# Strategic complementarity and asymmetric price setting among firms

Maiko Koga[1], Koichi Yoshino and Tomoya Sakata[2]

## Abstract

Using a large panel of firm survey data from Japan (*Tankan* survey), we provide micro evidence of strategic complementarity in firms' price setting. We find that a firm's price adjustment is affected by its competitors' pricing behaviour and that this adjustment is larger when the firm is lowering its price, which accords with the theoretical predictions of quasi-kinked demand. Our results also indicate that firms with greater pricing power tend to be less sensitive to their competitors' behaviour. Finally, we observe that heightened demand uncertainty mitigates the effect of shifts in demand conditions on the likelihood of price adjustment.

JEL classification: D22, D84, E31, E32.

Keywords: demand uncertainty, firm survey data, price setting, strategic complementarity.

1 Email: maiko.koga.8@gmail.com

2 Bank of Japan. Email: kouichi.yoshino@boj.or.jp; tomoya.sakata@boj.or.jp.

We thank Naohito Abe, Kosuke Aoki, Martin Berka, Andrew Filardo, Hibiki Ichiue, Ryo Jinnai, Naoya Kato, Takushi Kurozumi, Shinsuke Oyama, Toshitaka Sekine,Yosuke Uno and seminar participants at BSP-BIS Conference on "Inflation dynamics in Asia and the Pacific" for their comments and suggestions. The views expressed in this paper are those of the authors and do not necessarily reflect the official views of the Bank of Japan.

# 1. Introduction

Moderate inflation has been a pervasive phenomenon in advanced economies in the past two decades (see, for example, Blanchard et al (2015), IMF (2013)). Japan is often cited as an illustrative case, having struggled with prolonged deflation for a decade and a half. With this in mind, we investigate firms' price-setting behaviour using firm survey data from Japan. Our conjecture is that prolonged deflation may be attributed to firms' asymmetric price setting: firms may refrain from increasing their own prices because their competitors are doing the same. These interactions in pricing attitudes among firms can be described as price setting under a quasi-kinked demand curve. In this setting, theory predicts: (1) a price increase (decrease) by competitors makes it optimal for a firm to increase (decrease) its own price, so that firms' pricing decisions are mutually reinforcing; and (2) firms' reactions to their competitors' prices are asymmetric: they tend to be more responsive to price reductions by competitors than to price rises, and as a consequence, firms are more cautious about decisions to increase prices compared to lowering them.[3] The aim of our paper is to provide micro evidence to support such asymmetric price setting as predicted by the theory.[4]

## Data and main findings

Our firm survey data are from the "Short-term economic survey of enterprises in Japan" run by the Bank of Japan and known as the "*Tankan* survey". This covers approximately 10,000 firms in Japan and boasts excellent quality sampling, achieving a response rate of almost 99% from firms across a wide range of sectors. Results from analysing the data can thus be a reliable source of inference regarding the macroeconomy.

The advantage of the survey is that it allows us to identify competing firms for a given firm, using their reporting about the main products and services. We classify firms into 636 industry categories, which is broadly consistent with the 4-digit industry level in the Japan Standard Industrial Classification.

Using the data, we find the following results. First, we find that firms' price setting responds to their competitors' prices – evidence of strategic complementarity. Although the assumption of strategic complementarity in pricing is standard in the New Keynesian literature (Woodford (2011)), the empirical evidence to support this is scarce. Our study provides micro evidence in this respect. Second, the degree of strategic complementarity is stronger for price decreases. This asymmetry in the reaction to competitors' prices is consistent with the theoretical predictions for firms' price setting under a quasi-kinked demand curve. Third, we find that when firms hold

3 Strategic complementarity also directly affects the slope of the Phillips curve describing the relation between price changes and output; specifically, it acts to weaken this relation. In other words, the greater the degree of strategic complementarity, the less the price responds to an unexpected variation in nominal spending (Woodford (2011)).

4 Our analysis is also motivated by an attempt to identify particular sources of real rigidities. Studies on real rigidities describe persistent real effects being generated from nominal shocks. Levin et al (2008) demonstrate the importance of exploring the mechanisms underpinning these effects, since different mechanisms may lead to different implications for monetary policy even under equivalent New Keynesian Phillips curves. They also argue that utilising micro data reveals insights into the economic structure and implications that could not have been obtained from macroeconomic data alone. We exploit a large set of firm panel data to directly examine the presence and the source of real rigidities at the firm level – that is, the existence of strategic complementarity in pricing.

higher inflation expectations, they are more likely to raise the prices of their own goods. Fourth, by extending our main analysis, we also observe that firms are heterogeneous in their degree of strategic complementarity depending on their market share in an industry. Firms with higher pricing power tend to exhibit less caution in responding to competitors' price changes. Fifth, we find that demand uncertainty also affects pricing. Heightened demand uncertainty mitigates the demand effect on price adjustment probabilities, a phenomenon which we take to be evidence of "wait and see" pricing.

## Related literature

Our study is related to three strands of literature. The first of these is the literature on firms' price-setting behaviour, where current wisdom basically favours state-dependent pricing over time-dependent pricing (eg Klenow and Kryvtsov (2008), Nakamura and Steinsson (2008), Klenow and Malin (2010), Honoré et al (2012)). These studies demonstrate that price setting depends on *aggregate* variables. For example, Honoré et al (2012) find that a rise in inflation encourages firms to increase prices.[5] However, there are few studies exploring whether pricing decisions are dependent on *firm-specific states*. Notable exceptions are Lein (2010) and Amiti et al (2019). Lein (2010) presents evidence from Swiss manufacturing firms that pricing decisions rely on firms' current situations including the cost of intermediate goods. Amiti et al (2019) find that firms react to competitors' price settings using data on Belgian manufacturing firms. Our contribution to the literature is to provide new evidence of the asymmetric reaction of firms to competitors' prices, consistent with expected behaviour under a quasi-kinked demand curve, and to help explain why price increases occur less often than price decreases. This evidence is confirmed across a broad range of industry categories including non-manufacturing firms.

Second, our study is associated with the literature on the kinked demand curve and, more generally, work on variable elasticity of demand. Though constant elasticity of demand is still the most popular setting in macroeconomic models, a growing literature demonstrates that kinked demand, among other forms of variable demand elasticity, is a useful theoretical framework to account for real rigidities in which nominal shocks generate persistent real effects (eg Kimball (1995), Klenow and Willis (2016), Shirota (2015), Kurozumi and Van Zandweghe (2018)). However, micro evidence to support this setting is still limited. A notable exception is Dossche et al (2010), who provide such support using supermarket scanner data for price and quantity at the *goods level*. Our paper contributes to the literature by offering empirical support for the validity of the kinked demand curve theory at the *firm level*.

Third, our study also builds on a growing literature that uses firm survey data to demonstrate how heterogeneous expectations among firms result in diversified behaviour. Bachmann et al (2013) demonstrate that firm-level uncertainty leads to a significant reduction in production using firm survey data from Germany. Using Japanese firm-level data, Koga and Kato (2017) reveal how heterogeneity in firms' expectations regarding industry demand growth affects investment decisions. Tanaka et al (2019) study the relationship between the accuracy of macroeconomic forecasts and firm performance. Morikawa (2016) also demonstrates the negative relationship between subjective uncertainty and investment. In a similar vein, we explore how firms' heterogeneous expectations are reflected in their own pricing decisions.

[5] The authors provide empirical support for the prediction of Ball and Mankiw (1994).

## 2. Description of the survey data

The data we use are from the "Short-term economic survey of enterprises in Japan" (widely known as the *Tankan* survey) conducted by the Bank of Japan. The survey aims to provide an accurate picture of business trends among firms in Japan to support the appropriate implementation of monetary policy. The survey is conducted quarterly, in March, June, September and December, across broad industry categories. The survey population comprises private firms excluding financial institutions in Japan with a capital of JPY 20 million or more, and totals approximately 220,000 such firms. Sample firms are selected from the survey population based on industry and size classifications so as to meet the criteria for statistical accuracy, and the number of sample firms is about 10,000.[6] Firms are classified into 31 industry groups and three size groups. Industry groups are based on the Japan Standard Industrial Classification released by the Ministry of Internal Affairs and Communications. Size groups are based on capital size reported by firms: large enterprises (with capital of JPY 1 billion or more), medium-sized enterprises (with more than JPY 100 million but less than JPY 1 billion in capital), and small enterprises (with more than JPY 20 million in capital, but less than JPY 100 million).

Firms report assessments of 10 items including business conditions, employment conditions, demand conditions in each industry, changes in output prices, and changes in input prices. Answers are provided for two horizons: for the current quarter and the next quarter. They also report annual projections for sales, profits, fixed investment and so forth. The items on which we focus in this paper are firms' assessments of pricing attitude and related factors. In the question on pricing attitude, firms are required to choose from three possible responses: rise, unchanged and fall, and allocated scores for each response are 1, 0 and –1, respectively.

In addition, we adopt items that we presume reflect real marginal cost: namely, firms' views of changes in input price $\left(Cost_{i,t}\right)$ and changes in employment conditions $\left(LC_{i,t}\right)$. We use employment conditions to represent labour costs on the assumption that firms answering "excessive employment" tend to face lower labour costs. $Demand_{i,t}$ constitutes the demand conditions reported by firms in each industry.

Competitors' prices for each firm $ComPrice_{i,t-1}$ are calculated from the survey responses by computing the average score of the pricing attitudes of $N-1$ other firms in the same industry (excluding firm $j$ itself). We then take this figure to capture pricing attitudes of firm $j's$ competitors: that is, $dp_{-i,t} = \sum_{j \neq i,t} dp_{j,t}/(N-1)$. We then use the one-period lag of competitors' prices $ComPrice_{i,t-1}$ in our estimation. To identify the competitors for a given firm, we produce 636 specific industry categories based on firms' reporting about their main business products and services. This classification is broadly consistent with the four-digit industry level in the Japan Standard Industrial Classification.[7] When we compute the variable for competitors' prices, we use a one-period lag of competitors' prices $ComPrice_{i,t-1}$ as the explanatory variable for desired price at time $t$ to mitigate the endogeneity issue, assuming that firms react to competitors' prices one quarter later. As we cannot

[6] As a large number of sample firms are added in regular revisions conducted at three- to five-year intervals, our original data set is an unbalanced panel covering approximately 14,000 firms. The number of firms we use in the analysis is trimmed down to about 10,000 by computing the variable for competitors' prices, as explained later.

[7] The average number of competitors per industry is 12.78.

define competitors' prices for firms with no competitor in their market, such firms are excluded from the estimation.[8]

## 3. Empirical specification

Dotsey and King (2005) model the price-setting behaviour of firms under the quasi-kinked demand curve theory proposed by Kimball (1995).[9] The theoretical predictions derived from the model are as follows: (1) each firm's desired price depends on firm-specific states including its competitors' prices, real marginal costs, and demand; (2) the desired price is also affected by the aggregate inflation rate; and (3) the effect of competitors' prices is stronger for price reductions than for price increases. The aim of this paper is to examine the above predictions using a large panel of firm survey data.

To test the above theoretical predictions, we use survey responses to capture firms' pricing attitude. We model the relationship between $P^*_{i,t}$ and $PriceChange_{i,t}$ as in a limited dependent variable model, where $P^*_{i,t}$ is a latent variable describing changing prices, and we only observe $PriceChange_{i,t}$, which is a qualitative response on firms' pricing stances. When $P^*_{i,t}$ exceeds the threshold $\theta_2$, firms report a price increase; when $P^*_{i,t}$ drops below $\theta_1$, they report a decrease; in all other cases, they report that prices are unchanged.[10]

$$Price_{i,t} = \begin{cases} 1 \text{ if } \theta_2 \leq P^*_{i,t}\ (Increase) \\ -1 \text{ if } P^*_{i,t} < \theta_1\ (Decrease) \\ 0 \text{ if } \theta_1 \leq P^*_{i,t} < \theta_2\ (Unchanged) \end{cases}$$

We assume that the desired price is determined in the following way:

$$P^*_{i,t} = \beta_1 Cost_{i,t} + \beta_2 LC_{i,t} + \beta_3 Demand_{i,t} + \beta_4 ComPrice_{i,t-1} + \gamma_1 x_i + \gamma_2 y_t + \epsilon_{i,t},$$

where $P^*_{i,t}$ is the desired price. $Cost_{i,t}$ and $LC_{i,t}$ are variables representing the cost of intermediate goods and the cost of labour, respectively. We regard these variables as reflecting real marginal cost. $Demand_{i,t}$ describes the demand conditions reported by firms in each industry. All of the above variables are obtained from the survey responses, and take one of three possible values: 1, 0 or –1.

The variable for competitors' prices, $ComPrice_{i,t-1}$, is calculated from the survey responses as explained in the previous section.[11] Amiti et al (2019) address the

8 The number of sample firms in this paper is trimmed down to about 10,000 firms. This sample covers 72.7% of the original survey data in terms of the number of firms and 95.7% on a sales basis as of March 2015.

9 Koga et al (2019) derive the linear relations among the variables, since Dotsey and King (2005) do not explicitly show how each firm's desired price is affected by relevant factors in a linearised form.

10 We describe response categories as "Increase", "Decrease" and "Unchanged", while the original categories are "Rise", "Fall" and "Unchanged".

11 The use of the one-period lag relies on the assumption that firms react to competitors' prices one quarter later. This specification does not fully measure the effect of competitors' prices, since we do not capture faster or slower reactions to others' price changes. Thus, the effect that we estimate for competitors' prices may be considered a lower bound for observable relations among competing firms.

endogeneity issue by estimating the model with instrumental variables. They use imported components of the firm's cost as an instrumental variable for competitors' prices. In our analysis, as we do not have a suitable candidate for instrumental variables, we use the one-period lag of competitors' prices. Inflation expectations $\left(EInflation_{i,t}^{l_{yys}}\right)$ affect the desired price in our setting. However, as inflation data are only available from 2014, we omit this variable in the benchmark case of our estimation and add it later with a more restricted sample. $x_i$ is the vector of firm-specific variables. As there may be industry-specific or size-specific factors that affect not only firms' pricing attitudes but also cost and demand factors, $x_i$ includes industry dummies for the 31 industry categories and size dummies for the three capital size categories.

$y_t$ includes fixed effects for the year and two additional dummies to control for the effects of specific aggregate shocks such as the Great Financial Crisis (Q3 2008–Q1 2009) and the consumption tax increase (Q2 2014). The estimation is conducted for the period from Q1 2004 to Q4 2017. As a large sample revision was carried out in Q1 2004, the quality of the estimation might be impaired if we used older historical data. In robustness checks, we also consider whether there is a time-dependent pricing factor by adding Taylor dummies. These are dummy variables that denote when the last price change occurred, between one and eight quarters ago. Quarter dummies are also added to control for price changes occurring in a specific quarter. Our main results are robust to these controls for time dependency, as shown in Appendix Tables 1 and 2 of Koga et al (2019).[12]

# 4. Main results

## Baseline

This section describes the main results. All tables report average marginal effects. Standard errors are clustered at the firm level. Table 1 shows the regression results for price changes. The dependent variable is $PriceChange_{i,t}$ and the estimation is conducted by the ordered probit model.[13]

Variations in columns give the results for alternative measures of marginal costs. Columns (1) and (2) show the results using firms' responses for current input prices and forecast input prices, respectively; column (3) shows the results when using both. Column (4) shows the results of the correlated random effect model that controls for firm-specific heterogeneity, using historical averages of independent variables for each firm.[14] The results listed in column (1) are regarded as the benchmark case hereafter.[15]

12 Appendix Tables 1 and 2 are not reported here, and are available in the working paper version of our paper (Koga et al (2019)).

13 The dependent variable, $PriceChange_{i,t}$, takes the values of 1 (increase), 0 (unchanged) and –1 (decrease).

14 The correlated random effect model works as a robustness check when firm fixed effects cannot be controlled for in the probit model. A detailed explanation is provided in Wooldridge (2011).

15 When we use both current and forecast input price choices simultaneously, the coefficient on the latter is negative. This may reflect the correlation between current and forecast input prices. A similar result is found in Lein (2010).

The coefficient on current input price is significantly positive in all cases. The coefficient on employment conditions is significantly negative, suggesting that higher labour costs also push up the probability of a price change. The demand factor also contributes to the likelihood of price changes. Even after controlling for these factors, however, competitors' prices are positively correlated with the firm's pricing stance. Coefficients on all of these variables are statistically significant.

As for the magnitude of the impact, the estimates suggest that when average scores of input prices and competitors' prices show a one-unit increase, the probability of an adjustment in output prices is about 8 and 10 percentage points higher, respectively.

Baseline results — Table 1

| | | Price changes | | | |
|---|---|---|---|---|---|
| Sample period: Q1 2004～Q4 2017 | | (1) | (2) | (3) | (4) |
| $\mathrm{Cost}_t$ | (+) | 0.080*** | | 0.084*** | 0.081*** |
| | | (0.002) | | (0.002) | (0.002) |
| $\mathrm{LC}_t$ | (−) | −0.015*** | | −0.009*** | −0.015*** |
| | | (0.001) | | (0.001) | (0.001) |
| $\mathrm{E}_t(\mathrm{Cost}_{t+1})$ | (+) | | 0.038*** | −0.008*** | |
| | | | (0.001) | (0.001) | |
| $\mathrm{E}_t(\mathrm{LC}_{t+1})$ | (+) | | −0.015*** | −0.009*** | |
| | | | (0.001) | (0.001) | |
| $\mathrm{Demand}_t$ | | 0.042*** | 0.046*** | 0.042*** | 0.041*** |
| | | (0.001) | (0.001) | (0.001) | (0.001) |
| $\mathrm{ComPrice}_{t-1}$ | (+) | 0.099*** | 0.117*** | 0.099*** | 0.100*** |
| | | (0.003) | (0.003) | (0.003) | (0.003) |
| Dummy: Great Financial Crisis | | −0.005*** | −0.006*** | −0.005*** | −0.005*** |
| | | (0.001) | (0.001) | (0.001) | (0.001) |
| Dummy: Consumption tax | | 0.001 | 0.003** | 0.001 | 0.001 |
| | | (0.001) | (0.002) | (0.001) | (0.001) |
| Adjusted pseudo R-squared | | 0.136 | 0.117 | 0.136 | 0.133 |
| Observations | | 409,736 | 409,736 | 409,736 | 409,736 |
| Number of IDs | | 10,300 | 10,300 | 10,300 | 10,300 |
| Size fixed effect | | Yes | Yes | Yes | Yes |
| Industry fixed effect | | Yes | Yes | Yes | Yes |
| Year fixed effect | | Yes | Yes | Yes | Yes |
| Correlated random effect | | No | No | No | Yes |

Note: Standard errors in parentheses. *, **, *** denote significance at the 10%, 5%, and 1% levels, respectively.

## Asymmetry

Table 2 shows the results for asymmetric price setting, based on subsamples of firms reporting, respectively, price increases and price decreases, and the estimation is conducted utilising the probit model.[16] In this specification, the expected signs are reversed in the two halves of the table. For example, an increase in input price pushes up the probability that a firm raises its price, and pushes down the probability of a price reduction. According to our theoretical setup in the previous section, a firm is expected to react asymmetrically to competitors' prices. The empirical results bear out this prediction. The most substantial difference is observed in the average marginal effects of competitors' prices, and the effect of a price decrease is more than double in absolute value the effect of a price increase. These results support the premises of price setting under a quasi-kinked demand curve.[17]

Results: asymmetry — Table 2

| 1: increase (decrease)<br>0: otherwise | | Price increases | | Price decreases | |
|---|---|---|---|---|---|
| Q1 2004～Q4 2017 | | (1) | (2) | (3) | (4) |
| $\mathrm{Cost}_t$ | (+) | 0.095*** | 0.095*** | –0.070*** | –0.072*** |
| | | (0.002) | (0.002) | (0.002) | (0.003) |
| $\mathrm{LC}_t$ | (−) | –0.009*** | –0.009*** | 0.030*** | 0.030*** |
| | | (0.001) | (0.001) | (0.002) | (0.002) |
| $\mathrm{Demand}_t$ | | 0.020*** | 0.021*** | –0.085*** | –0.083*** |
| | | (0.001) | (0.001) | (0.002) | (0.002) |
| $\mathrm{ComPrice}_{t-1}$ | (+) | 0.067*** | 0.067*** | –0.149*** | –0.150*** |
| | | (0.002) | (0.002) | (0.005) | (0.005) |
| Dummy: Great Financial Crisis | | 0.008*** | 0.008*** | 0.013*** | 0.013*** |
| | | (0.002) | (0.002) | (0.003) | (0.003) |
| Dummy: Consumption tax | | 0.001 | 0.001 | 0.006 | 0.006 |
| | | (0.002) | (0.002) | (0.004) | (0.004) |
| Adjusted pseudo R-squared | | 0.152 | 0.152 | 0.184 | 0.224 |
| Observations | | 409,736 | 409,736 | 409,736 | 409,736 |
| Number of IDs | | 10,300 | 10,300 | 10,300 | 10,300 |
| Size fixed effect | | Yes | Yes | Yes | Yes |
| Industry fixed effect | | Yes | Yes | Yes | Yes |
| Year fixed effect | | Yes | Yes | Yes | Yes |
| Correlated random effect | | No | Yes | No | Yes |

Note: Standard errors in parentheses. *, **, *** denote significance at the 10%, 5%, and 1% levels, respectively.

Empirically, a similar asymmetry shows up also for labour costs and demand. The absolute values of the coefficients on $LC_{i,t}$ and $Demand_{i,t}$ are larger for price decreases than for price increases. This is broadly consistent with the implications of the quasi-kinked demand curve: when firms face higher labour costs or demand and

16 In the price increase (decrease) case, the dependent variable $PriceIncrease_t(PriceDecrease_t)$ takes the value of 1 when a firm reports a price increase (decrease) and 0 otherwise.

17 The results may be sensitive to the difference in the respective numbers of observations for price increases and decreases. By randomly deselecting observations from the price decrease subsample, we confirm that the main results remain unaltered when the number of observations in each subsample is the same.

their prices are likely to be higher than those of other firms, they refrain from adjusting their prices upwards to avoid the large concomitant profit loss. As for intermediate good cost factors, these do not exhibit such asymmetry and the differences in the coefficients on price increases and decreases are relatively small.[18] This may be the result of cost shocks common to rival firms. In a kinked-demand framework, shifts in demand following changes in relative prices are the source of asymmetric price setting. When firms face a common cost increase, it is unlikely to induce relative price changes, and consequently they do not exhibit asymmetric pricing.

When we add the Taylor dummy variables to control for time-dependent pricing, the above results remain unchanged (see Koga et al (2019) Appendix Tables 1 and 2).

### Inflation expectation[19]

Next, we examine the connection between firms' inflation expectations and their price-setting stance. Unlike previous studies exploring the relation between expected price changes in firms' own goods markets and their price setting (eg Boneva et al (2016)), our focus is on how firms' expectations regarding general inflation affect their price setting, and whether these effects vary depending on the direction of the price change and the time horizon. The results are shown in Koga et al (2019), who report the positive association between firms' inflation expectations and their pricing attitude.

## 5. Extensions

In this section, we further investigate heterogeneity in strategic complementarity in pricing by extending the analysis to include market structure, and examine the effect of demand uncertainty on firms' price setting. The results are not shown here due to space constraints, and are reported in Koga et al (2019).

### Strategic complementarity and market structure

The effect of strategic complementarity on pricing may differ across markets. Our conjecture is that when firms' pricing power is stronger, they can set their prices without needing to worry about competitors' prices.[20] We add an interaction term for market share and competitors' prices to examine this hypothesis. The market share of each firm is calculated based on annual sales volume as reported in the survey.

[18] The existing studies demonstrate that prices tend to respond faster to input increases than to decreases in various markets (eg Peltzman (2000), Loupias and Sevestre (2013)).

[19] Since the first quarter of 2014, The *Tankan* survey has been collecting firms' assessments of the inflation outlook for both general prices and the output prices of their own products or services; it is the former item which we use in this paper. Firms are asked how general prices will have changed relative to current levels one year, three years and five years ahead on an annual basis. They choose from an incremental series of 1% inflation ranges, starting at –3% and going up to +6%. We replace each inflation range with its midpoint and label this variable $EInflation_{i,t}^{l_{yY(s)}}$ ($l$=1, 3 and 5).

[20] Amiti et al (2019) present a model where the price elasticity of demand depends on market share, and argue that strategic complementarity is stronger when a firm's market share is larger.

Our estimation results show that the coefficient on the interaction term for competitors' prices and market share is significantly negative, suggesting that firms with a high market share do not care greatly about their competitors' pricing stance. The estimates suggest that a 10% higher market share means around 3–4 percentage points less impact from competitors' prices on average. As an alternative approach, we replace market share with the market concentration ratio computed using the Herfindahl-Hirschman Index for 636 industry categories, thus capturing the degree of competition at the industry level. Firms in monopolistic industries show a reduced sensitivity to competitors' prices relative to those in competitive industries. In addition to the interaction term, the independent market share and market concentration ratio terms also have negative coefficients, reflecting the fact that firms with higher pricing power or in a monopolistic industry are likely to adjust their prices less often.

### Demand uncertainty

We now turn to the question of whether heightened demand uncertainty affects the probability of changing output prices.

We examine the impact of uncertainty on a firm's price-setting behaviour in the manner employed in Bachmann et al (2013) and Bachmann et al (2019). As our data set contains firms' responses to demand changes in both the preceding quarter and the following quarter, we can compute the measure of subjective uncertainty as in their studies. We calculate the difference between the expected demand change in the current period and the realised demand change in the next period, ie the forecast error, and take absolute values. Our interest is in whether firms' price-setting behaviour is affected by uncertainty regarding demand in the next quarter.

Our results show that uncertainty makes price adjustment by firms more likely. This finding is consistent with the existing studies. In addition, we also examine whether demand uncertainty has a significant impact on the responsiveness of firms' price setting to shifts in demand conditions. The results show that when firms face uncertainty the impact of shifts in demand on price setting is reduced. In other words, under uncertainty, they are reluctant to adjust their prices, even when demand conditions change.

Our findings, therefore, broadly confirm the results of the previous studies, but they also extend these to provide new evidence of "wait and see" pricing in the case of demand uncertainty.

## 6. Conclusions

Using a large panel of firm survey data from Japan, we examine firms' price-setting behaviour. Our paper contributes to the existing literature by providing micro evidence for firms' price setting under a quasi-kinked demand curve. Under such a mechanism, pricing decisions by firms are mutually reinforcing, and firms tend to be cautious about raising their prices. Specifically, we find the following results. First, we find evidence for strategic complementarity in firms' price setting across broad sectors. Second, firms' reactions to their competitors' prices are asymmetric depending on the direction of price adjustment, in accordance with the theoretical predictions of the quasi-kinked demand curve setting. Specifically, they tend to be more responsive to price reductions by competitors than to price rises. Third, we find a positive relationship between the inflation expectations of firms and the probability of them increasing prices. Fourth, the degree of strategic complementarity differs across firms: firms with greater pricing power are likely to care less about competitors' prices. Fifth, heightened demand uncertainty promotes price adjustment by firms, and also mitigates the effect of shifts in demand conditions on the likelihood of price adjustment.

Our findings provide implications for a prolonged deflation that Japan has experienced. Strategic complementarity in pricing is one explanation for firms' cautious stance: firms refrain from increasing their own prices because their competitors are doing the same. This caution may be left behind once some firms start to adjust their prices upwards, as interactive pricing behaviour reinforces the upward adjustment. In addition, our results suggest that encouraging firms to expect higher inflation acts to break them out of their conservatism towards price adjustment.

# References

Amiti, M, O Itskhoki and J Konings (2019): "International shocks, variable markups, and domestic prices", *The Review of Economic Studies*, vol 86, no 6, November, pp 356–402.

Bachmann, R, B Born, S Elstner and C Grimme (2019): "Time-varying business volatility and the price setting of firms", *Journal of Monetary Economics*, vol 101, January, pp 82−99.

Bachmann, R, S Elstner and E Sims (2013): "Uncertainty and economic activity: evidence from business survey data", *American Economic Journal: Macroeconomics*, vol 5, no 2, April, pp 217−49.

Ball, L, and N G Mankiw (1994): "Asymmetric price adjustment and economic

fluctuations", *The Economic Journal*, vol 104, no 423, pp.247-261.

Blanchard, O, E Cerutti and L Summers (2015): "Inflation and activity – two explorations and their monetary policy implications", *NBER Working Paper Series*, no 21726, November.

Boneva, L, J Cloyne, M Weale and T Wieladek (2016): "Firms' expectations and price-setting: evidence from micro data", *Bank of England External MPC Unit Discussion Paper,* no 48, August.

Dossche, M, F Heylen and D Van den Poel (2010): "The kinked demand curve and price rigidity: evidence from scanner data", *Scandinavian Journal of Economics*, vol 112, no 4, December, pp 723−52.

Dotsey, M and R King (2005): "Implications of state-dependent pricing for dynamic macroeconomic models", *Journal of Monetary Economics*, vol 52, no 1, January, pp 213−42.

Honoré, B, D Kaufmann and S Lein (2012): "Asymmetries in price-setting behaviour: new microeconometric evidence from Switzerland", *Journal of Money, Credit and Banking*, vol 44, no s2, December, pp 211−36.

International Monetary Fund (2013): "The dog that didn't bark: has inflation been muzzled or was it just sleeping?", *World Economic Outlook*, April.

Kimball, M (1995): "The quantitative analytics of the basic neomonetarist model", *Journal of Money, Credit and Banking*, vol 27, no 4, pp 1241−77.

Klenow, P and B Malin (2010): "Microeconomic evidence on price-setting", in B Friedland and M Woodford (eds), *Handbook of Monetary Economics*, vol 3, pp 231−84, Elsevier.

Klenow, P and O Kryvtsov (2008): "State-dependent or time-dependent pricing: Does it matter for recent US inflation? " *The Quarterly Journal of Economics,* vol 123, no 3, pp 863-904.

Klenow, P and J Willis (2016): "Real rigidities and nominal price changes", *Economica*, vol 83, no 331, July, pp 443−72.

Koga, M and H Kato (2017): "Behavioural biases in firms' growth expectations", *Bank of Japan Working Paper Series*, no 17-E-9, July.

Koga, M, K Yoshino and T Sakata (2019): "Strategic complementarity and asymmetric price setting among firms", *Bank of Japan Working Paper Series*, no 19-E-5, March.

Kurozumi, T and W Van Zandweghe (2018): "Variable elasticity demand and inflation persistence", *Federal Reserve Bank of Kansas City Research Working Paper*, no 16-09, April.

Lein, S (2010): "When do firms adjust prices? Evidence from micro panel data", *Journal of Monetary Economics*, vol 57, no 6, September, pp 696–715.

Levin, A, D López-Salido, E Nelson and T Yun (2008): "Macroeconometric equivalence, microeconomic dissonance, and the design of monetary policy", *Journal of Monetary Economics*, vol 55, Supplement, October, pp S48–S62.

Loupias, C and P Sevestre (2013): "Costs, demand, and producer price changes", *The Review of Economics and Statistics*, vol 95, no 1, March, pp 315–27.

Morikawa, M (2016): "Business uncertainty and investment: evidence from Japanese companies", *Journal of Macroeconomics*, vol 49, September, pp 224–36.

Nakamura, E and J Steinsson (2008): "Five facts about prices: a re-evaluation of menu cost models", *The Quarterly Journal of Economics*, vol 123, no 4, November, pp 1415–64.

Peltzman, S (2000): "Prices rise faster than they fall", *Journal of Political Economy*, vol 108, no 3, June, pp 466–502.

Shirota, T (2015): "Flattening of the Phillips curve under low trend inflation", *Economics Letters*, vol 132, July, pp 87–90.

Tanaka, M, N Bloom, J David and M Koga (2019): "Firm performance and macro forecast accuracy", *Journal of Monetary Economics*, forthcoming.

Woodford, M (2011): *Interest and prices: foundations of a theory of monetary policy*, Princeton University Press.

Wooldridge, J (2011): "A simple method for estimating unconditional heterogeneity distributions in correlated random effects models", *Economics Letters*, vol 113, no 1, October, pp 12–15.