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PRICE SETTING IN GERMAN MANUFACTURING

NEW EVIDENCE FROM NEW SURVEY DATA

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The Eurosystem Inflation Persistence Network

This paper reflects research conducted within the Inflation Persistence Network (IPN), a team of Eurosystem economists undertaking joint research on inflation persistence in the euro area and in its member countries. The research of the IPN combines theoretical and empirical analyses using three data sources: individual consumer and producer prices; surveys on firms' price-setting practices; aggregated sectoral, national and area-wide price indices. Patterns, causes and policy implications of inflation persistence are addressed.

Since June 2005 the IPN is chaired by Frank Smets; Stephen Cecchetti (Brandeis University), Jordi Galí (CREI, Universitat Pompeu Fabra) and Andrew Levin (Board of Governors of the Federal Reserve System) act as external consultants and Gonzalo Camba-Méndez as Secretary.

The refereeing process is co-ordinated by a team composed of Günter Coenen (Chairman), Stephen Cecchetti, Silvia Fabiani, Jordi Galí, Andrew Levin, and Gonzalo Camba-Méndez. The paper is released in order to make the results of IPN research generally available, in preliminary form, to encourage comments and suggestions prior to final publication. The views expressed in the paper are the author's own and do not necessarily reflect those of the Eurosystem.

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Abstract:

This paper presents new evidence on the formation of producer prices based on a one-time survey that was conducted on a sample of 1200 German firms in manufacturing in June 2004. Most of the firms have price-setting power and apply mark-up pricing. Indexation is negligible. Fixed nominal contracts are the most important reason for postponing a price adjustment. The second most likely reason is coordination failure, which causes more upward than downward stickiness. For every second firm both reasons are important. Firms can be assigned to four different groups according to an increasing complexity of reasons of price stickiness.

Keywords: Price rigidity, cluster analysis

JEL-Classification: E30, D40

Non-Technical Summary

This paper presents the results of a survey among 1200 German manufacturing firms on the formation of their prices. The aim was to investigate why firms adjust their prices only with a certain delay to a change in market conditions and which rules govern their adjustment.

The firms' replies are confronted with several theories on price-setting behavior. We conclude that some theoretical models fit the real world better than others. Replies consistent with state-dependent models are frequent, whereas time-dependent models seem to be less important. There is only scant evidence that physical menu costs are relevant for explaining rigid price adjustment. In contrast, competition seems to be important. Overall, the survey shows that real world price-setting behavior is more complex than deliberately simplified models assume. The results confirm those of similar previous studies. This shows that the survey approach is robust and complements theoretical and more econometrically-oriented analyses.

Nicht technische Zusammenfassung

Dieses Papier enthält die Ergebnisse einer Umfrage bei 1200 Firmen des Verarbeitenden Gewerbes in Deutschland bezüglich deren Preissetzungsverhaltens. Herausgefunden werden sollte zum einen, warum Unternehmen ihre Preise nur verzögert an geänderte Marktbedingungen anpassen und zum anderen, nach welchen Regeln sie anpassen.

Die Umfrageergebnisse werden mit einer Reihe von Theorien über das Preissetzungsverhalten konfrontiert. Zudem werden die Ergebnisse mit ähnlichen früheren Umfragen verglichen. Wir kommen zu dem Schluss, dass einige theoretische Modelle die Praxis besser widerspiegeln als andere. Vergleichsweise häufig findet man Antworten, die mit zustandsabhängigen Modellen in Einklang stehen, während so genannte zeitgebundene Preissetzungsregeln seltener eine Rolle zu spielen scheinen. Wenig Unterstützung finden Theorien, wonach physische Menukosten wichtig sind, um

verzögerte Preisanpassungen zu erklären. Dagegen scheinen die Wettbewerbsverhältnisse der Unternehmen eine wichtige Rolle zu spielen. Insgesamt machen die Umfrageergebnisse deutlich, dass in der Praxis das Preissetzungsverhalten komplexer ist, als dies in notgedrungen vereinfachten Modellen dargestellt wird. Die Ergebnisse bestätigen vielfach diejenigen ähnlicher früherer Umfragen. Dies unterstreicht die Robustheit des Umfrageansatzes und seinen Wert als Ergänzung zu theoretischen und stärker ökonometrisch orientierten Ansätzen.

1 Introduction

If nominal prices adjust only incompletely after monetary shocks, monetary policy has real effects, at least in the short run. The nature of incomplete nominal adjustment affects the costs of alternative disinflation strategies and may even cause inflation persistence. More and more micro-founded theories seeking to explain nominal price rigidity have evolved in the past few years, but empirical research has begun only recently. It proved to be difficult if not impossible to discriminate different micro-founded macro models of price stickiness from aggregate data or even from the micro-data collected by the National Statistical Offices. There are several explanations for these difficulties. At the macro level, different micro-founded models are almost observationally equivalent, and no official statistic contains explicit information on why firms do not adjust prices instantaneously. Official microdata normally do not contain any explanatory variables, and the samples underlying the datasets might be heterogeneous. This makes the empirical analysis difficult. Let us assume that there are two sectors and that the reasons for price rigidity differ between the two sectors. If a dataset does not contain any information on the sector, the outcome of a pooled analysis will be either that for each firm each reason of price stickiness applies to a certain extent or the effects may even cancel each other out, rendering both reasons statistically insignificant. In this vein, Blinder *et al.* (1998) pioneered, for the United States, the use of special surveys to test some of the theories of price adjustment.

This paper presents results of such a survey on price-setting behavior among 1200 manufacturing firms in Germany. The firms reported why they respond with a delay to shocks and how they adjust their prices. The study confirms Blinder *et al.*'s findings that there exists no single simple theory to explain delayed price adjustment. Thus, a hybrid model will be necessary to capture the features of the data adequately.

Some basic ingredients of their model are generally acceptable for Germany, too: Written contracts explicitly prohibit price increases for a substantial share of output, and many firms postpone price increases for fear that competitors will not follow suit and that they will lose market share. For Germany, one can add to this picture that most firms apply mark-up pricing, as is assumed by most of the sticky price models. Indexation (e.g. Christiano *et al.*, 2005) and purely time-dependent models (Taylor, 1980, and Calvo, 1983), i.e. models that take the point of time of a price change as exogenous, do not play an important role.

Similar surveys have been conducted in the meantime for the UK (Hall *et al.*, 1997, 2000), Sweden (Apel *et al.*, 2005) and Canada (Amirault *et al.*, 2004). Comparable surveys have recently been administered in several euro-area countries:[1] Fabiani *et al.* (2004) for Italy, Loupias and Ricart (2004) for France, Kwapil *et al.* (2004) for Austria, Aucremanne and Druant (2004) for Belgium, Hoeberichts and Stokman (2004) for the Netherlands and Martins (2005) for Portugal. Fabiani *et al.* (2005) summarize the results of the surveys for the euro area.

The rest of the paper is organized as follows. Section 2 starts with a description of the survey. Section 3 investigates how prices are set and, in particular, whether firms have price-setting power. Section 4 analyses factors hampering price changes and section 5 why firms adjust prices. Section 6 reports the results of a cluster analysis, which aims at identifying groups of firms with distinct reasons for price stickiness. Section 7 summarizes and concludes. An English translation of the questionnaire, including the averages of the responses, can be found in the Annex C.

2 The survey

The German survey on producer price-setting behavior was carried out on behalf of the Deutsche Bundesbank by the Ifo Institute in Munich, which sent out the

[1] In the course of 2003 and 2004 nine national central banks (NCBs) in the euro area conducted special surveys on firms' pricing behavior in their respective country. This was part of a collaboration project called the Inflation Persistence Network (IPN), a Eurosystem research network designed to achieve a better understanding of inflation persistence in the euro area. These surveys were aimed at providing useful complementary information to the quantitative price data that are also analyzed in the research network.

questionnaire to the 2500 participants of its monthly business cycle survey in manufacturing. The enclosed letter stated that the questionnaire is part of the business cycle survey, enabling the matching of cross-sectional and time-series information at the plant level. This approach also avoided a duplication of questions which otherwise might have annoyed participants.

The sample of the business cycle survey developed historically and is by purpose.[2] Large firms are overrepresented. Firms report for product groups, which in most cases coincide with plants. Most firms are single-plant firms. Larger plants may reply for several product groups. In these cases the largest product group was selected for the special survey. The name of the product group was mentioned at the beginning of the questionnaire. Eventually, 1200 firms or 47 per cent of all firms participated, mainly those that participate regularly in the business cycle survey. All descriptive results are weighted with post-stratification weights. The weights are the number of plants according to 2-digit NACE classification and size class of employees.

The questionnaire (see Annex C) consists of two parts: "General information" and "Information regarding price formation". The first part mainly concerns the market the firm operates in. In the second part firms are asked how they set their prices and, on a four-point scale, whether price setting and price reviewing follow a time-dependent or a state-dependent rule, whether firms behave forward or backward-looking, what causes price changes and what the likely reasons for a postponement of price changes are. The questionnaire states that the scale goes from (1)=minor importance to (4)=great importance. In the tables and text of the present paper, the numeric scale is translated as follows: (1)=not important, (2)=moderately important, (3)=important and (4)=very important.

The questionnaire focuses on domestic sales prices as opposed to price setting in foreign markets. This turned out not to be a major problem. According to the responses to questions 2 and 3, domestic price setting should apply for roughly 60 per cent of firms and 95 per cent of sales. This astonishingly high share is partly due to exports

[2] Germany had no register of firms before 1995; therefore, no random sampling was possible. Instead, researchers had to decide deliberately which firms to ask, e.g. based on published sales figures. This is called sampling by purpose or purposive sampling. In recent years, the sample has been updated to make it more representative.

through wholesalers. For domestic producers this is domestic demand sold at domestic prices.

The survey took place in June 2004, at a time of weak growth. Following strong growth in 1999 and 2000, total real GDP virtually stagnated and grew in the first two quarters of 2004 by 2.0 per cent change over previous year after adjustment for seasonal and working day variations. Within industry, it was 1.5 per cent. The CPI rose by 1.4 per cent and the PPI by 0.7.

3 Price setting

If all markets were perfectly competitive, prices should be perfectly flexible and there should be a unique equilibrium price. Therefore, all sticky price models have to assume some kind of market imperfection. Most models (e.g. Woodford 2003, and Rotemberg 1982) postulate that firms are price setters and that they apply some type of mark-up pricing. However, these models do not generate the inflation persistence diagnosed by vector autoregressions. Two ways of mitigating this problem are to let a fraction of firms index their prices to another price or price index (Yun 1996, and Christiano *et al.* 2005) and to assume that a fraction of firms follow a price leader with a lag, a form of strategic complementarity.

Table 1: Types of price setting of firms with price-setting power

Type of price setting	Share of firms
Constant mark-up on calculated unit costs	4
Taking calculated unit costs as a reference and varying the mark-up, taking into account market and competition conditions	69
Taking the price of the main competitor as a reference	17
Tying the price to another price (e.g. wage)	2 (5)
Other	7 (12)
Total	100 (107)

Nota bene: Values in brackets include double counts. For instance, 5% report tying their price to another price and applying another type of price setting.

Most of the firms (88%) report that they do have a certain margin for setting their prices (question 8). Mark-up pricing[3] (73%) dominates the price setting of firms with market power. There are only a few firms which set their prices by applying a constant mark-up on calculated unit costs (4%). These firms may be price leaders, i.e. the most powerful firms. The largest share of firms has a time-varying mark-up (66%). They use calculated unit costs as reference and take market conditions and competition into account. The second most likely behavior of firms is to take the price of the main competitor as a benchmark. This is the case for 17 per cent of price setters.[4] Most of them may be price followers and less powerful than mark-up price setters. However, there may also be powerful firms in an oligopoly that have to watch their competitors closely. Indexation to another price is almost non-existent.

4 Reasons for price stickiness

This section investigates, why firms do not adjust their prices immediately after shocks, even if they have some market power. Since the present questionnaire was restricted to two pages, it includes only some of the theories asked by other euro-area countries. Theories that seemed *a priori* less important in manufacturing or had turned out to be of low importance in other studies were disregarded. Two examples are Blinder *et al.*'s "Psychological Pricing Points" and "Judging Quality by Price" that ranked 22nd and 25th out of 27 theories in Köhler's (1996) survey. Physical menu costs did not perform well in the Blinder *et al.* and Köhler studies either, but since this explanation is so prominent in the literature, it was included nonetheless. The following theories were eventually included.

Nominal contracts If prices are fixed for a certain period in nominal terms by contract, plants can no longer react to unexpected shocks by changing prices.

[3] The questionnaire does not specify whether firms apply the mark-up to marginal cost or to average cost. It is not at all clear whether firms calculate marginal cost. After all, if they fix prices for a certain time, the mark-up should be applied to average expected marginal costs. Further, if the mark-up is not constant but instead related to other factors, the distinction between marginal cost and average cost is probably no longer important.

[4] Though not asked, two out of three price takers answered this question, so some estimation can be provided for them, too. If it is assumed that those who did not answer question number 8 set their price differently (item 5 of question 8), then 28 per cent follow their main competitor.

Physical menu costs The theory of menu costs (e.g. Sheshinsky and Weiss 1977) assumes that price adjustment entails fixed costs. Prices will not be adjusted unless the foregone profit following from fixed prices exceeds the adjustment costs. The questionnaire focuses on a narrow definition of menu costs and mentions printing costs as an example.

Coordination failure/kinked demand curve According to the theory of coordination failure firms hesitate to increase prices for fear that competitors will not follow suit and that they will therefore lose customers. There is no symmetric definition for price reductions. Two lines of argument exist. In the first, firms are reluctant to reduce prices because they fear competitors will reduce their prices too and that this may even trigger a price war. This reasoning is almost the same as for the theory of the kinked demand curve (Hall and Hitch 1939 and Sweezy 1939). The second is that firms follow the price reductions of competitors for fear of losing market share if they do not reduce their prices.

Transitory shock If firms really optimize their prices over a longer time horizon and there are some costs of price adjustment, then firms should react to permanent shocks but not to transitory shocks.

Sluggish costs This "theory" is taken from Apel *et al.* (2001). It states that c. p. output prices will not change if there are no permanent shocks in input costs.

Time-dependent price setting Since time-dependent price setting implies sluggish adjustment even without further theory, two questions on time-dependence have been added in the present paper, namely whether firms change their prices predominantly at a specific point of time or after a certain time interval.[5]

Price elasticity of demand If the price elasticity of demand is smaller than one, in absolute terms, a price reduction will lower profits and therefore no firm will change its price.

[5] If a firm changes its price once a year and always during the same month, say in January, the answers to both questions have to coincide. However, if there is an exceptional price change, say in April, then the firm that preferably changes its price at a fixed point of time should next change its price again in January, whereas a firm that preferably changes its price after a fixed time interval should next change its price in April of the following year.

For transitory shocks, coordination failure and the price elasticity of demand, different replies were possible depending on whether prices are increased or reduced.

On average, explicit nominal contracts were the most important reason for price stickiness at the plant level. One reason for this is that they are almost ubiquitous. A tabulation of the average importance of fixed nominal contracts by the duration of contracts indicates that firms do not feel hampered by short contracts but by contracts with a duration longer than half a year (see Table A1).

Table 2: Average importance assigned to various reasons of price stickiness

Variable	Price increase	Price reduction	Total mean	Rank
Nominal fixed-term contract	-	-	2.4	1
Coordination failure	2.6	1.9	2.2	2
Price elasticity of demand	2.2	2.1	2.1	3
Regular date	-	-	2.0	3
Regular time interval	-	-	1.9	3
Transitory shock	1.8	2.0	1.9	6
Sluggish costs	-	-	1.8	7
Menu costs	-	-	1.4	8
Other	1.1	1.1	1.1	-

Nota bene: A t-test at the level of 1 per cent does not reject the hypotheses that the means of the reasons with rank three are equal.

Coordination failure achieved the second rank. With a mean score of 2.6 compared to 1.9 it causes more upward than downward stickiness, on average. The third rank is shared by three theories: Price elasticity of demand, price change preferably at a fixed point of time and price change preferably according to a fixed time interval. A two-sided t-test did not reject the hypothesis of equality. Then follow transitory shocks and sluggish costs. However, their average importance is not much lower than that of the theories ranked second and third. A clear difference shows up for physical menu costs that earned the lowest rank with an average importance of 1.4.

5 Reasons for price adjustment

While the last section focused on reasons for postponing a price change, this section focuses on reactions to cost and demand shocks and to price changes of competitors and investigates whether these reactions are symmetric or asymmetric. In question 16 firms had to grade several shocks on a four-point scale of importance for a price increase or price reduction. On the cost side, increases in labor costs were split into permanent and transitory increases because the face-to-face interviews revealed that the firms' understanding of labor costs referred to permanent increases in hourly wages. They claimed that reductions in wage costs never happen. The same split for reductions of labor costs was prevented by space constraints. At least, lay-offs were explicitly mentioned in the question to improve understanding.

The question for demand changes contains a double asymmetry. Firms are not only asked which importance they attach to demand increases for price increases and demand decreases for price reductions but also whether demand decreases are important for price increases or demand increases for price reductions. The second asymmetry is motivated by the fact that with a high share of overhead costs unit costs should decrease with an increase in demand and vice versa. Further, it is frequently argued that marginal costs are decreasing because discounts are growing in line with the quantity purchased.

It turned out that the most important motivation for price changes is changes in the costs of materials (see Table 3). Their impact is larger for price rises than for price reductions. Labor costs matter in the event of permanent wage increases but transitory increases, as well as reductions of labor costs, have only a modest impact. For reductions of labor costs, permanent changes may likewise be more important than transitory changes. This could explain why the average grade for reductions lays between the grade for permanent and transitory increases. Financing costs are not important either. The pass-through is larger for increases than for reductions. An increase in productivity, which can be seen as a permanent cost reduction, received an average score of 2.4. Thus, firms are more likely to react to cost increases than to cost reductions. For the demand shocks, there are almost no differences in mean grades between the four alternatives. They range from 2.0 to 2.3. Yet it is questionable whether all firms understood the double dichotomy. Approximately 25 per cent attached a grade

of 3 or 4 to the importance of a demand decrease for a price increase as well as for a price reduction. On the other hand, when asked for the reasons for a price increase (reduction), about 10 per cent of firms assigned a high grade to a demand decrease (increase) and a low grade to a demand increase (decrease). These may be firms with high fixed costs.

Table 3: Asymmetric reactions of price changes to shocks

Type of shock	Price		p-values	
	Increase	Reduction	Chi2	LR
	mean score			
Increase (reduction) of costs of materials	3.4	2.8	0.000	0.000
Permanent increase of labor costs (e.g. negotiated wage increase)	2.7	-	-	-
Transitory increase of labor costs (e.g. overtime hours, bonuses)	1.5	-	-	-
Reduction of labor costs (e.g. bonuses, lay offs)	-	1.9	-	-
Increase (reduction) of financing costs	1.9	1.6	0.000	0.000
Increase of productivity	-	2.4	-	-
Product improvement	2.3	-	-	-
Demand increase (reduction)	2.2	2.3	0.000	0.000
Demand reduction (increase)	2.2	2.0	0.000	0.000
Price increase (reduction) by a competitor	2.1	2.6	0.000	0.000
Other	1.9	1.8	0.894	0.887

An asymmetric reaction can be observed for price changes of competitors. Firms react strongly to price reductions by competitors but to a lesser extent to price increases, in accordance with the theory of coordination failure. A chi-square test and a likelihood-ratio test[6] reject the null hypotheses of symmetry for all reactions besides "other reasons".

A cross-tabulation of type of price setter with the importance of several reasons for price increases and reductions (see Table A2) confirms the results obtained in section 3 on price setting. Firms with a constant mark-up respond to cost changes but

[6] The chi2 test is a generalization of the (2 x 2) McNemar test for a (r x r) contingency table (Hartung 1989) and the likelihood-ratio test follows Bowker (1948). These tests ignore the main diagonal and consider only the off-diagonal elements.

rarely to demand changes, and are less likely than other firms to respond to competitors' price reductions. Firms that take the price of their main competitor as a reference are more likely to react to competitors' price changes and to demand changes than other firms. These firms may take not directly observable demand changes as an indication of price changes by their competitors. This would also explain why they are less likely to react to permanent wage increases than other firms. They react to permanent wage increases only insofar as they react to their competitors' reaction to permanent wage increases. Another explanation for the stronger reaction to demand increases is that these firms are price followers most of the time, but occasionally have to act as price leaders to avoid being punished by their competitors. Thus, from time to time, they have to sacrifice some market share that is least detrimental to their profits at times of exceptional demand. Firms with a variable mark-up are caught in the middle between firms with a constant mark-up and firms that take the price of their main competitor as a reference.

Firms with indexation raise their prices more often in response to cost increases than other firms do. It is irrelevant whether the costs are costs of materials, permanent wage increases or financing costs. In the case of cost reductions, they behave like other firms. Yet, indexation does not necessarily imply that prices are adjusted continuously, in the way macro models typically assume. Indexation may also be lump-sum.[7] This is obvious by indexation to wage contracts. In a face-to-face interview, a manufacturer of car parts reported that one of his customers usually makes a proposal for a one-time price adjustment if input prices have increased more than expected.

6 Clustering of firms

The analysis of the importance of various reasons for postponing a price change in section 4 yielded no dominant explanation. We will therefore need to use a more complicated model. One possibility may be a model with several groups of firms, each group facing a simple but distinct explanation for its behavior. This section reports the results of a cluster analysis that uses the answers to questions 16 and 17, i.e. the reasons for changing a price and the reasons for postponing a price change, to identify such groups. The analysis reveals that it is difficult to identify different homogeneous groups

of firms. Instead, firms may be grouped by increasing complexity of reasons of price stickiness. The results suggest that eventually an alternative model where each firm has many reasons, and not just one or a few, to postpone a price change would be more appropriate. Such a model has to be developed in the future. The following paragraphs present the analysis in more detail. The methodology proceeds in two steps following a proposal by Bacher (1994).

The aim of the specific cluster analysis in this paper is to partition the firms into a distinct number of nonoverlapping clusters. In the words of Kendall (1980, p. 32), a cluster is "a group scattered around some central value, possibly condensing in a nuclear set, not necessarily spherical but not excessively elongated into a rod-like shape". Within clusters, the objects should be as similar as possible, yet the distance between the central values of the different clusters should be as great as possible. Thus, the cluster analysis requests a measure of similarity or dissimilarity. In the present analysis we understand the distance of the object to its central value as a residual and use the Euclidean distance or the sum of squared residuals as dissimilarity measure, depending on the clustering method.[8]

As a preparation of the cluster analysis we must clarify whether the variables used are comparable. Variables may not be comparable because there might be some latent variables that are under- or overrepresented. For example, there are two variables to measure the importance of transitory shocks for postponing a price change, one for a price increase and the other for a price cut, but only one to measure the importance of sluggish costs. Without any correction, transitory shocks would be overrepresented in the analysis, which likely leads to biased central values and distances.[9] Therefore, in a first step, a factor analysis will be used to identify a few (latent) variables for changing a price or representing the reasons for postponing a price change. In a second step, for the

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7 Indexation needed a special permission before EMU.

8 Someone who is not familiar with cluster analysis should think of the present cluster analysis as of assigning firms to groups by minimizing the within variance and maximizing the between variance.

9 Bacher (1994), p. 154/155. E. g. to cluster people by income, it should be ensured that only one person per household is asked. Otherwise the income by household should be averaged, which may even reduce measurement error. The factor analysis is intended to determine which items belong to one and the same "household".

cluster analysis, variables are grouped together based on the factor analyses[10] and group averages are used.[11] The factor analysis is presented in Appendix B.

For clustering, we use Ward's method and as an alternative the k-means method. Ward's method is an agglomerative hierarchical clustering method. These methods start by considering each observation as a separate group. The closest two groups are combined, and this process continues until all observations belong to the same group. Ward's method joins the two groups that result in the minimum increase in the error sum of squares. Once created, clusters are no longer dissolved in a further step of clustering. Although this results in a reduced statistical fit, it makes it easier to choose the number of clusters. In the k+1 cluster solution just one cluster of the k cluster solution is split into two clusters. Hence, the comparison of both outcomes is easy.

The k-means method starts by selecting k observations as the centers of k clusters. Each observation is assigned to a specific cluster by minimizing the squared Euclidean distance. New cluster centers are calculated and the process is iterated. The method is non-hierarchical. Firms that have been assigned to a specific cluster in an earlier step can be assigned to different clusters in a more advanced step. The iteration stops if no observation is reallocated. Through reallocation k-means clustering allows a better statistical fit than Ward's method. Hence, we use Ward's method in a first step to choose the number of clusters and we use the k-means method in a second step to improve the assignment of the individual firms to the different clusters.

The preferred outcome is four clusters (see Table 4). The assignment of the individual firms to the four clusters of Ward's method and the k-means method coincides for two out of three firms. Differences occur in the assignment to the first and fourth cluster, which will be discussed below.

[10] Dotted lines in tables B2 and B4 distinguish the different groups.
[11] In the cluster analysis, all variables are standardized using their theoretical values for mean (2.5) and standard deviation (1.25).

Table 4: Comparison of the assignment of firms using Ward's method and the k-means method

K-means	Ward				Total
Cluster	1	2	3	4	
1	76	64	1	36	177
2	37	178	23	3	241
3	1	9	186	42	238
4	33	9	36	116	194
Total	147	260	246	197	850

Nota bene: Figures are unweighted.

Do these four clusters describe four distinct groups of firms where for each group just one reason for postponing a price change matters? The outcome is mixed. Two out of four clusters, the first and the second, seem to represent distinct groups in this sense (see Table 5). The k-means method separates these clusters even better than Ward's method.

Table 5: Average importance assigned to various reasons of price stickiness by cluster

	k-means method				Ward's method			
Cluster	1	2	3	4	1	2	3	4
Nominal fixed-term contract	1.4	1.4	**3.5**	**3.2**	1.6	1.4	**3.4**	**3.3**
Coordination failure (+)	2.0	**2.5**	**2.6**	**2.9**	**2.2**	**2.4**	**2.6**	**2.8**
Coordination failure (-)	1.6	1.9	1.8	**2.3**	1.8	1.8	1.9	2.0
Price elasticity of demand (+)	1.7	**2.2**	**2.2**	**2.4**	1.9	**2.1**	**2.2**	**2.3**
Price elasticity of demand (-)	1.6	**2.2**	**2.2**	**2.3**	1.9	**2.1**	**2.2**	**2.1**
Transitory shock (+)	1.5	2.0	1.8	2.0	1.7	1.9	1.8	1.7
Transitory shock (-)	1.6	2.0	1.8	**2.3**	2.0	1.9	1.9	2.0
Sluggish costs	1.5	1.8	1.9	2.0	1.7	1.7	2.0	1.9
Menu costs	1.3	1.3	1.2	1.6	1.5	1.4	1.2	1.4
Fixed point of time	**2.2**	1.4	1.4	**3.1**	**3.1**	1.4	1.5	**2.4**
Fixed time interval	1.9	1.5	1.3	**3.2**	**3.1**	1.3	1.6	**2.4**
Price change in advance	1.4	**3.1**	**3.1**	**2.2**	**2.3**	**2.7**	**3.3**	1.8
Share of firms (%)	21	28	28	23	13	35	31	21

Nota bene: Figures are weighted. Average importance figures greater than 2.0 are in **boldface**.

- Cluster one represents firms that do not feel much hampered in their price adjustment. If at all, it is because of time-dependent price setting. The share of these firms is smaller in the case of Ward's method (13%) compared to the k-means method (21%) but the firms in the second cluster of Ward's method feel more hampered (3.1) than the firms in the respective k-means cluster (2.2). However, coordination failure plays some role in the second cluster of both methods.

- Cluster two represents firms that feel hampered by coordination failure and the price elasticity of demand. These firms may face a kinked demand curve. They change prices in advance if possible.

- Cluster three is similar to cluster two. However, nominal fixed-term contracts are very important in addition to the already important kinked demand curve. The firms in the third cluster feel more hampered than in the second cluster. However, this is not because a reason that already had an above average importance in the second cluster has become even more important but instead because a reason that was of only minor importance in the second cluster has now become more important.

- In cluster four time-dependent price setting increases the complexity further.

Hence, a research strategy may be to start with a simple model for part of the firms and subsequently to increase the complexity of the model.

7 Summary

The survey of 1200 German manufacturing firms taken in 2004 reveals that almost all manufacturing firms (88%) have a certain margin for price setting. Most of them set their prices relative to the prices of their main competitors and apply mark-up pricing. This confirms the basic assumptions of widespread sticky price models. Yet indexation is rejected by the data.

Asked why they postpone a price adjustment, firms attached the greatest importance, on average, to fixed nominal contracts, followed by coordination failure as

the second most likely source of price rigidity. Coordination failure results in more upward than downward stickiness. No one single theory can explain delayed price adjustment. A model has to take into account several reasons for postponing a price change for each firm. However, for almost 50 per cent of firms price stickiness may be explained by a relatively simple model whereas for the other half a quite complex model is necessary.

In accordance with mark-up pricing, firms are most likely to change prices in response to changes in the costs of materials. Their impact is greater for price increases than for price reductions. Labor costs matter in the event of permanent wage increases. Transitory increases as well as reductions of labor costs have only a modest impact. In accordance with coordination failure, firms react strongly to price reductions by competitors but to a lesser extent to price increases.

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Annex A

Table A1: Importance of written contracts according to contract length

Duration in months	Average importance	Share of firms	Average sales share, %
0	1.4	13	0
1<x<=3	2.3	18	53
3<x<=6	2.4	19	59
6<x<=9	2.7	1	53
9<x<=12	2.7	45	62
12<x	2.6	3	57
Total (mean)	2.4	100	51

Table A2: Type of price-setting according to reason for a price change

Reason for a price change	Type of price-setting									
	Constant mark-up		Variable mark-up		Competitor		Indexation		Total	
	increase	decrease	increase	decrease	increase	decrease	increase	decrease	increase	decrease
	Mean score									
Increase / decrease in costs of materials	3.5	2.5	3.4	2.9	3.3	2.8	3.8	2.9	3.4	2.9
Labor costs										
Permanent increase (e.g. negotiated wage)	2.7	-	2.7	-	2.4	-	3.2	-	2.7	-
Transitory increase (e.g. overtime hours)	1.3	-	1.5	-	1.5	-	1.5	-	1.5	-
Decrease (e.g. bonuses, lay offs)	-	1.7	-	1.9	-	1.8	-	1.8	-	1.9
Increase / decrease in financing costs	1.8	1.6	1.9	1.6	1.9	1.7	2.2	1.7	1.9	1.6
Demand increase / reduction	1.4	1.3	2.2	1.9	2.4	2.1	1.9	1.9	2.2	1.9
Demand reduction / increase	1.5	1.8	2.1	2.4	2.4	2.6	1.8	2.1	2.2	2.4
Product improvement	2.0	-	2.3	-	2.4	-	2.6	-	2.3	-
Increase in productivity	-	2.1	-	2.4	-	2.5	-	2.6	-	2.4
Price increase / decrease by a competitor	2.0	2.0	2.0	2.5	2.6	3.1	2.0	2.4	2.1	2.6
Other	1.2	1.0	1.8	1.9	1.6	1.5	1.0	2.2	1.7	1.8
Total	1.9	1.8	2.2	1.9	2.3	2.3	2.2	2.2	2.2	2.2

Annex B: Factor analysis

The general aim of a factor analysis is to reduce the correlation between several variables by a few common factors and residual factors.[12] The common factors are assumed to be unobservable but to correlate strongly with the observable variables. The factor analysis decomposes the variance of the i-th variable into two parts

$$Var(X_i) = h_i^2 + u_i^2 .$$

u_i^2 is the residual variance of the i-th variable and h_i^2 is the so called communality. The communality measures the share of the i-th variable that can be attributed to the k common factors. In the case of standardized variables the variance is 1 and therefore

$$Var(Z_i) = h_i^2 + u_i^2 = 1 .$$

The factor analysis decomposes the correlation matrix R according to

$$R = L \cdot L^T + U .$$

L is the loading matrix, calculated from the eigenvalues and –vectors of the R-matrix according to

$$L = E \cdot D^{1/2} .$$

E is the matrix of the k first eigenvectors of R and $D^{1/2}$ is a diagonal matrix containing the k largest eigenvalues of R. U is a diagonal matrix containing the residual variances of the t variables as elements.

The residual variances and the communalities can be estimated according to

$$\hat{u}_i^2 = 1 - \sum_{i=1}^{k} \hat{l}_{ij}^2 \quad \text{and}$$

[12] This presentation follows Marinell (1995).

$$\hat{h}_i^2 = \sum_{i=1}^{k} \hat{l}_{ij}^2$$

where $\hat{l}_{ij}$ are the elements of the loading matrix L, calculated from the eigenvalues and –vectors of the observed correlation matrix.

The loading matrix L describes the relationship between variables and factors. The interpretation is simple if each factor is loaded highly by some variables and lowly by the remaining variables. To get a good interpretation of the loading matrix it can be transformed by an orthogonal matrix M without changing the communalities and the residual variances. If L^* denotes the transformed loading matrix then

$$L^* = L \cdot M$$

and

$$L \cdot L^T + U = L \cdot M^T \cdot M \cdot L + U = L^{*T} + U .$$

This transformation is called factor rotation, since multiplication by an orthogonal matrix rotates the coordination system. After rotation, the order of the factors no longer has any intrinsic meaning.

There are several ways to determine the number of retained factors. According to the Kaiser-criterion all factors with an eigenvalue greater than 1 are retained. An alternative is to determine the number of factors at that factor where a sizeable drop in the eigenvalue occurs. Another alternative is to specify the desired share of the total variance that should be explained by the factors.

The factor analysis for the reasons of postponing a price change shows two factors with an eigenvalue larger than one (Table B1), where the second eigenvalue is only slightly larger than 1. However, the eigenvalue of the third factor (0.3) is clearly smaller. Thus, the Kaiser-criterion favors at most two factors. A sizeable drop in the eigenvalue occurs between the first and the second factor and between the second and the third factor, so that again at most two factors should be retained. The first factor already explains 73 per cent of the total variance. The two factor solution explains

slightly more than the total variance thereby indicating that in a two factor solution some variables are assigned to both factors, what is undesirable. Hence, from a formal point of view a one factor solution might even be preferable to the two factor solution. However, the interpretation of the outcome of the one factor solution is almost impossible and the residual variances of most variables are too large. Therefore, we choose two factors.

Table B1: Eigenvalues for the factor analysis of the reasons for postponing a price change

Factor	Eigenvalue	Difference	Proportion	Cumulative
1	2.5885	1.4247	0.7315	0.7315
2	1.1638	0.8575	0.3289	1.0604
3	0.3063	0.0210	0.0866	1.1469
4	0.2853	0.1449	0.0806	1.2276
…	…	…	…	…
Total	3.53854	-	-	1.0000
Number of observations				895

Since the second factor is easier to interpret than the first, the discussion starts with the second factor. It is named "time-dependence" because the variables "price change preferably at a specific point of time" and "price change preferably after a specific period of time" are assigned uniquely to this factor. A negative loading shows up for the variable "price change in advance if possible". This negative sign is interpreted as reflecting state-dependent price setting because state-dependence is the opposite of time-dependence. However, this variable should not exclusively be assigned to the second factor since it displays a positive factor loading for the first factor that is not much smaller than the one for the time-dependent factor. The menu cost variable shows similar behavior. It loads positively with the time-dependent factor yet also correlates with the first factor. All the other reasons can be assigned to the first factor. The price elasticity of demand, transitory shocks and coordination failure are the variables that mainly constitute the first factor. For nominal fixed-term contracts and sluggish costs, the two-factor model is a poor fit.[13] There is no good catchword for the

[13] In fact, if one allows for four factors, nominal fixed-term contracts show up as a distinct factor.

first factor, yet as the price elasticity of demand and coordination failure are related to competition, the first factor is called "competition".

Table B2: Factor loadings for reasons for postponing a price change

Reason	Factor 1: Competition	Factor 2: Time-dependence	Communalities
Regular date	0.0171	**0.7092**	0.5032
Regular time interval	0.0677	**0.6687**	0.3517
Foreseeable price change in advance	**0.2067**	**-0.3351**	0.1550
Menu costs	**0.2195**	**0.2902**	0.1324
Nominal fixed-term contract	**0.2305**	0.0294	0.0540
Sluggish costs	**0.3162**	0.1308	0.1171
Coordination failure (increase)	**0.5222**	-0.0898	0.2808
Transitory shock (increase)	**0.6208**	-0.0044	0.3854
Price elasticity of demand (increase)	**0.6531**	0.0083	0.4265
Coordination failure (decrease)	**0.5669**	0.0873	0.2290
Transitory shock (decrease)	**0.6430**	0.0896	0.4215
Price elasticity of demand (decrease)	**0.7029**	0.0403	0.4957

Nota bene: The table displays the rotated (principal) factors. Loadings of items that are designated to a specific factor are in **boldface**. Dotted lines distinguish groups of reasons that were used for the cluster analysis.

Although two interpretable factors were identified, the exercise reveals several serious problems. First, the assignment of the items to the factors is not unique: physical menu costs are one example. Second, the communalities of several items are very low (see Table B2). For example, both factors explain only 1 per cent of the variance of sluggish costs. In other words, the number of explanations for price stickiness cannot be reduced to a small number of possibly latent reasons by a factor analysis. This would lead to a substantial loss of information. For the cluster analysis we therefore group the reasons for postponing a price change as indicated in Table B2 by the dotted lines. However, the factor analysis suggests that the question of time-dependence versus state-dependence and the remaining reasons are two distinct issues, which is an interesting outcome.

The factor analysis for the reasons for price changes again gives us two factors "costs" and "demand" (see Table B3 and B4). However, the fit of the model does not

favor the use of the factors for the data analysis in general. Their use should be restricted to cases where simplicity is preferable to a good fit.

Table B3: Eigenvalues for the factor analysis of the reasons of changing a price

Factor	Eigenvalue	Difference	Proportion	Cumulative
1	3.1315	1.3957	0.5432	0.5432
2	1.7358	0.9232	0.3011	0.8443
3	0.8126	0.2722	0.1410	0.9852
4	0.5404	0.1786	0.0937	1.0790
…	…	…	…	…
Total	5.7649	-	-	1.0000
Number of observations				1067

Table B4: Factor loadings for reasons of changing a price

Reason	Factor 1: Costs	Factor 2: Demand	Communalities
Permanent wage increase	**0.5277**	-0.1178	0.2923
Temporary wage increase	**0.4383**	0.1744	0.2236
Financing costs, increase	**0.5499**	0.1493	0.3247
Costs for material, increase	**0.3962**	-0.1281	0.1733
Wages, reduction	**0.6738**	0.0328	0.4551
Financing costs, reduction	**0.6646**	0.1823	0.4750
Costs of materials, reduction	**0.5419**	0.0124	0.2938
Productivity increase	**0.5361**	0.2234	0.3373
Demand increase (price reduction)	**0.3410**	**0.4856**	0.3520
Demand increase (price increase)	0.0682	**0.6837**	0.3821
Demand decrease (price reduction)	0.1091	**0.6189**	0.3949
Demand decrease (price increase)	0.2222	**0.5953**	0.4037
Price increase by competitor	-0.0930	**0.5171**	0.2760
Price reduction by competitor	-0.1215	**0.5013**	0.2660
Product improvement	0.1499	**0.3240**	0.1275

Nota bene: The table displays the rotated (principal) factors. Loadings of items that are designated to a specific factor are in **boldface**. Dotted lines distinguish groups of reasons that were used for the cluster analysis.

Annex C

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98 53 69

Special survey on the formation of producer prices

The questions concern the product mentioned below (in the sequel denoted by XY). Please mark the relevant box.

Your answers are analysed strictly confidential. The respective laws are warranted.

Identification no.

Product (XY):

Please refer your answers to the above mentioned product!

General information

1) The share of XY with respect to total sales amounts to 81 %

2) Our customers for XY are from (share of sales)

Germany	76 %
other Euro-area countries	14 %
other countries	10 %
	100 %

3) Our price setting in the remaining Euro-area / other countries differs from our domestic market with respect to

	other Euro-area countries	other countries
to the timing	8 %	10 %
the amount	13 %	17 %
the reasons	11 %	15 %
It is not different	75 %	68 %

Please refer your answers from now on to the domestic market, respectively to the whole Euro-area if the price setting there is not different from the domestic market!

4) The breakdown of our sales with XY with respect to customers is

our own group	7 %
other industrial enterprises	50 %
wholesale	17 %
retail, department stores, hypermarkets, mail order houses	12 %
private costumers	6 %
government	4 %
others	4 %

5) Our sales share of XY with customers, who regularly ask for prices, amounts to 57 %

6) The number of our most important competitors for XY on the domestic market amounts to

less than 5	18 %
between 5 and 20	54 %
more than 20	28 %
We do not have any significant competitor	0 %

Information regarding price formation

7) Our prices are revised (without being necessarily changed)
regularly 81 %
daily 6 % weekly 4 % monthly 10 %
quarterly 13 % semi-annual 13 % yearly 21 %
on certain events (e.g. if costs changes are large) 54 %
within the scope of an ex post calculation 46 %

8) We have a certain margin for setting our price and determine it

by applying a constant mark-up on calculated unit costs	4 %
by taking calculated unit costs as reference and varying the mark-up taking into account market and competition conditions	69 %
by taking the price of our main competitor as a reference	17 %
by tying it to another price (e.g. wage)	5 %
in a different manner	12 %

9) We have almost no margin for price setting 12 %

10) We warrant our price on average for a period of 7.7 months.

11) Our sales share of XY under written contracts that set prices for a stated period amounts to 60 %
These prices are tied by contract to the development of other variables (e.g. collectively negotiated wages) 11 %
Prices are fixed for 9 months on average.

12) Our per unit profit is lower during a downturn 51 %

13) Our price is constantly reduced during the life-cycle 17 %

Please mark according to significance.
(1)=minor importance to (4)=great importance

14) The calculations underlying our price setting are based on

	(1)	(2)	(3)	(4)
extrapolating past values (e.g. average price increase of intermediate inputs during the preceding year, past cost development)	22	29	31	18
the actual development	8	15	32	45
expectations, that are not based on extrapolating past values (e.g. future cost increases)	28	33	26	13

(page 1 of 2)

Please take into account from now on only those price changes that belong to transactions and not to pure list price changes.

15) Our price for XY

is the same for all customers 11 % depends on the amount bought 50 % is decided upon case by case 62 %

16) Starting from a satisfying business situation we change our prices if there is an	minor importance (1)	(2)	greater importance (3)	(4)
Price increase				
permanent increase in labor costs (e.g. negotiated wage increase)	15	28	33	24
transitory increase in labor costs (e.g. overtime hours, bonuses)	62	29	6	3
increase in financing costs	40	35	20	5
increase in costs of materials	4	7	33	56
product improvement	22	39	28	10
demand increase	26	38	26	10
demand reduction	32	32	25	11
price increase by a competitor	29	37	25	9
other reasons	58	16	7	19
Price reduction				
decrease in labor costs (e.g. bonuses, lay offs)	44	30	18	8
decrease in financing costs	53	34	11	3
decrease in costs of materials	15	21	29	35
increase of productivity	17	36	36	11
demand increase	38	35	20	7
demand reduction	24	32	30	14
price reduction by a competitor	21	24	34	21
other reasons	61	14	8	17
17) We change our prices at a regular date if possible (e.g. beginning of the year)	51	14	19	16
We change our prices according to a regular time interval if possible (e.g. after 12 months)	52	17	17	15
We make a foreseeable price change in advance if possible	19	20	39	22
We postpone a price change because				
a fixed term contract explicitly prohibits a price change	31	20	24	25
a price change entails high costs (e.g. printing of price lists)	71	20	8	1
our variable costs hardly vary during the business cycle	42	41	14	3
We postpone a price increase for fear that				
competitors do not rise their prices too	20	23	35	23
after a short while a price reduction would be necessary	46	29	19	6
the hoped for additional revenues due to a higher unit price do not compensate for the feared losses due to a lower number of units sold	30	34	25	11
other reasons	94	3	1	3
We postpone a price decrease for fear that				
competitors decrease their prices too	42	31	18	9
after a short while a price increase would be necessary	40	31	20	9
the hoped for additional revenues due to a higher number of units sold do not compensate for the feared losses due to a lower unit price	33	31	25	10
other reasons	96	3	1	1

Thank you very much for your cooperation!

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