Staggering versus Synchronization in Retail Price Changes[*]

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Abstract

This paper presents non-parametric evidence on the degree of synchronization and staggering in retail price changes. Staggering is found to be more common across stores than products, though a non-negligible degree of synchronization exists across different stores.

Key words: Retail Price Data, Microeconomic Evidence, Synchronization versus Staggering

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1   INTRODUCTION

In most monetary models of the business cycle, some form of price stickiness is a necessary

prerequisite for nominal shocks having a long-lasting impact on the macroeconomy. However, it

is not a sufficient one.[1] If all stores reset their prices at the same time, the aggregate impact of

demand shocks lasts no longer than the duration of individual price quotations, a claim typically

at variance with macroeconomic facts. To make sticky price theories consistent with the

aggregate data, the extra assumption invoked in business cycle models is staggered

microeconomic price setting.

      Based on a new panel of retail prices recorded in Hungary, the purpose of this paper is to

provide direct store level evidence on the relevance of the staggering assumption. To do so, the

paper documents basic patterns in the timing of price changes in a novel store level price date

set. To preview the main results, first, staggering is found to be more common across stores than

across products within a store. Nonetheless, a non-negligible degree of synchronization exists

across different stores. Price setting is particularly synchronized in times of large input price

shocks.

      The rest of the paper is organized as follows. After briefly reviewing the relevant theory

motivating the empirical work in Section 2, the retail price dataset is described in Section 3. In

Section 4 the results are presented, while the concluding remarks are offered in Section 5.

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[1] The terms staggered and asynchronized are used interchangeably throughout.

The degree of coordination in the timing of lumpy microeconomic pricing decisions is key in assigning any role to monetary policy in generating persistent fluctuations in the aggregate economy.[2] The basic idea in classic models of time-dependent price (or wage) determination with exogenously imposed staggering mechanism as developed in Taylor (1980) and Blanchard (1983) is the following. Firms operating in monopolistically competitive markets set their price for fixed durations several periods in advance. In each period, a constant fraction of the multi-period contracts governing price-setting behavior is renewed, while others left unaltered. Overlapping contract-periods give rise to persistence in output and price dynamics at the aggregate level. Caplin and Spulber (1987) demonstrate that even microeconomic price stickiness and staggering in price changes together may not be sufficient to do the job, however. With an one-sided (S,s) policy and a uniform distribution of price deviations, demand shocks may instantaneously change the aggregate price level and have no real effect. Caplin and Leahy (1991) show that the neutrality result does not extend to two-sided (S,s) pricing policies.

Even if one takes the idea of staggering seriously, it is not obvious *why* stores would endogenously choose to stagger their price changes. Ball and Cecchetti (1988) present a model of endogenous (a)synchronization with time-dependent pricing rules and optimal signal extraction from imperfect information on local demand conditions. In the model firms are tempted to wait for others and keep their own price changes fixed as the preceding decisions of other firms in their neighborhood contain information relevant to their pricing decision. Information gains from staggering outweigh the costs of relative price fluctuations when

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[2] See the survey article of Taylor (1999).

aggregate shocks common to all firms are small relative to idiosyncratic ones. Conversely, if costs to relative price variation are relatively high (corresponding to high demand elasticity), synchronization is superior to staggering.

Models of staggered price setting are often silent or vague about the actual level of coordination in the timing of price changes. Besides purely geographical variation, it is useful to distinguish two other complementary stages of comovement in price changes, the cross-store and the cross-product one. First, for instance, if store-specific shocks dominate product-specific ones, misalignments in the timing of price changes are more likely to show up across the different stores selling the same product, rather than within individual stores. Conversely, if product-specific shocks reign, one could be more interested in the extent to which multi-product stores coordinate the timing of price changes across the different items they sell. Finally, if pricing decisions are dominated by industry-specific shocks, staggering must prevail across the different industries, with stores or firms in an industry bunching their price changes together.[3]

In the sticky price literature it is normally assumed that a monopolistically competitive firm sells a single product. Modeling explicitly multi-product stores along these lines is still in its infancy. Sheshinski and Weiss (1992) are the first ones who study the optimal pricing policy of a monopolist selling two different goods in the presence of fixed cost of price adjustment. They show that with strategic complementarities in the profit function, the only stable equilibrium is the synchronization of price changes within stores. In contrast, when the adjustment cost is proportional to the number products sold and the profit function exhibits strategic substitutability, within-store staggering is dominant.

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[3] Bhaskar (2002) shows that stronger intra-industry than inter-industry strategic complementarity implies intra-industry synchronization and inter-industry-staggering as a stable equilibrium.

The focus of this study is on a longitudinal data set of store level retail prices. The sample includes monthly frequency observations of prices of fourteen processed meat products.[4] The items are important, well-defined, homogeneous food products with insignificant variation in non-price characteristics. The observations are recorded in nine continuously operating, distinct and geographically dispersed stores in Budapest, Hungary. Out of the nine stores six are larger department stores and three are smaller grocery stores, called Közért. Stores sell many other products besides the ones considered here. The market structure of stores is relatively stable and their identity did not change over time. The store coverage ratio is 100 percent in the sample; whenever data collectors visit a particular store, all the fourteen prices are available and recorded. During the sample period, there was no government control of the product-prices considered here.

The sample period starts in January 1993 and ends in December 1996. It splits into two parts (Period 1 and Period 2) due to a five-month long intermission in data collection between April and September 1995. The sample is unbalanced: the number of months with non-missing observations for a particular store ranges from 31 to 43 with an average of 38.22. The average

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[4] They include back ribs, boneless chop, brisket, center chop, fat bacon, hot dog, leg, round, roast, sausage for boiling, shoulder, smoked loin/ham, spare ribs, thin flank. Meat products are standard food items in Hungary; their purchases constitute a significant portion of aggregate spending. The Central CSO uses a 5.69% weight for meat items in computing the CPI.

number of stores observed in a month is 8.01. The total number of store-product-month specific observations is 2968 in Period 1 and 1848 in Period 2.

Sample price aggregates are informative of economy-wide measures of inflation during the episode at hand. First, the correlation between average price changes in the current sample and a similar measure of processed meat product price changes tabulated by the Central Statistical Office, Hungary and based on a larger sample of stores is 0.98.[5] Second, the correlation between the present price index and the food CPI compiled by the CSO is 0.94. Finally, both visual inspection and simple regressions confirm that these meat product prices and overall food prices follow similar seasonal patterns.

The duration of price quotations and the size of price changes indicate that pricing decisions are lumpy. Prices in the sample are unchanged in 58 percent of the cases and the average duration of price quotations is about three months. The longest spell is 17 months. The average size of non-zero price changes is about 9 percent in the whole sample, with the largest size being about 63 percent. The average size of positive changes is 11.3 percent. The corresponding figure for average negative changes is -7.15.

4   RESULTS

How to measure the degree of synchronization? To fix ideas, first, the overall average of the proportion of price adjustments in a given month, $\alpha_{.t}$, is computed as

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[5] Meat product prices tend to track well food prices in general: the correlation coefficient between the food CPI inflation and CSO measured meat product price inflation is 0.52 during the sample period.

$$\alpha_{.t} = \frac{\sum\limits_{i=1}^{P_t}\sum\limits_{j=1}^{S_{jt}} I_{ijt}}{P_t S_{jt}},$$

where P_t is the number of products sold in a store at time t (that is, fourteen), S_{jt} is the number of

stores observed in a particular month and I_{ijt} is an index number that equals zero if store i at time

t decided not to change the price of product j, and equals one if it did. Conforming to the average

duration of price quotations in the sample, the average value of α_t calculated over the whole

period is 0.41. As a first glance at temporal agglomeration in price setting, Figure 1 plots the

time series of α_t. The resulting picture indicates temporal concentration in pricing activity,

especially in the third quarter of the year. Stores tend to change their prices in concert; the

average adjustment proportion is 0.61 in the third quarter. Not surprisingly, periods of high

pricing intensity exhibit similar seasonal patterns as monthly inflation spikes.

4.1   Across-Store Patterns

For each product j and period t, the proportion of stores making price adjustment is defined as

$$\alpha_{jt} = \frac{\sum\limits_{i=1}^{S_{jt}} I_{ijt}}{S_{jt}}.$$

The graphs in Figure 2 plot separately the time series for all the all the fourteen product-specific

proportions. To highlight the specific role of third quarters in adjustment intensities, the dashed

lines connect the proportions observed in July, August and September. Assuming perfect

staggering, one would expect to see stable sequences of adjustment proportions with moderate

fluctuations centered on the inverse of price quotation durations. A visual inspection of the

graphs does not seem to corroborate the presence of perfect staggering. By often taking on the

extreme values of zero and one, the series fluctuate substantially over time. At the same time,

when third quarter proportions are excluded, somewhat smoother patterns appear to emerge.

Figure 3 displays the histogram of adjustment proportions. With perfect staggering, given the

frequency of price adjustments, the histogram would feature a mode at the 0.3-0.4 bins.

Entries in Table 1 summarize product-specific mean values and standard deviations of α_{jt}

both for the full sample of proportions and the ones excluding third quarter proportions. In the

former category, product-specific standard deviations vary between 0.22 and 0.32 with the

corresponding mean values of adjustment proportions being between 0.26 and 0.57. Excluding

third quarter proportions reduces standard deviations by about 10 percent.[6]

It is instructive to compare actual standard deviations to ones obtained from the two

counterfactual extremes: perfect synchronization and perfect staggering. In the former case,

standard deviations are computed by inserting alternating zeros and ones in the proportion

sequences. In particular, given that the average duration of price quotations is about three

months, every third proportion is set to one and the others to zero. This approach leads to an

expected standard deviation of about 0.48. With perfect staggering, about one-third of stores is

assumed to alter its price at a time. This assumption implies sequences of product specific

proportions of 0.33 and expected standard deviations that are small, close to zero at the very

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[6] Though the rejection probabilities of F-tests indicate that the reduction is statistically not
significant.

extreme. Comparison of the counterfactual standard deviations to the actual ones displayed in Table 1 indicates that the actual standard deviations are at about equal distance from the two extremes.

Taking into account the differences in average durations and the small number of stores in the sample, staggering could be defined in more flexible ways. If all realizations of adjustment proportions between 0.1 and 0.5 assumed to indicate staggering, 56.2 percent of the proportions count as staggering. Alternatively, all adjustment proportions different from perfect synchronization, that is, adjustment proportions between 0.1 and 0.9 are assumed to count as realizations of staggered price setting. According to this definition, 84.5 percent of the proportions indicate staggering.

4.2   Within-Store Patterns

Due to the relatively large number of homogenous products sold continuously in all stores in the sample, the current data set is particularly suitable for analyzing the extent to which the timing of price changes *within* individual stores are synchronized. First, the proportion of products whose price changed in store i at time t is defined as

$$\beta_{it} = \frac{\sum_{j=1}^{P_t} I_{ijt}}{P_t}$$

where P_t is the number of products in a store (14 in the present sample) and I_{ijt} is an index that equals zero if store i did not change the price of product j at time t, and equals one if it did.

Separately for the nine different stores, the panels in Figure 4 plot the time series of the constructed adjustment proportions. Producing occasionally sharp twists, the series are bouncing around quite a bit; the proportions often take on extreme high and low values in tandem. As shown in Table 2, the average of the store-specific means of adjustment proportions is 0.4 with some variation across stores ranging from 0.3 to 0.51. The average of standard deviations is 0.29. Excluding third quarter proportions gives rise to proportion series with standard deviations of more than 10 percent smaller on average than that of the original series.[7] Note that standard deviations for both the full series and the ones without the third quarter are larger than the corresponding standard deviations for across-store proportions.

Now, consider again the two extreme counterfactual cases of perfect staggering and synchronization. With perfect staggering standard deviations should be close to zero, while with perfect synchronization they are expected to be about 0.5. Similarly to across-store proportions, within-store figures displayed in Table 2 suggest that standard deviations are about equal distance from the two hypothetical extremes. Figure 5 depicts the histogram of within-store adjustment proportions. It shows that adjustment proportions between 0.1 and 0.5 constitute 40.4 percent of all proportions and proportions between 0.1 and 0.9 make up 69.6 percent.

5 RELATED EVIDENCE

Microeconomic evidence on the extent of concurrence in microeconomic price changes is sparse. The current data is most comparable to the present one in its size and the nature of products

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[7] The difference in the standard deviations is statistically significant for only one of the stores.

involved are the ones analyzed in Lach and Tsiddon (1996). Lach and Tsiddon examine pricing practices in an unbalanced panel of stores selling processed meat and liquor products during a highly inflationary era in Israel in 1978-79 and 1982. Analogously to the present results, Lach and Tsiddon arrive at the conclusion that the "data exhibit *across-store staggering* and *within-store synchronization* in the timing of price changes".[8] A clear advantage of the Israeli sample is that it includes a relatively large number stores in a given month. At the same time, its store coverage ratio is only about 60 percent.

Tommasi (1993) examines retail price data collected in Argentinean in a highly inflationary period in the early 1990s. He finds that price adjustments tend to be asynchronized within stores at the *weekly* frequency. This result is not necessarily incongruent with the finding of synchronization obtained in monthly frequency data. In general, if sampling intervals are long enough compared to actual price durations, price changes are almost bound to be synchronous. At high rates of inflation it is especially conceivable that prices are staggered at the weekly frequency, yet they are bunched when observed on a monthly basis. The argument does not work in the opposite direction, of course. If prices are bunched at the weekly frequency then they cannot be staggered at the monthly one.

Fisher and Konieczny (2000) provide both descriptive and parametric evidence on the degree of synchronization in Canadian daily newspaper prices over a sixteen years period. The sampling frequency in their sample is irregularly spelled over time, on average it is about six

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[8] One should be careful with this interpretation though. For example, the proportion of stores adjusting meat product prices is larger than 0.6 in about 70 percent of the cases in the sample. A preferable reading of their findings might be that elements of synchronization and staggering coexist, and their relative weight is contingent on the metric chosen.

months.[9] They find that the degree of synchronization tends to be stronger for newspapers that are published by the same company, providing evidence for synchronization of price changes by multi-product firms.

5   SUMMARY AND DISCUSSION

Even if one accepts the view that microeconomic prices are sticky, it awaits clarification in what particular way they are so and how microeconomic stickiness is related to the macroeconomy. An important mission of empirical studies like the present one is to provide food for thought for modeling price setting behavior.

This study explores the role of heterogeneity in the timing of price changes in a sample of individual retail prices collected in Hungary. While the results are based on a relatively small number of stores and products, several conclusions emerge. First, synchronous price changes tend to be concentrated into the same part of the year, the third quarter. A possible interpretation of this timing pattern could be that stores' pricing behavior contains a time-dependent component as well. Stores may mechanically change their price at the same time of the year, at other times they do so only when their price deviation sufficiently gets eroded that the fixed adjustment cost is worth paying. In addition, as argued by Ball and Cecchetti (1988), if the common shocks are large enough different stores may optimally react to these shocks in a

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[9] However, as price quotations on average are three times longer than the average sampling frequency, the irregularity is unlikely to cause any bias in the results.

synchronous manner. As in Bhaskar (2002), synchronization can be also explained by that the items are relatively close substitutes to each other.

Results of within-store synchronization are informative of the multi-product (S,s) pricing model of Sheshinski and Weiss (1992). There adjustment costs could be strictly linear in the number of price changes of distinct items within a particular store (decision cost), or they may contain a store-specific component (menu cost). The finding of significant within-store bunching lends more support to the menu cost interpretation of price adjustment costs. That is, restrictions placed on a multi-product store's optimization problem should include the assumption of store-specific menu costs.

Finally, the degree of synchronization in the timing of lumpy pricing decisions is a critical issue for policymakers in countries attempting to fight inflation. In a model of time-dependent price setting, Blanchard (1983) shows that imperfectly coordinated price changes lead to higher persistency in output and increased output costs of disinflation. Costly disinflation may in turn actually perplex policymakers' ability to reduce inflation inertia. In the end, countries fighting inflation may actually enjoy the benefits of a microeconomic arrangement in which price setting is dominated by strong bunching effects.

REFERENCES

Bhaskar, V. (2002): On Endogenously Staggered Prices, *Review of Economic Studies*, pp. 99-116

Blanchard, Olivier Jean (1983): Price Asynchronization and Price Level Inertia, in *Inflation, Debt and Indexation*, R. Dornbusch and M. H. Simonsen, eds., Cambridge, MA: MIT Press, pp. 3-24

Caplin, Andrew S. and Daniel F. Spulber (1987): Menu Costs and the Neutrality of Money, *Quarterly Journal of Economics*, pp. 703-726

Caplin, Andrew S. and John Leahy (1991): State-Dependent Pricing and the Dynamics of Money and Output, *Quarterly Journal of Economics*, pp. 683-708

Fisher, Timothy C. G. and Jerzy D. Konieczny (2000): Synchronization of Price Changes by Multiproduct Firms: Evidence from Canadian Newspaper Prices, *Economics Letters*, pp. 271-277

Konieczny, Jerzy D. and Andrzej Skrzypacz (1999): Inflation and Relative Price Variability in a Transition Economy, manuscript

Lach, Saul and Daniel Tsiddon (1996): Staggering and Synchronization in Price Setting: Evidence from Multiproduct Firms, *American Economic Review*, pp. 1175-1194

Sheshinski, Eytan and Yoram Weiss (1992): Staggered and Synchronized Price Policies under Inflation: The Multiproduct Monopoly Case, *Review of Economic Studies*, pp. 331-359

Taylor, John B. (1980): Aggregate Dynamics and Staggered Contracts, *Journal of Political Economy*, pp. 1-24

Taylor, John B. (1999): Staggered Price and Wage Setting in Macroeconomics, Chapter 15 in John B. Taylor and Michael Woodford (eds.), *Handbook of Macroeconomics*

Tommasi, Mariano (1993): Inflation and Relative Prices: Evidence from Argentina, in *Optimal Pricing, Inflation, and the Cost of Price Adjustment*, E. Sheshinski and Y. Weiss, editors, Cambridge, MA: MIT Press, pp. 485-514

Table 1

Average Proportion of Stores Adjusting Price

Products	rk	hk	sc	so	sd	mf	mr	msz	vi	lk	sl	st	fft	esz	Average
Mean[a]	0.52	0.54	0.57	0.50	0.51	0.30	0.26	0.27	0.29	0.27	0.55	0.54	0.35	0.28	0.41
Standard Deviation[a]	0.31	0.30	0.31	0.30	0.30	0.26	0.27	0.28	0.23	0.22	0.32	0.30	0.23	0.24	0.27
Mean[b]	0.44	0.47	0.51	0.43	0.44	0.26	0.20	0.22	0.25	0.23	0.48	0.47	0.32	0.24	0.35
Standard Deviation[b]	0.28	0.27	0.30	0.28	0.27	0.22	0.22	0.22	0.21	0.21	0.30	0.27	0.23	0.23	0.25
F-test[c]	0.61	0.60	0.84	0.64	0.59	0.33	0.22	0.18	0.73	0.98	0.77	0.67	0.92	0.84	0.64

Notes: [a]   Product-specific adjustment proportions - full, untruncated series.

               [b]   Product-specific adjustment proportions - series with third quarter proportions excluded.

               [c]   The probability of not rejecting the null hypothesis of the equality of the variance of the two series.

Table 2
Average Proportion of Products with Nominal Price Adjustment

Stores	n4	n2	n1	n11	n5	n3	k6	k4	k3	Group Average for Larger Stores (n)	Group Average for Smaller Stores (k)	Overall Average
Mean[a]	0.31	0.40	0.30	0.41	0.51	0.50	0.42	0.32	0.46	0.40	0.40	0.40
Standard Deviation[a]	0.32	0.29	0.27	0.31	0.29	0.29	0.28	0.28	0.32	0.29	0.29	0.29
Mean[b]	0.24	0.36	0.30	0.33	0.46	0.44	0.37	0.22	0.37	0.36	0.32	0.34
Standard Deviation[b]	0.30	0.28	0.27	0.26	0.29	0.29	0.23	0.19	0.28	0.28	0.23	0.27
F-test[c]	0.74	0.77	0.96	0.40	0.97	0.91	0.31	0.05	0.49	0.79	0.28	0.62

Notes: [a] Store-specific adjustment proportions - based on full series.

[b] Store-specific adjustment proportions - based on series with third quarter proportions excluded.

[c] The probability of not rejecting the null hypothesis of the equality of the variance of the two series.

Figure 2

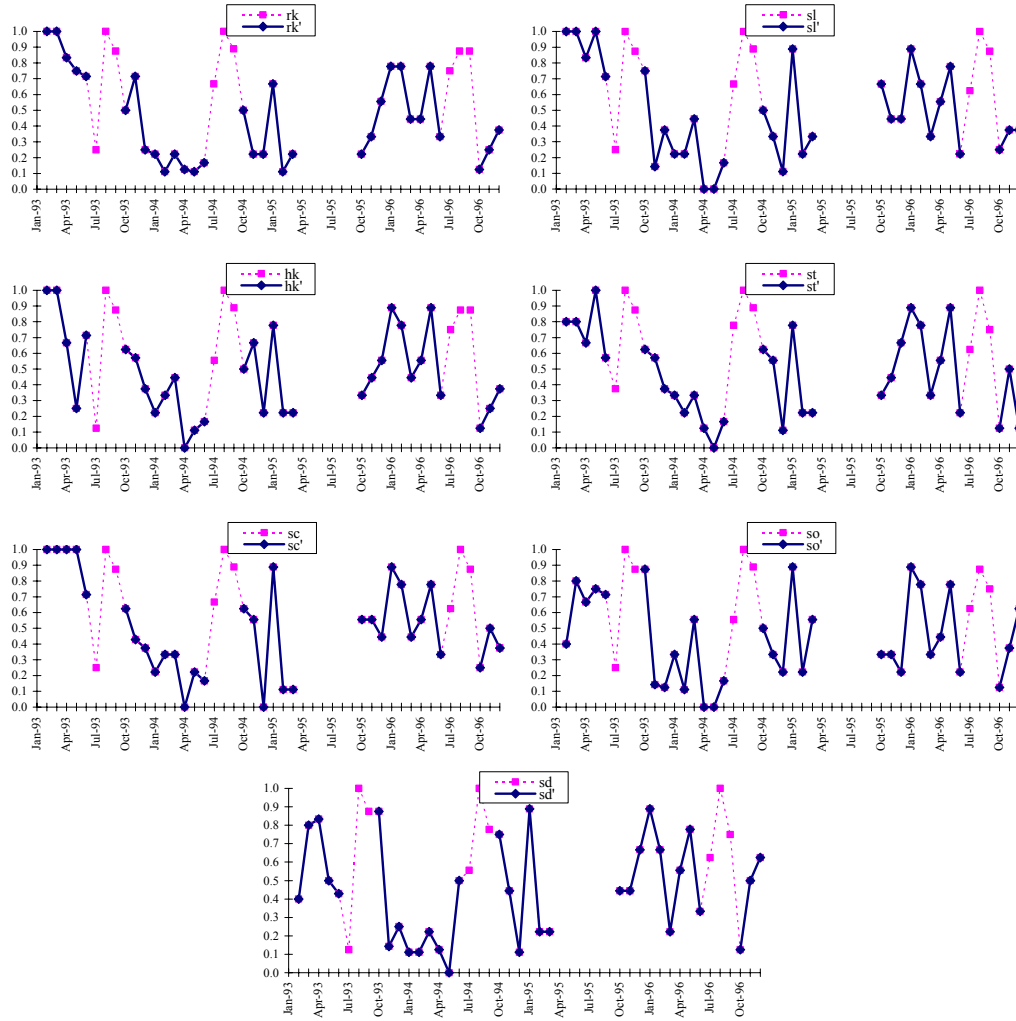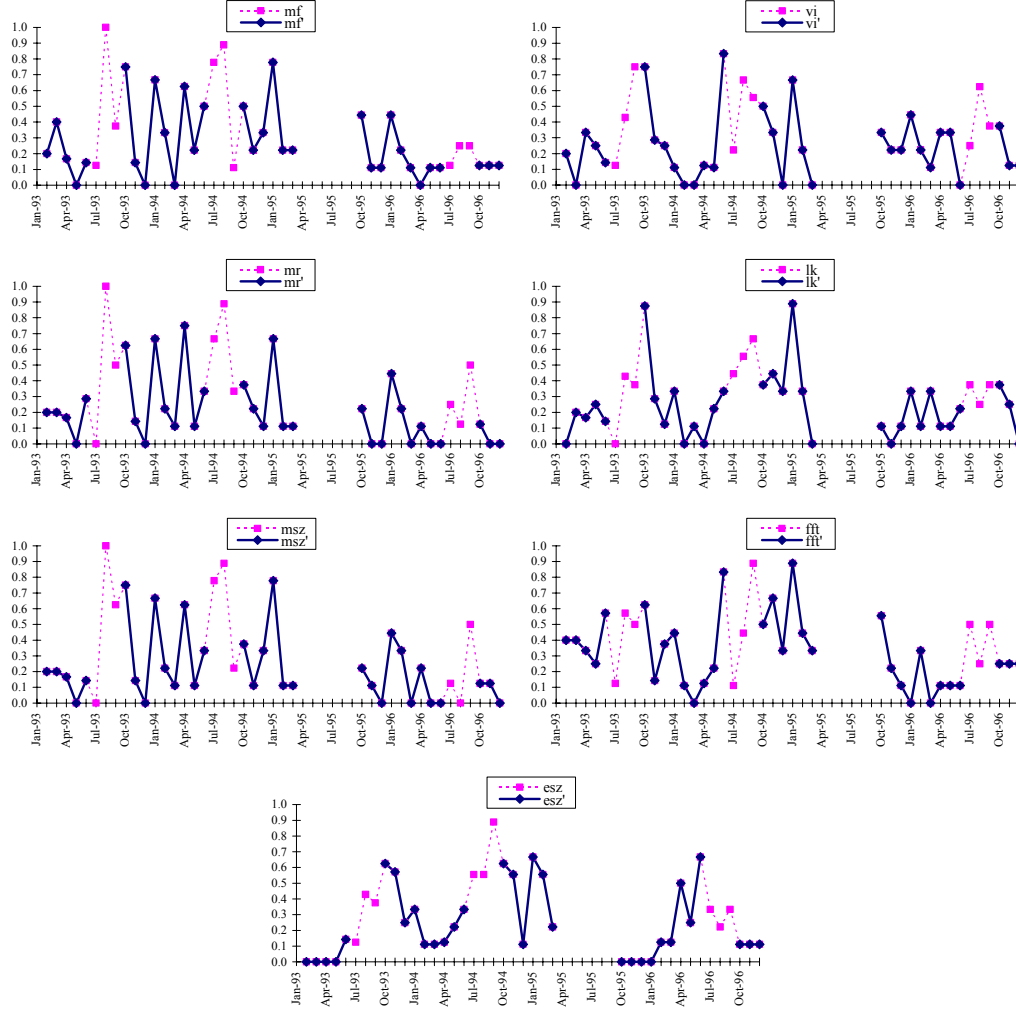## Product-Specific Proportion of Stores Changing Prices

Figure 2 (cont'd)
Product-Specific Proportion of Stores Changing Prices

Figure 3
Histogram of Proportions of Stores Adjusting at a Time
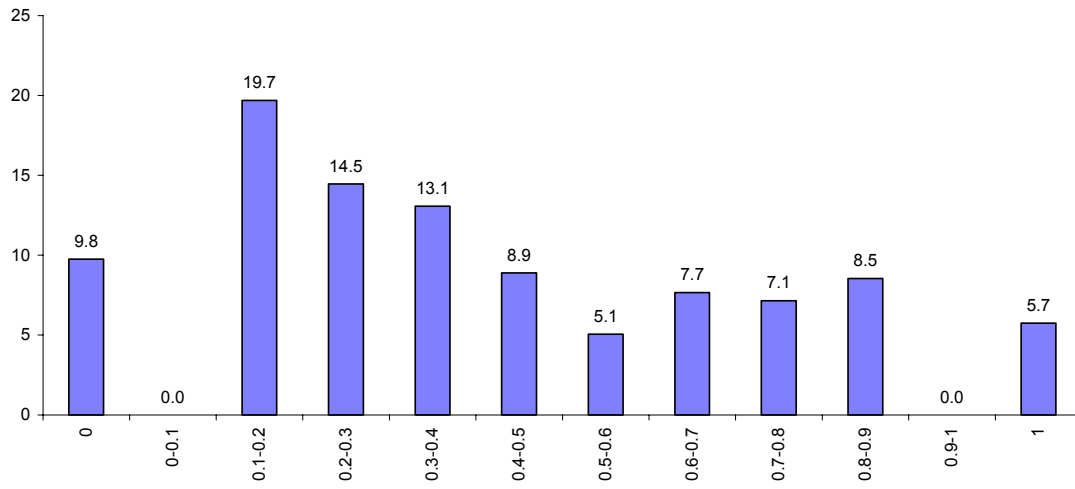**(in percentage)**

Figure 4
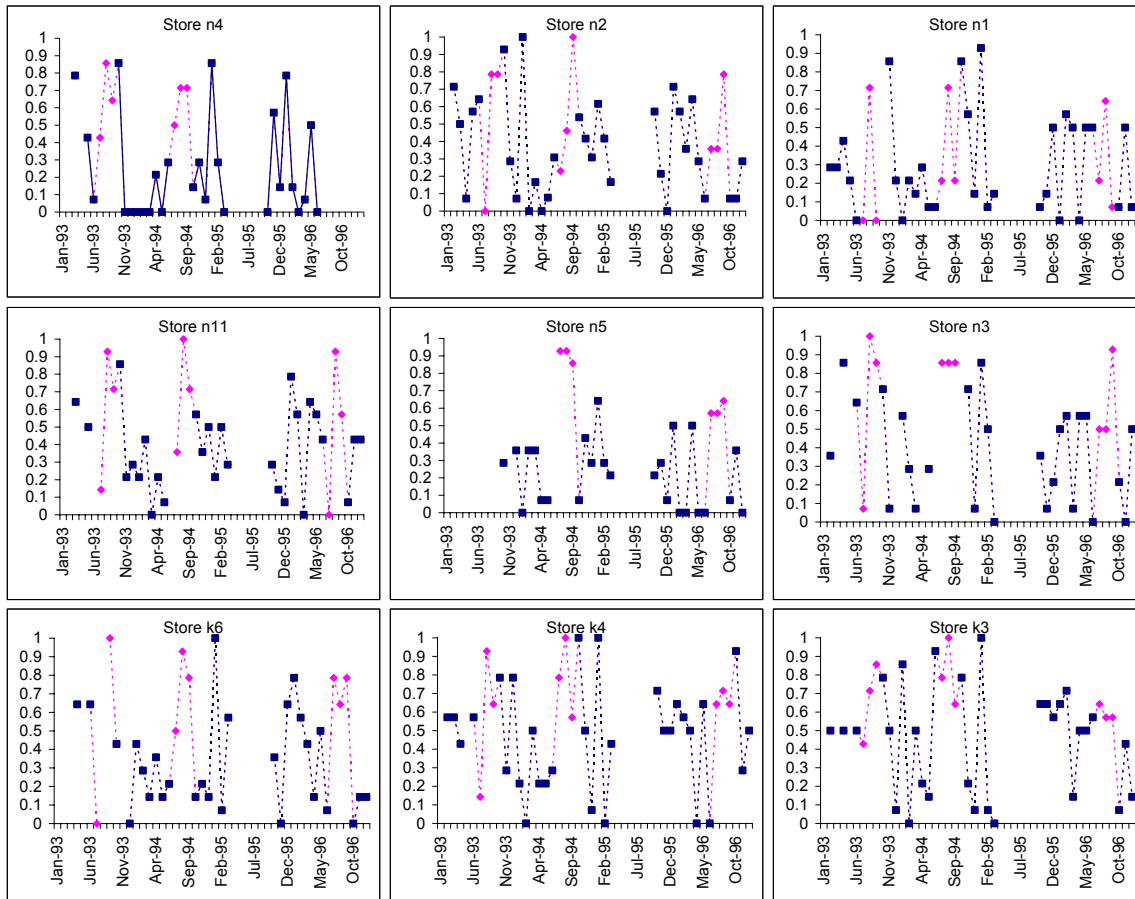Proportion of Products with Price Change Within Stores

Figure 5
Histogram of Proportion of Products with Price Change Within Stores
(in percentage)