Price Change Synchronization within and between Firms

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Price Change Synchronization within and between Firms♣

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Abstract

This paper provides evidence on price rigidity at the product- and firm-level in Norway. A strong within-firm synchronization is found supporting the theory of economies of scope in menu costs. The industry synchronization effects are found to be small suggesting that firms either have some monopoly power, or that a firm's costs of changing their own prices may be larger than the benefit of responding to their competitors' price changes. These findings have potentially important implications for the micro-foundations of macroeconomic models, and thus the policy advice derived from such models.

Keywords: Price Setting, Monthly Micro Data, Selection Effects.
JEL classification: E31, D43, C35

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1. Introduction

This paper explores to what degree within-firm synchronization of price changes exists, and also the existence of synchronisation between firms in the same industry. We find strong evidence of within-firm synchronization. This synchronization is independent of the direction of the price changes, supporting the theory of economies of scope in menu costs. The industry synchronization effects are found to be small, suggesting that firms either have a degree of pricing power, and/or that the costs of changing prices in response to their competitors' behavior exceed the benefits. Our findings give support to the prevalence of menu costs, scope economies in price changes, and a high degree of within-firm synchronization already documented in a number of countries (Lach and Tsiddon, 1996; Fisher and Konieczny, 2000; Midrigan, 2011; Alvarez and Lippi, 2014; Bhattarai and Schoenle, 2014; Yang, 2020; Dedola *et al*., 2019; Letterie and Nilsen, 2021; Bonomo *et al*., 2020). Combined with earlier literature these findings have potentially important implications for the micro-foundations of macroeconomic models and monetary policy

2. Data and methodological issues

The primary dataset consists of monthly survey data for approximately 630 distinct product groups, for which prices are collected by Statistics Norway to construct the Norwegian producer price index (PPI).[1] The monthly prices are merged with annual firm level information, using the firm identifiers in the price survey data. The firm level information includes records on the number of employees, net revenues, and wage costs. Missing or incomplete records are deleted. If prices are reduced by more than 49%, or increased by more than 99%, these observations are excluded.[2] The final dataset covering the manufacturing industry contains 166 466 price

[1] Not all firms are surveyed, and firms may be targeted for certain, but not all of their products. Firms represented in the price data tend to be larger than the average of Norwegian firms.

[2] A price change is calculated as $\frac{P_{ijk,t} - P_{ijk,t-1}}{P_{ijk,t-1}}$, where *i* denotes product, *j* firm in industry *k* in period *t*.

observations for 2 880 unique products, distributed across 516 firms covering the years 2005-2016.[3]

To measure synchronisation two indicator variables are defined, $U_{ijk,t}$ and $D_{ijk,t}$, taking the value one if a price change is positive or negative, respectively, where *i* denotes product, *j* denotes firm in industry *k* in period *t*. The fraction of within-firm positive and negative price changes, $UF_{ijk,t}$ and $DF_{ijk,t}$, is then given by the sum of $U_{ijk,t}$ and $D_{ijk,t}$ respectively, over the sum of price observations for firm *j* at time *t*, excluding the good we are trying to explain.

$$UF_{ijk,t} = \frac{\left(\sum_{i=1}^{I}\sum_{k=1}^{K} U_{ijk,t}\right) - U_{ijk,t}}{\sum_{k=1}^{K} Z_{jk,t} - 1}$$

$$DF_{ijk,t} = \frac{\left(\sum_{i=1}^{I}\sum_{k=1}^{K} D_{ijk,t}\right) - D_{ijk,t}}{\sum_{k=1}^{K} Z_{jk,t} - 1}$$

where $K_{(t)}$ denotes the total number of industries, $I_{(t)}$ denotes the total number of products, and $Z_{jk,t}$ is the observed number of products within firm *j* and industry *k* in period *t*. The within-industry fractions are calculated in correspondence as the within-firm synchronisation indices, i.e. by summing the number of upward and downward changes over all products and firms for each industry in a given time period, excluding the good we are trying to explain.

We use the HS code to categorize the products.[4] From Figure 1 we see a substantial part of the unique HS-codes only has one product in our sample independent of aggregation. At the 4-digit HS level, 67% of the observed products have relevant competing products. We therefore categorise our products according to the 4-digit HS code.

"Figure 1: Number of products per HS code"

[3] We focus on prices recorded in the domestic market only, as prices of imported and exported products are likely to be set considering different criterion, for instance changing exchange rates.
[4] The Harmonized System, HS, is an international customs and statistical nomenclature (SSB, 2020).

The HS 4-digit product groups are grouped into the behavioral categories "frequent" and "infrequent" price changes. If a HS 4-digit product group has an average share of price changes below (above) 0.09 per year, i.e. slightly above one change per year, it is defined to be a group with "infrequent" ("frequent") price changes. 69% of the products are classified as frequent changers. Thus, heterogeneity in the data are addressed to some degree.

3. Empirical results

We apply a standard multinomial logit model with three discrete outcomes; negative- , no-, and positive- price changes.[5] We include 2-digit SIC sectoral monthly PPI to control for exogenous shocks at the sector level. Log-transformed wage per employee is also included as control variable, since wages are a major cost component for firms.[6] Finally, yearly and monthly dummies are included. Standard errors are clustered at firm level to mitigate potential problems related to the dependency between the various products within a firm.

"Table 1: Multinomial Logit Model Results"

The upper panel of Table 1 shows significant relationships between the fraction of both positive and negative price changes within the firm and the probability of positive and negative price changes. The marginal effects seem to be somewhat larger when we consider only the products with frequent price changes, suggesting a higher degree of within-firm synchronization of price changes for these products compared to all products. All within-firm marginal effects are positive, suggesting that an increasing share of positive price changes within the firm also increase the probability of a negative price change, and vice versa. If the observed synchronization was solely caused by firm specific shocks, we would not see this as

[5] Firms tend to behave differently when increasing and decreasing prices (Ball and Mankiw, 1994).
[6] The labour cost share in the Norwegian manufacturing industry is in the 0.75-0.90 interval (NOU 2019:6).

such a shock would impact all products within a firm in the same direction. However, in the presence of economies of scope in menu costs the result seems fully reasonable; a firm can very well choose to reduce the price of one product while increasing the price of most other.

The lower panel of Table 1 gives the marginal effect of the fraction of both positive/negative prices changes to see the average effect of price changes of the other products. The marginal effects (dy/dx) are in between the corresponding individual fractions up and down, while the marginal effects of a one standard deviation change (+/- 1/2 Std.Dev) are somewhat larger relative to the corresponding individual fractions – caused by larger std. dev of the fraction of prices changes relative to the individual ones.

We plot the predicted probabilities of the three discrete outcomes using the estimates for the frequently changing products. Figure 2a shows that the probabilities of both a positive- and a negative- price change on a given product increase as the fraction of positive price changes in the same firm increases. The effect is strongest for the probability of a positive change. Conversely, the probability of not changing the price of product *i* decreases as the fraction of positive changes increases. We see the same trends in Figure 2b, the probability of a change increases with the fraction of negative changes in the firm. Both plots suggest a strong degree of within-firm price synchronization.

“Figure 2a: Prob. of price change conditional on the fraction of other positive changes in firm”

“Figure 2b: Prob. of price change conditional on the fraction of other negative changes in firm”

Turning to between-firms price synchronization, we see that even though the marginal effect of the fraction of positive price changes in the industry is statistically significantly, the economic effect is small. When graphing the estimated probabilities conditional on the share of other price changes in the industry (not shown, but available from the authors on request), the predicted probabilities stay relatively unchanged as the fractions of positive and negative price changes in the industry vary. One potential explanation for the weak between-firms price synchronisation, also found by Bhattarai and Schoenle (2014), might be monopoly power in the manufacturing sector. Note however, the left bar in Figure 1 shows that 67% (1 minus 33%) of the products have relevant competing products - even though parts of these are products within the same firms. On the other hand, small price changes by competitors may not be matched when the firm faces menu costs (Ball and Romer, 1991). It is also worth pointing out that at least for the positive price changes in the upper panel of Table 1, firms are responding positively to competitors' price increases, and negatively to competitors' price reduction such that pricing decisions are strategic complements. For negative price changes the marginal effects of the industry price changes are all statistically insignificant.[7]

4. Concluding remarks

We find the synchronization of price changes to be largely independent of the direction of changes. This supports the theory of scope economies in menu costs rather than firm- or sector-specific shocks, as such shocks are likely to impact all products in the same direction. As emphasized in literature, within-firm synchronization reduces the responsiveness of a single product price to shocks, as the pricing decision depend on the benefits of changing other prices too. The between-firm synchronization within the 4-digit HS product groups are of minor importance in explaining pricing behaviour. A potential limitation of these latter findings is the relatively few competitors in some of the narrowly defined industries.

The economics of scope in the price change technology found might reduce the degree of state dependency. This again might affect the importance of selection effects in menu-cost

[7] We have included lags of (log-transformed) wages and lags of sectorial PPIs as control variables in one set of regressions. The marginal effects from these new regressions are hardly changing relative to the ones in Table 1 (see Table A1).

models, and in the end, the degree of monetary non-neutrality, thus the response of real variables to monetary shocks.

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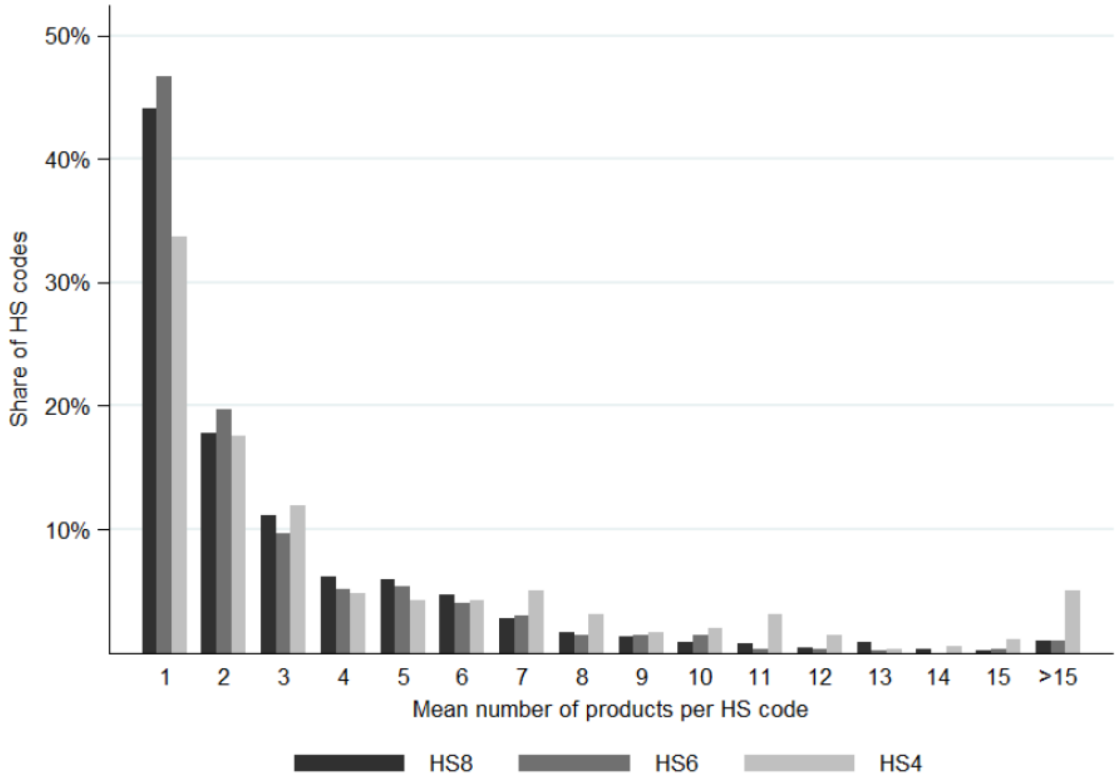
Figure 1: Number of products per HS code, conditional on aggregation



Note: For each aggregate of the HS code, the number of products in a year is found. We then calculate the means over the years, and round to nearest integer. For the same HS aggregates, we show the distribution over the "mean number of products per HS code".

Figure 2a: Prob. of price change conditional on the fraction of other positive changes in firm

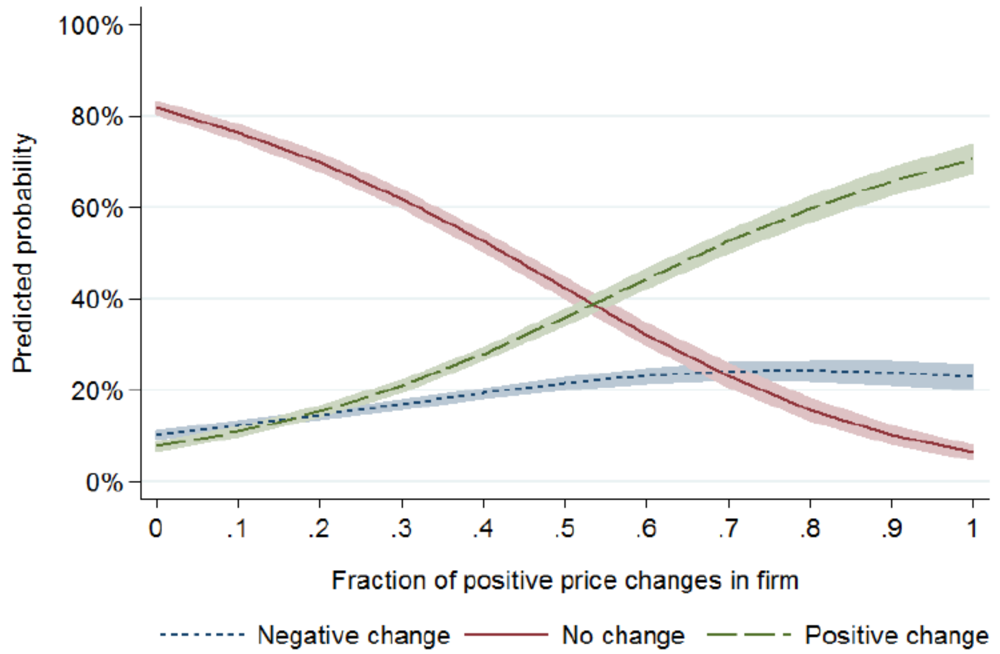
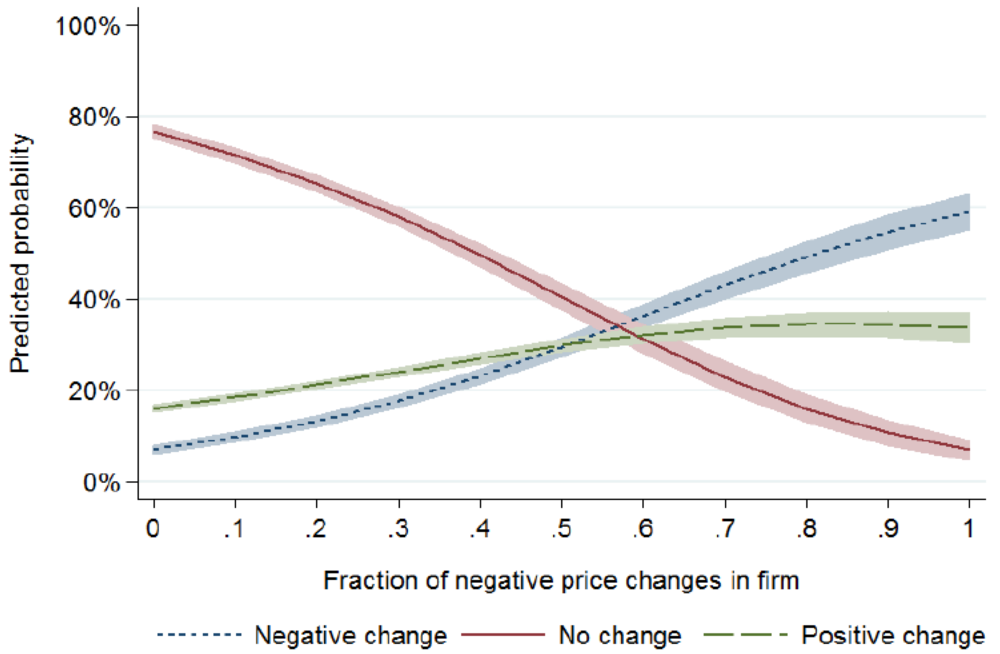


Figure 2b: Prob. of price change conditional on the fraction of other negative changes in firm



Note: Estimates based on the multinomial logit model – products with frequent changes. Predicted probabilities are calculated for HS2 category 36 "Plastics and articles thereof" in April 2010. All other variables are held at their mean. The shaded area represents the 95% confidence interval. Standard errors clustered at firm level.

Table 1: Multinomial Logit Model Results, Marginal Effects

	Marginal effects (dy/dx)		+/- 1/2 Std. Dev.	
	All products	Products with frequent changes	All products	Products with frequent changes
Positive price change				
Fraction up firm	0.48**	0.61***	6.69***	8.56***
	(0.04)	(0.05)	(0.59)	(0.64)
Fraction down firm	0.37**	0.46**	4.05**	5.06***
	(0.03)	(0.03)	(0.35)	(0.37)
Fraction up industry	0.06**	0.05*	0.66***	0.56*
	(0.02)	(0.02)	(0.19)	(0.25)
Fraction down industry	-0.02	-0.05*	-0.15	-0.48*
	(0.02)	(0.03)	(0.18)	(0.23)
Negative price change				
Fraction up firm	0.27***	0.34***	3.85***	4.76***
	(0.03)	(0.04)	(0.48)	(0.51)
Fraction down firm	0.36**	0.45***	3.95***	4.97***
	(0.05)	(0.05)	(0.50)	(0.55)
Fraction up industry	0.00	-0.03	0.01	-0.28
	(0.01)	(0.02)	(0.13)	(0.17)
Fraction down industry	0.03	0.01	0.24	0.09
	(0.02)	(0.02)	(0.17)	(0.22)
Positive price changes				
Fraction price changes firm	0.43***	0.55***	8.18***	10.46***
	(0.04)	(0.04)	(0.70)	(0.76)
Fraction price changes industry	0.04*	0.02	0.54*	0.28
	(0.02)	(0.02)	(0.24)	(0.33)
Negative price changes				
Fraction price changes firm	0.33***	0.41***	6.28***	7.76***
	(0.05)	(0.05)	(0.87)	(0.95)
Fraction price changes industry	0.01	-0.01	0.14	-0.21
	(0.01)	(0.02)	(0.21)	(0.28)

Significance levels: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Number of observations: All products - 166 466 , Products with frequent changes - 124 716.

Notes: "Positive (Negative) price change" gives the marginal effect on the probability of a positive (negative) price change. Control variables include sector specific PPI, (log-transformed) wages, monthly- and yearly dummies, and industry dummies at the HS2 level. Standard errors clustered at firm level in parentheses. Marginal effects are calculated for HS2-category 36 "Plastics and articles thereof" in April 2010, all other variables held at their mean. The shares of positive and negative price changes for "all products" are 14.8% and 9.9%, respectively, and for "products with frequent changes" 19.4% and 13.9%, respectively.

Table A1: Multinomial Logit Model Results, Marginal Effects - additional control variables

	Marginal effects (dy/dx)		+/- 1/2 Std. Dev.	
	All products	Products with frequent changes	All products	Products with frequent changes
Positive price change				
Fraction up firm	0.48***	0.61***	6.79***	8.62***
	(0.04)	(0.04)	(0.57)	(0.61)
Fraction down firm	0.37***	0.46***	4.08***	5.045***
	(0.03)	(0.03)	(0.34)	(0.36)
Fraction up industry	0.06**	0.05	0.62**	0.50
	(0.02)	(0.02)	(0.19)	(0.26)
Fraction down industry	-0.02	-0.06*	-0.18	-0.51*
	(0.02)	(0.03)	(0.18)	(0.24)
Negative price change				
Fraction up firm	0.27***	0.34***	3.87***	4.74***
	(0.03)	(0.04)	(0.49)	(0.52)
Fraction down firm	0.36***	0.45***	3.98***	4.97***
	(0.05)	(0.05)	(0.51)	(0.56)
Fraction up industry	0.00	-0.03	-0.01	-0.30
	(0.01)	(0.02)	(0.13)	(0.18)
Fraction down industry	0.02	0.00	0.19	0.04
	(0.02)	(0.03)	(0.18)	(0.23)

Significance levels: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Number of observations: All products - 149 660 , Products with frequent changes - 112 229.

Note: In this set of results, lagged (1 year) wage costs and lagged wages (1 month) are included as additional control variables relative to the ones in Table 1. See also notes to Table 1.

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