2021	Ajinomoto AGF	
	06-Aug-2021	01-Oct-2021	Key Coffee	
	01-Nov-2021	01-Jan-2022	Nestle	
Pasta	25-Oct-2021	04-Jan-2022	Nisshin Foods	
	28-Oct-2021	04-Jan-2022	Showa Sangyo	
	10-Nov-2021	04-Jan-2022	NIPPN	

Theoretical Investigations

Key Features in Price Setting

- Oligopoly
  - strategic
  - not monopoly
- Asymmetry
- How important are they for the macroeconomy?

Model Setup

- Hotelling model
  - A more general model is under construction.
    - ★ Elasticity, superelasticity, and cross elasticity matter.
- Two firms A and B in one sector
  - Produce one unit of product using one unit of labor, which costs nominal wage W_t.
  - Asymmetry in Calvo-type price stickiness θ_A and θ_B (frequency is exogenous)
  - Asymmetry in competitiveness δ and 1
  - The elasticity of substitution across sectors is one.
- A household
  - comprised of an infinite number of consumers, who are located uniformly.
  - They go shopping, consume, and supply labor.
- Monetary authority supplies money.

A head of household maximizes

$$U = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\log C_t - (L_t + \tau D_t) \right],$$

where aggregate consumption C_t and shopping distance D_t are given by

$$\log C = \int_0^1 \log c^j \, dj \quad \text{and} \quad D = \int_0^1 d^j \, dj. \tag{5}$$

Parameter τ is the transport cost incurred per unit of distance.
The budget constraint:

$$M_t + B_t + P_t C_t \leq M_{t-1} + R_{t-1} B_{t-1} + W_t L_t + \Pi_t + T_t, \tag{6}$$

Nominal spending must be equal to the money supply:

$$P_t C_t = M_t \Rightarrow M_t = W_t. \tag{7}$$

Money supply exogenous:

$$\log(M_t / M_{t-1}) = \varepsilon_t = \rho \varepsilon_{t-1} + \mu_t. \tag{8}$$

- Consumers located uniformly at $x \in [0, 1]$
- Firm A and B located at 0 and δ. (symmetric if $\delta = 1$)
- A consumer at x will buy from firm A if

$$\log p^A + \tau x \leq \log p^B + \tau(\delta - x). \tag{9}$$

- Log-linearized optimal reset prices:

$$p_t^{A*} = \Gamma^{AA}\hat{p}_{t-1}^{A} + \Gamma^{AB}\hat{p}_{t-1}^{B} + \Gamma^{A\varepsilon}\varepsilon_t \tag{10}$$

$$p_t^{B*} = \Gamma^{BB}\hat{p}_{t-1}^{B} + \Gamma^{BA}\hat{p}_{t-1}^{A} + \Gamma^{B\varepsilon}\varepsilon_t \tag{11}$$

- Dynamic strategic complementarity if Γ^{AB},$\Gamma^{BA} > 0$ (which we denote by Γ^* later)
- Price rigidity if $\Gamma^{A\varepsilon}$and/or $\Gamma^{B\varepsilon}$ decrease whereas $\Gamma^{AB}, \Gamma^{BA} > 0$

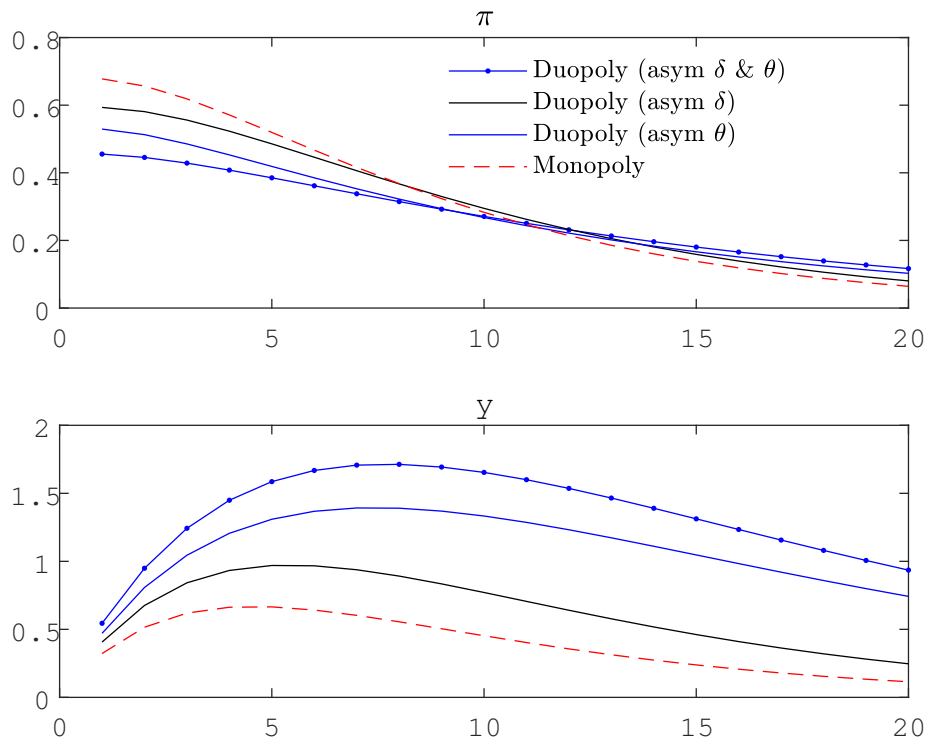
When firm A has a chance to set its price at t, it sets $\bar{p}_t^A$ to maximize

$$\max \sum_{k=0}^{\infty} \theta_A^k \beta^k \mathbb{E}_t \left[\left(1 - \frac{M_{t+k}}{\bar{p}_t^A} \right) \theta_B^{k+1} \left(\frac{\delta - \frac{\log \bar{p}_t^A - \log p_{t-1}^B}{\tau}}{2} \right) \right] \cdot \frac{\Lambda_{t+k}}{\Lambda_t} \frac{P_t}{P_{t+k}} \frac{M_{t+k}}{M_t}$$
$$+ \sum_{k=0}^{\infty} \theta_A^k \beta^k \mathbb{E}_t \left[\left(1 - \frac{M_{t+k}}{\bar{p}_t^A} \right) \sum_{k'=0}^{k} (1 - \theta_B) \theta_B^{k-k'} \left(\frac{\delta - \frac{\log \bar{p}_t^A - \log \bar{p}_{t+k'}^B}{\tau}}{2} \right) \right] \cdot \frac{\Lambda_{t+k}}{\Lambda_t} \frac{P_t}{P_{t+k}} \frac{M_{t+k}}{M_t}. \tag{12}$$

Note that $\bar{p}_t^A$ affects $\bar{p}_{t+k'}^B$ for $k' = 1, 2, \cdots$.
Steady-state price (markup) increases by dynamic strategic complementarity if $\theta > 0$.

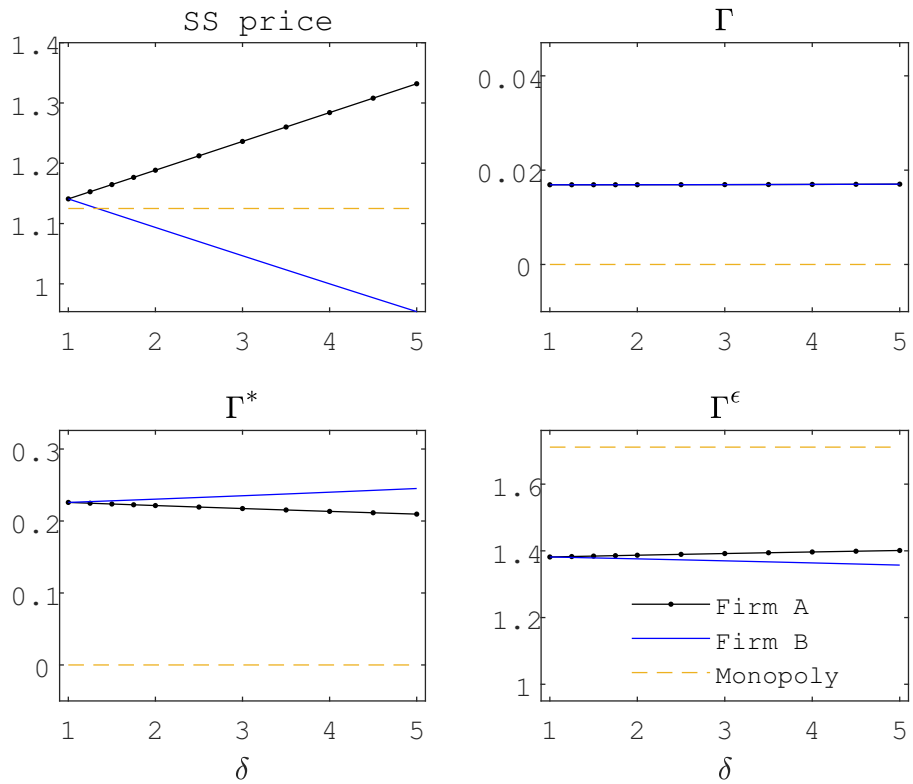
IRF under asymmetry

- Strategic pricing increases price stickiness, amplifying the real effect of monetary policy.
- Asymmetry of price stickiness further increases it.
  - Not in monopolistic competition
- Asymmetry of competitiveness further increases it, although the asymmetry of competitiveness per se hardly matters.



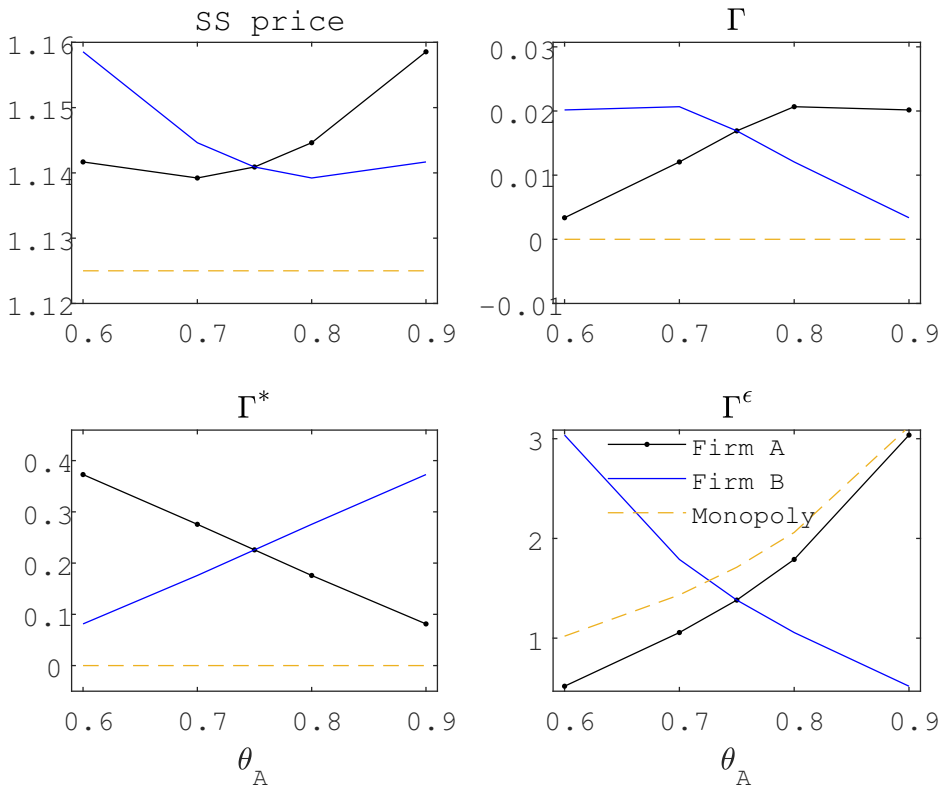
Policy function under asymmetry in competitiveness δ

- Increase in $\delta \rightarrow$ firm A more competitive
- Firm A cares firm B less ($\Gamma^* \downarrow$), while firm B cares firm A more ($\Gamma^* \uparrow$).
- In aggregate, this asymmetry has almost no effect.



Policy function under asymmetry in price stickiness θ

- Change θ^A and θ^B so that $(\theta^A + \theta^B)/2 = 0.75$.
- Low θ^A (more flexible) and high θ^B (stickier)
  - Firm A cares firm B more ($\Gamma^* \uparrow$), while firm B cares firm A less ($\Gamma^* \downarrow$).
    - ★ Firm A makes staggered pricing. Firm B hardly revises price anyway.
  - Gap of Γ^ε between monopoly and firm A increases when θ decreases.
    - ★ Because firm A cares firm B, while firm B does not care firm A much.
  - In aggregate, this asymmetry increases stickiness.



Final Thoughts

- Large firm's pricing
- Competitive
  - Large market share
  - Little need to pay attention to rivals. Aggressive price increase.
- However, low nominal price stickiness
  - When I raise price, rivals may not follow quickly...
  - Greater need to pay attention to rivals. Small price increase.
- In aggregate, nominal stickiness increases.