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## Staggering and Synchronisation of Prices in a Low Inflation Environment: Evidence from German Food Stores

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# Staggering and Synchronisation of Prices in a Low Inflation Environment: Evidence from German Food Stores<sup>1</sup>

## *Abstract*

*Only a few studies have analysed staggering and synchronisation in pricing behaviour of multi-product firms. These studies used low-frequency data in an environment of high rates of inflation. This paper investigates staggering and synchronisation of weekly prices for ten food products in 131 grocery stores in Germany over the period from May 1995 to December 2000 (296 weeks). Different forms of staggering and synchronisation (across-store synchronisation, within type-of-store synchronisation, within retailer synchronisation or across-product synchronisation) have been analysed. None of these forms of synchronisation is supported empirically however. In contrast, perfect staggering can only be rejected in very few cases indicating that fixed or firm specific menu costs are not major causes for price stickiness.*

JEL classification: L11, D40

Keywords: Food Retail Market, Germany, Pricing Behaviour, Menu Costs

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## 1 Introduction

Much of the motivation for studying staggering and synchronisation of prices originates from the macroeconomic literature, where the stickiness of prices and wages are blamed for real effects of nominal shocks. Whereas traditional Keynesian analysis took the assumption of sluggish price adjustment for granted, new-Keynesian economics has primarily involved the search for rigorous and convincing models of wage and/or price stickiness based on maximising behaviour and rational expectations. This requires first to argue for individual firms not to change prices and secondly, to show that individual price stickiness translates into aggregate rigidity. Within this second task, the analysis of staggering versus synchronisation of price changes is a key issue. In two seminal papers, Taylor (1979 and 1980) shows that staggering of prices between firms causes aggregate price level inertia.

Analysing staggering and synchronisation however also is of intrinsic value as it provides essential information for understanding firms pricing behaviour in different markets. To what extent, for instance, do firms react to price changes of competitors? Parallel pricing behaviour could be an indicator of collusion and it is thus interesting to see, to what extent firms actually synchronise their pricing strategy. Do multi-product firms change prices of all products simultaneously (within-store synchronisation) or are these price changes distributed uniformly over time (within-store uniform staggering)? To what extent do stores belonging to the same retailer chain follow an independent pricing strategy as opposed to changing prices simultaneously.

Recent studies in this field have been carried out for retail prices in Israel (Lach and Tsiddon, 1992 and 1996), Argentina (Tommasi, 1993), the United States (Cecchetti, 1986; Kashyap, 1995) and Canada (Fisher and Konieczny, 2000). We provide some first empirical evidence for Europe by investigating data from German food retail stores over the period from 1995 to 2000. Besides this regional aspect, the present paper differs from this literature in a number of ways.

Firstly, we analyse high-frequency data (weekly data in contrast to monthly observations used in many studies) in an environment characterised by low inflation rates. If the frequency of observations is too low (which is particularly likely in high inflation countries and where low-frequency data are used) staggering may not be observed accurately. Secondly, we investigate products where quality changes over time are very unlikely. Survey results (Blinder, 1991) reinforce the view that quality adjustment is important: survey participants often cite the ability to vary non-price attributes of a good as a reason for price rigidity. The products under

investigation here are exactly defined and the study period is relatively short. Further, delivery lags or stocks outs are unlikely. Thirdly, we investigate the pricing behaviour of a number of different products (in contrast to many studies looking at one good only). This allows us to investigate pricing behaviour of multi-product firms. And finally, focusing on prices of different products also permits investigating the importance of the degree of substitution between products (strategic complementarity) by analysing within-store synchronisation between and within classes of products.

The following section gives a brief review of the theory on price staggering and synchronisation, the existing empirical literature is summarised in section 3. Section 4 describes the data and the empirical results are reported in section 5. Section 6 concludes.

## **2 Brief review of the theory**

One of the most popular explanations for the phenomenon that prices are kept at constant nominal levels over at least some time at the firm level is the existence of menu cost. Menu costs include all costs related to the adjustment of prices. Under menu costs, prices will only be changed if the change of economic conditions is significant enough that potential losses from not adjusting prices exceed the threshold that is set by the menu costs. Food retailers, for instance, often announce their prices by printing price lists, by advertisements, and by in store labels. Adjusting prices calls for printing new lists, placing new advertisements, and changing in store labels. Such costs lead to a reduction of price adjustment. In measuring the magnitude of menu costs for drugstore and supermarket chains, Dutta et al. (1999) argue that the menu costs are sufficiently large to form a barrier to price changes (the ratio of menu costs to revenues is 0.7% for supermarket chains and 0.74% for drugstore chains). Marginal changes in the economic environment do not automatically lead to product price changes of a specific firm. The basic menu-cost models (Akerlof and Yellen 1985; Mankiw, 1985) have been extended in different ways (a) to consider a distribution of shocks rather than one-off shocks (Ball and Romer, 1989), (b) to analyse price adjustment in oligopolistic markets (Rotemberg and Saloner, 1987), (c) to simultaneously consider adjustment costs in prices and quantities (Ander- sen, 1995; Lucke, 1995) and (d) to examine the effects of menu costs in a dynamic setting.<sup>2</sup>

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<sup>2</sup> A significant literature has developed in the 1990s to examine the effects of menu costs in a dynamic setting. This literature has two branches: time-dependent pricing and state dependent pricing. For a good overview see Cassino (1995).

In addition to menu costs, some other explanations for individual firms not to change prices have been offered. Nominal price rigidities at the retail level can also follow from negotiating nominal contracts, which implicitly keeps marginal costs of buying in constant over the time of the contract. Interviews with practitioners indicate that this is widely applied procedure (Blinder et al., 1998). The issues discussed here are very similar to those in the menu cost literature.

Another argument for sticky prices is based on the existence of psychological pricing points. It is assumed that the marginal revenue curves for suppliers are discontinuous at such pricing points. Firms setting prices slightly below such pricing points will not adjust prices upwards (or jump to the next price just below a pricing point) as a consequence of an exogenous demand or cost shock.

Carlton (1983) raises an important point when arguing that non-price features such as product quality, service, extra gifts etc. can also cause nominal rigidities when firms use these items to react to changes in the economic conditions. Under periods of inflation, for example, firms can keep prices constant and at the same time gradually adjust quality (downwards). In this case we do not have a nominal rigidity of the product value, but a spurious price stickiness caused by the exclusive focus on product prices.

Irrespective of the specific reason for an individual firm not to adjust prices it is important to note that sticky prices at the firm level not necessarily implies price rigidity at the aggregate level (industry or macro-economy). At the aggregate level, the relative timing of price changes by individual firms becomes a central issue. Whether all firms review prices simultaneously (“synchronisation”) or only a fraction of firms adjusts prices each period (“staggering”) has important macroeconomic consequences. If all firms change their prices simultaneously with a lag of one period, then the aggregate price level will have adjusted fully to the new equilibrium level by the end of this period and exogenous nominal shocks will not have persistent real consequences. If, however, price-setting is staggered, the effect of nominal shocks will be prolonged. In two seminal papers, Taylor (1979 and 1980) shows that staggering of prices between firms causes aggregate price level inertia.

The assumption of price-staggering is a necessary condition for explaining macroeconomic price rigidity. Whether this assumption is plausible and consistent with firms profit maximising behaviour quickly became a heavily debated issue. Blanchard and Fisher (1989) conclude: “staggering is unlikely to be an (stable) equilibrium” (p. 400). Their conclusion also rests on the strategic complementarity in price-setting decisions. Each firm takes into account that not all competitors have adjusted prices yet, which prevents the firm to change prices fully as

well. If the proportion of firms changing prices ( $\pi$ ) increases above  $\pi = \frac{1}{2}$ , it will be more attractive for firms with fixed prices to adjust too and vice versa. This implies that synchronisation (with either  $\pi = 1$  or  $\pi = 0$ ) is always a stable equilibrium. Staggering can only be an equilibrium if  $\pi = \frac{1}{2}$ , but this equilibrium is unstable.

A number of different models have been proposed to defeat this argument. Fethke and Policano (1984) and Parkin (1986) argue that price changes tend to be synchronized when changes in economic conditions are common shocks to all firms, while idiosyncratic shocks lead to synchronisation of prices.<sup>3</sup> Ball and Cecchetti (1988) develop a model in which firms have imperfect knowledge of the current state of the economy and use the behaviour of other firms in their market to make inference about demand. This gives each firm an incentive to postpone price adjustment and set prices shortly after other firms set theirs. Staggering can be an equilibrium outcome. In the case of wage setting in oligopolistic markets, De Fraja (1993) and Lau (1996) focus on strategic incentives to stagger. Staggering is possible if the economy consists of a small number of large firms. The relative attractiveness of staggering vs. synchronisation also depends on the form of price adjustment costs. Sheshinski and Weiss (1992) argue, that firms tend to synchronise when menu costs are fixed but stagger with variable menu costs.<sup>4</sup>

An important extension of this literature is the analysis of pricing in a multi-product setting. Kashyap (1995) argues that if information, which is costly to gather and evaluate, arrives at the same time and has the same content for all agents, then price changes over close substitutes should be synchronised. In a dynamic (sS)-pricing model Sheshinski und Weiss (1992) argue that price changes will be staggered if the goods supplied are strategic substitutes, while they will be synchronised if these are strategic complements. A similar result has most recently been proposed by Bhaskar (2001). Given that the elasticity of substitution between products of the same industry is larger than between products of different industries,<sup>5</sup> he argues that price changes will be synchronised within the industry but staggered between industries and in the aggregate economy.

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<sup>3</sup> For a critical discussion of this argument see Blanchard and Fisher, 1989, p. 401.

<sup>4</sup> Fixed, or store specific menu costs, such as the costs of printing a new menu, are shared by all products. Variable menu costs, on the other hand, are not independent with the number of prices to be changed. Decision costs are one example for variable menu costs.

<sup>5</sup> This implies that strategic complementarities are stronger within industries than across industries.

### 3 Brief review of empirical studies

The vast majority of empirical studies in the macroeconomic literature aims at measuring the consequences of staggering (the lag of price adjustment to exogenous shocks) and thus reports only indirect evidence on staggering.<sup>6</sup> More direct evidence on pricing behaviour, staggering and synchronisation is available in a few studies using micro-data such as Cecchetti (1985 and 1986), Lach and Tsiddon (1992 and 1996), Tommasi (1993), and Fisher and Konieczny (2000). However, reviewing this literature is rendered difficult due to problems associated with finding an unequivocal definition and thus an appropriate measure of staggering. Different measures have been used and the relationship between these is often unclear.

One of the most widely cited pieces of evidence on the rigidity of prices are Cecchetti's (1985 and 1986) studies on the newsstand prices of magazines. Looking at 38 magazines over the period 1953 to 1973, the author reports a remarkable infrequency of price changes. In the 1950s, the average length of time between price changes was 7 years; in the high inflation years of the 1970s, the time span of constant prices declined to 3 years. Cecchetti interprets this evidence of price stickiness by high fixed costs of price changes.<sup>7</sup> However, no evidence on staggering or synchronisation of prices is reported.

Domberger and Fiebig (1993) use the coefficient of skewness of the price change distribution as a measure of price staggering.<sup>8</sup> They find the coefficient of skewness to decline and thus staggering to be reduced when inflation rates are high. Further they provide evidence for less staggering in concentrated industries which they interpret as indication for more price coordination in these industries.

Investigating prices of 12 products from retailer catalogs for a 35 year period (from 1953 to 1987),<sup>9</sup> Kashyap (1995) finds that (a) prices are typically fixed for more than one year, (b)

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<sup>6</sup> For a recent review of this literature see Taylor (1999).

<sup>7</sup> Koelln and Rush (1993), however, point to the fact that publishers may alter some aspects of their product's quality to adjust the "effective price" during periods of high inflation. Studying prices and quality characteristics of seven magazines over the period 1950 to 1989, they find that as inflation erodes the real price of a magazine during the period of fixed nominal prices, the number of text pages (as an indicator of quality) tends to decline. Similar arguments have been made in Carlton (1983). He points out that the observation that the price of a product is inflexible for long periods is meaningless if the product changes over time (see also section 2).

<sup>8</sup> "A typically staggered price behaviour pattern is one in which a few firms lead with relatively large price changes and the remainder follow with little or no adjustment" (p. 299).

<sup>9</sup> The author sidesteps the problem of dealing with quality changes of a long time period by carefully selecting items that are homogenous over long periods. Even in this case, the decision not to alter quality may be an en-



they are more likely to change during periods of high overall inflation and (c) the synchronisation of prices across goods is generally low. When measuring whether changes and non-changes of prices for one product are sufficiently aligned with changes and non-changes of prices of a second product, the author finds that only 12 of the 66 pairwise comparisons were sufficiently correlated so that the hypothesis of staggering could be rejected. Lach and Tsiddon (1992 and 1996) devote specific attention to the pricing behaviour of multi-product firms. Analysing a data set of monthly food retail prices for Israel over the period from 1978 to 1984, Lach and Tsiddon (1992) report an average duration of constant prices between 1.6 to 1.9 month. The rate of inflation negatively affects the average duration. Considering the fact that the rate of inflation is between 4.9 and 6.6 per month, the average duration of prices is relatively high. Further, the authors find that prices are staggered across stores; however, they do not apply a formal test to prove this. In their subsequent paper (Lach and Tsiddon, 1996), they extend this analysis by explicitly distinguishing between (and formally testing for) staggering of price changes across price-setters (between stores) as well as across products (within stores). On the basis of monthly price observations for 21 products (nine different wine products and 12 meat products) for the period 1978:1 to 1979:6 for approximately 80 stores in Israel, they find evidence for across-store staggering and within-store synchronisation.

The observation of within-store synchronisation is rejected, however, in Tommasi (1993). On the basis of weekly price observations for 7 goods over a 46 week period in five retailer stores in Argentina, the author interprets his findings as suggestive of some staggering, both across stores as well as within stores (across products).

An interesting extension to this literature is the study of Fisher and Konieczny (2000) on prices of 46 Canadian newspapers over the period from 1975 to 1993 (with irregular observation intervals). Newspapers were selected into three groups on the basis of ownership structure. Applying a probit model they show that the likelihood of a particular paper to change prices increases with the proportion of the remaining papers belonging to the same chain to change prices too. They interpret this as evidence for synchronisation within the newspaper chains. In contrast, prices of newspapers belonging to different chains are staggered.

This brief review of the literature suggests a more precautionary conclusion about the empirical relevance of staggering or synchronisation as in Taylor (1999), who summarizes: "Price setting is also staggered. These facts, which are apparent in casual observation, are confirmed in

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ogenous one, as the author notes, which underlines the problems associated with studying pricing behaviour over a long time horizon.

studies of wages, retail prices, and industrial prices” (p. 25). Most studies, however, have so far been carried out for high inflation countries and/or by focusing on a small set of products only. Further, are only a few studies testing for synchronisation between different groups of stores as well as within stores. These aspects deserve more attention.

## **4 Data**

### **4.1 Data collection and sample reduction**

The data used for this study have been provided by the “Zentrale Markt- und Preisberichtsstelle” (ZMP) in Bonn, Germany. The ZMP is an independent organisation that has a mandate from the German Government to provide, among other things, representative consumer price data. The Government’s mandate aims to inform all market participants on agricultural and food markets about the actual market developments. However, the Government has not outlined any directions to fulfil this mandate. Thus, the ZMP has developed its own rules and taken specific actions to achieve the goal. To inform consumers and retailers about the developments in food retail prices, the ZMP has set up a price reporting system on a weekly basis. The ZMP maintains a network of roughly 450 so-called ‘Melder’ (melden = to report) who visit about 1,300 retail food stores in Germany on a weekly basis and collect price data for a variety of standard fresh foods.<sup>10</sup> The sample is designed to represent the geographic regions and the type of stores with respect to their population values. Thus, the ZMP tries to reflect the relative weights of the region measured by its population and the number of store types for the underlying population in construction of the sample. Germany is divided into 8 geographic regions for this purpose, and retail stores are divided into 6 categories (small supermarkets (SSM: primarily food less than 400 square meter shopping area), big supermarkets (BSM: primarily food more than 400 but less than 800 square meter shopping area), combined supermarkets (CSM: food and other items more than 800 square meter shopping area), discounter (DC: primarily food with self service), butchers (BU), fruit and vegetable markets (FV)). In accordance to the relative weights given by the underlying populations with respect to regional, peoples’, and store types’ aspects the ZMP decides what kind of store from what region enters the sample.

Price data is collected for 56 fresh food products. To ensure the comparability of reported prices, the Melder are given detailed instructions on the quality of the product and the measure (price per piece or per kg). The Melder decides on what day of the week he or she visits

the stores that he or she is reporting on. Special offers are to be considered. The Melder fills out a standard sheet that is send back to the ZMP weekly. The ZMP does not publish individual store prices or any information on the price setting behaviour. Instead, on a weekly or monthly basis, average prices for regions and store types for all products are published. The data sent by the Melder are processed as follows by the ZMP prior to publishing:

- i) Removal of ‘obvious outliers’ (e.g. misplaced decimal points) by hand and removal of observations that deviate by more than 2.6 standard deviations from the mean. Roughly 1-2 % of the available observations are lost in this way.<sup>11</sup>
- ii) Calculation of the unweighted average price for each store type within a region.
- iii) Calculation of the regional average as a weighted average of the store type averages from ii), with weights equal to share of each store type in total purchases of the commodity in question.
- iv) Calculation of the national average price for each store type as the weighted average of the store type averages from ii), with regional population shares as weights.
- v) Calculation of the national average over all store types as the weighted average of the regional averages from iii), with regional population shares as weights.
- vi) Average product prices are only published if at least 100 observations were available over all store types and regions.

The resulting regional, store type and national averages for each food product are published weekly and also provide the basis for a variety of monthly, quarterly, and annual publications produced by the ZMP (see ZMP internet page at <http://www.zmp.de>). Furthermore, this data is reproduced in many other publications, such as local farm journals and consumer affairs publications etc.

The ZMP-panel ought to be a random sample of the above mentioned types of food stores in Germany. However, reporters decide on the store they visit to report prices and neither the reporter nor the store he or she selects is chosen *a priori* randomly. As we do not have information about the group of reporters, such as age, education, income etc. we can only speculate towards which direction the actual sample might be biased. For instance, it is likely that low income pensioners are over represented in the sample of reporters; thus, it might well be that

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<sup>10</sup> The list of products does only include some processed items, such as butter, yoghurt, or sausage.

<sup>11</sup> The automatic routine to remove outliers has not been applied to the raw data set that is used here; however, the data have been corrected for irregular observations by hand.

these people prefer to report on low price stores. In this case estimates of average prices would be biased downwards. By controlling the regional number of stores and the number of the various store types, potential biases of sample parameters due to these characteristics are limited.

For our study we selected ten out of the 56 food products. As we focus on the price setting behaviour we aimed to get a full panel data set, which means each store in our sample reports prices for all ten food items over the entire period of observation. For this reason, specialised fruit and vegetable as well as butcher shops have been excluded from the analysis. We first selected the food products by excluding the items that are only offered seasonally, such as cherries, by excluding the items that are only reported on a monthly basis, such as milk products. The remaining products can be classified into meat, fruits, and vegetables. We selected 4 meats, 3 fruits and 3 vegetables by choosing the product items with the maximum number of observations in the raw data set. Thereby we hoped to maximise the number of stores with a continuous reporting over time. For these 10 food products we selected only those stores that carry all items at all times. We defined continuous price reporting by availability of price observations for each product in more than 92 % of all weeks from May 1995 to December 2000 ( $n = 296$ ). For the missing observations we set the price of the product in the store in week before respectively. This entire selection process reduced the number of observations from around 250.000 for each product to 38.776, which corresponds to observations from 131 food stores over a period of 296 weeks. For the individual stores, information on the corresponding zip code (exact regional location), the type of the store (see above for definition), the name of the store, and the company that owns the store are also available. Our final sample of products consists of fresh beef (braised beef quality without bones), liver sausage (from calves, thin cut, packed in gold skin), fresh pork steak (“Schnitzel” without bones), fresh turkey breast steak (without skin and bones), apples (Golden Delicious, size 70 to 80 mm in cross section), pears (table pears of different sort), citrons (regular quality), lattice (ice salad), carrots (without foliage), onions (regular quality of typical sort). Prices are reported in German cent or pennies per kilogram, except for lattice and citrons for which prices are reported in cent or pennies per piece.

The stores in our final sample belong to the following store type and companies. The real names of the companies have been suppressed and substituted for alphabetical letters by confidentiality reasons.<sup>12</sup>

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<sup>12</sup> Because of the small number of observations in some cases we have to be cautious with some conclusions. For instance, with respect to DI and retail chains D and F.

Insert Table 1 about here

#### 4.2 Descriptive statistics

The sample is a complete panel of retail prices for ten basic food items in 131 retail stores that have been collected continuously on a weekly basis from 1995 to 2000. In Figure 1 the average prices over all stores ( $m = 131$ ) are shown for the entire period of observation to indicate the common price dynamics. Average prices do not show significant linear trends, except the prices of citrons which exhibit a slight upward shift in this period. For meat products some longer term cyclical behaviour can be observed which differs somewhat for the selected products. Because of the short period of observation this phenomenon cannot be analysed in more detail. Fruit and vegetable prices indicate significant seasonal patterns, which also vary between products and in time. Again, formal statistical testing is not possible because of the short time horizon covered by the sample.

Insert Figure 1 about here

Besides the deterministic time series components all series have an autocorrelated stationary residual component which is less significant for fruits and vegetables.<sup>13</sup> The average prices change from week to week and the magnitudes of changes are much bigger for meat products than for fruits and vegetables. The same holds for the volatility around the deterministic components.

To what extent are individual retail store prices represented by these average figures? In perfect markets, the law of one price ought to hold; thus, the average series should perfectly match all characteristic properties of individual prices. In Table 2 average prices over the entire period of observation and three measures of variation are calculated. The figures in the first row for each product in Table 2 show that average prices vary significantly between store types and between retailer chains.

Insert Table 2 about here

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<sup>13</sup> All series have been tested for stationarity using the ADF-test and the procedure by Phillips and Perron (1988). The Null-hypothesis is rejected at the 95 % significance level.

On each of the ten product markets we observe significant differences in average prices. Pork, for instance, is on average about 5 German Marks or 12 % cheaper at CSM or DC compared to SSM. Although the absolute differences decline for products of lower value, such as fruits and vegetables, relative deviations between store types occur to be at similar levels for most products. In sum, CSM and DC report the lowest price level compared to SSM and BSM. For meat products CSM and DC are the cheapest store types, fruits and vegetable prices are always the lowest at DC followed by CSM. SSM are most expensive for meat products, BSM report the highest average price level in fruits and vegetables.

Even though the stores within the clusters indicate a high level of variation in prices for the respective items, average price differences between clusters (store types and retailer companies) are mostly statistically significant.<sup>14</sup> In 80% of all cases the average price for the cluster is tested to be significantly different from the average price over all stores.

As for store types, we observe big differences in average price levels of the various retailer companies. In this case chain E and F are the cheapest supplier at almost all products. Chain D is (with the exception of citrons) always the most expensive chain. The result for the retailer companies E and F might partly be related to the fact that E and F include a high percentage of CSM; however, as almost half of the stores of chain D do also belong to CSM, the latter conclusion has to be interpreted with caution. These differences in most cases are statistically significant.

Even though the grouping of retail stores leads to significant differences in average price levels between groups, the variation within each group still is substantial (often at the same level as for the total sample). The second row of Table 2 reports the standard deviation of prices. For instance, the standard deviation of beef prices for the store types is between 239 and 444 German cent per kg, the overall standard deviation is 299 German cent per kg. Thus, the clustering by store types does not substantially reduce the within group variation, meaning prices seem to vary as much within cluster as they do in the entire sample. The reduction in variation by clustering in the case of beef is 11%. For the other products the cluster effect is between 2 % and 11 %. The reduction is higher for meat products compared to fruits and vegetables. Interestingly, the clustering by retailer companies indicates an even lower reduction in the within group variation even though the number of clusters is increased by 4. In relative terms the standard deviations is between 20 to 30 % of the corresponding average price level for all products. Even though some variation in this relative measure can be observed, no systematic

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<sup>14</sup> Total variation is measured by the standard deviation of all observations in the respective cluster.

relationship with respect to either the type of the store, the retailer chain, or the product type occurred to us.

To analyse the variation of prices between individual stores, we develop the measure Var1 which is the ratio between the average of the variance between all stores of the respective group over time and the total variance (Var<sup>2</sup>) in %:

$$\text{Var1}_{k,m} = \frac{\frac{1}{n \cdot m} \sum_{i=1}^n \sum_{j=1}^m (p_{i,j,k} - \bar{p}_{i,k})^2}{\frac{1}{n \cdot m} \sum_{i=1}^n \sum_{j=1}^m (p_{i,j,k} - \bar{\bar{p}}_k)^2} \cdot 100$$

with:  $\frac{1}{n \cdot m} \sum_{i=1}^n \sum_{j=1}^m (p_{i,j,k} - \bar{\bar{p}}_k)^2 = \frac{1}{n \cdot m} \sum_{i=1}^n \sum_{j=1}^m (p_{i,j,k} - \bar{p}_{i,k})^2 + \frac{1}{n} \sum_{i=1}^n (\bar{p}_{i,k} - \bar{\bar{p}}_k)^2$

$n$  = time index (1,..., 296)

$m$  = index for stores (1, ..., 131 in case of first column in Table 2)

$k$  = index for food items (1, ..., 10)

$p$  = price ( $p$  bar is the average price in each period for the respective group,  $p$  double bar is the average price for the respective group over time)

Note that the total variance (in the denominator) can be separated into the variance at each point in time (first expression on the right hand side) and the variance of the means over time (second expression on the right hand side)<sup>15</sup>. Thus, Var1 describes to what extent the average price variation between shops of the respective group contributes to the total variation. Similarly, 100-Var1 indicates the share of variation caused by movements of average prices over time. A high value for Var1 implies that most of the variation comes from variation of prices between shops and only a little is contributed through changes in the average price level over time. The results in the respective third row of Table 2 indicate that in the case of meat products more than 90 % of the total variation comes from price differences between shops. Even though fruits and vegetables indicate stronger movements in average prices over time the measure is still above 75 %, except for citrons which besides the seasonal pattern also show a trend.

Another way of decomposing the total variance is by asking whether the variation between stores is short lived or inherent (Var2):

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<sup>15</sup> We get the right hand side expression by calculating the variance of the average prices shown in Figure 1.

$$\text{Var } 2_{k,m} = \frac{\frac{1}{n \cdot m} \sum_{j=1}^m \sum_{i=1}^n (p_{i,j,k} - \bar{p}_{j,k})^2}{\frac{1}{n \cdot m} \sum_{i=1}^n \sum_{j=1}^m (p_{i,j,k} - \bar{\bar{p}}_k)^2} \cdot 100$$

$$\text{with: } \frac{1}{n \cdot m} \sum_{i=1}^n \sum_{j=1}^m (p_{i,j,k} - \bar{\bar{p}}_k)^2 = \frac{1}{n \cdot m} \sum_{j=1}^m \sum_{i=1}^n (p_{i,j,k} - \bar{p}_{j,k})^2 + \frac{1}{m} \sum_{i=1}^m (\bar{p}_{j,k} - \bar{\bar{p}}_k)^2$$

Now the first expression on the right hand side of the denominator is the average of the variance of prices for each individual store over the group  $m$  of stores, the second expression is the variance over the mean prices levels for each store. Thus, Var2 measures to what extent price changes in individual stores have contributed to the total variation of prices. If stores differ in the price level, but never change prices over time, then Var2 is 0. In that case all variation comes from differences in average prices between store. The results are shown in the respective fourth row of Table 2. For the total sample, Var2 for meat products ranges from 43 % to 58 %. Variation of price over time at the store level is as important as variations in average prices between stores. Fruits and vegetables (with the exception of citrons) show higher values that range from 72 % to 91 %; thus, most of the variation comes from movements in time at the store level.

Var1 and Var2 have also been calculated for the various store types and retailer chains; however, again we cannot identify any systematic differences compared to the values for the total sample that might be related to either the store type or the retailer company.

Even though the average price levels indicate big deviations between stores and price movements are only weakly correlated between shops, the use specific price levels seems to indicate some typical or common behaviour of stores in this sector. So called psychological pricing points or threshold prices occur most often for fruits and vegetables. In Table 3 the fifteen most frequent prices are listed for each product. For instance, 60 % of all carrot price observation equal either 99, 149, or 199 German cent per kg. For the fruit and vegetable products the fifteen most frequent prices account for about 90 % of all observation. For meats this measure ranges from 49 to 72 %, which is likely related to the bigger absolute range of prices between stores for meats.

Insert Table 3 about here



## 5 Empirical results

The terms “perfect staggering” and “perfect synchronisation” characterise two extreme features of the timing of price changes. Under perfect synchronisation, the conditional probability of a price change of item  $i$  given a price change of another item  $j$  is one. Perfect staggering would imply the conditional probability of a price change of item  $i$  given a price change of another item  $j$  to be zero. Hereby items  $i$  and  $j$  might indicate the same product at different stores (Across-Store Synchronisation), different products at the same store (Within-Store Synchronisation) or a number of different products at different stores belonging to the same retailer (Within-Retailer Synchronisation). For the analysis of these issues the data frequency is obviously of critical importance. When time intervals between observations become too long, we might end up with the obvious result of perfect synchronisation as every supplier has adjusted prices since the last point of observation (spurious perfect synchronisation). Food retail markets in Germany often announce prices via newspaper or special advertisements on a weekly basis. Thus, there is some reason to consider weekly price observations appropriate for this type of analysis.

### 5.1. Across-Store Synchronisation

If price changes were perfectly synchronized and all stores would change prices of a given item at the same time, the proportion of price changes in any given period would be either 0 (no store changes prices) or 1 (all change prices). Under perfect staggering, the proportion of price changes in any period would be equal to the average proportion of price changes over time.

Figure 2 reports the proportion of stores changing prices in a given time period. Over the entire time period of 296 weeks, 47% of all prices in all stores changed on average (the solid line in Figure 2). The proportion of stores changing prices in a given week (the individual observations) is very close to the solid line, however, they are not exactly located on the solid line, as “uniform perfect staggering” would imply.<sup>16</sup>

Insert Figure 2 about here

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<sup>16</sup> Cecchetti (1983) defines uniform staggering (or uniform nonsynchronisation) as a situation where firms setting prices for  $k$  periods are uniformly distributed over the interval from zero to  $k$ .

Tommasi (1993), Lach and Tsiddon (1996) as well as Fisher and Konieczny (2000) use the standard deviation of the proportion of stores changing prices each period. It will be at its maximum (close to 0.5) with full synchronisation and will be zero under uniform staggering. The standard deviation here is 0.03 which is extremely low compared to the results reported in Lach and Tsiddon, Tommasi and Fisher and Konieczny.

This is, of course, not a formal test of staggering. Whether individual observations significantly deviate from the “perfect staggering” situation can be tested more formally on the basis

of a  $\chi^2$ -test:  $\chi^2_{n-1} = \sum \frac{(h_i - E(h_i))^2}{E(h_i)}$ , where  $h_i$  is the number of price changes in store  $i$  during

the 296 weeks and  $n$  is the number of stores. This test clearly rejects the hypothesis of “perfect staggering” at the 5%-level (the  $\chi^2$  test statistic is 642 and the critical value for the test statistic with 294 degrees of freedom is 335).

Although price changes are far from being perfectly synchronised across stores, there is no indication for perfect staggering either and we cannot rule out some form of synchronisation in pricing. Following Sheshinski and Weiss (1992) as well as Bhaskar (2001) we would expect to find the amount of staggering to be related to the degree of product heterogeneity. Less heterogeneity between items implies stronger strategic complementarity and increases the benefits of synchronising price changes. Assuming that the elasticity of substitution between the same products at different stores exceeds the elasticity of substitution between different products within the same store, this leads us to an expectation of a stronger tendency towards synchronisation when investigating pricing behaviour for each of the ten products in our sample separately.

On first sight, the results shown in Figure 3 look very similar to those shown above. The proportion of shops changing prices differs between products. On average, 60% of all stores change prices per week in the case of beef, whereas this figure is 30% in the case of onions. Secondly, Figure 3 exhibits a cyclical pattern in pricing behaviour for fruits and vegetables.<sup>17</sup> A few weeks with a low frequency of price changes are followed by a short period of intensive price adjustments.

Insert Figure 3 about here

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<sup>17</sup> Note that in this case, cyclicity does not refer to the level of prices but to the frequency of price adjustments.

With respect to the issue of staggering and synchronisation however, our expectation of more synchronisation across stores is not supported. The  $\chi^2$ -test rejects the assumption of perfect staggering for five products only (apples, pears, salad, carrots, and onions) but does not reject the null-hypothesis for the other five products (meat products).

This lack of synchronisation across stores reported might however be the result of two countervailing influences. Assuming that co-ordination is stronger within identical types of stores and within groups of stores being a member of the same chain of retailers, pricing behaviour could (a) be synchronised within individual types of stores and staggered between them or (b) synchronised within retailers but staggered between retailers.

## **5.2. Within-Type of Store and Within-Retailer Synchronisation**

To start with the first question, we compute the proportion of price changes for all products within specific types of stores. Table 4 indicates that perfect staggering is rejected for big supermarkets and combined supermarkets but cannot be rejected for small supermarkets and discounters. Again, investigating pricing strategies for individual products within specific types of stores suggests that perfect staggering can only be rejected in four out of 40 cases.

Insert Table 4 about here

A similar result can be obtained for within-retailer-synchronisation. Note that 108 stores in our sample are all members of six large retailer chains and the question to be addressed here is whether retailers synchronise price changes between their stores. We find that within retailer staggering can be rejected for one chain only. A more disaggregated analysis for the price-setting for individual products show that the null hypothesis of perfect staggering can only be rejected in two out of 60 cases.

The results reported so far lend themselves to a “glass is half-full, glass is half empty” interpretation. On the one hand, staggering is rejected when considering all stores and all products simultaneously. On the other hand, hardly any evidence for more synchronisation can be found when investigating individual products as well as the behaviour of specific types of stores or retailers.

The final hypothesis to be explored refers to Lach and Tsiddon’s (1996) result according to which prices of different products sold within the same store are highly synchronised.

### 5.3. Within-Store Synchronisation (Across-Product Synchronisation)

The use of the Chi-Square procedure to test for staggering versus synchronisation of prices is unapt for situations where the expected number of weekly price changes is less than five. Due to the relatively small number of products in the sample, a formal test cannot be applied here. Alternatively, we use the standard deviation of the share of price changes as proposed by Fisher and Konieczny (2000). When price changes between products within a store are perfectly synchronized in each period, the share of price changes is either zero or one. If for instance, a store changes prices every other week and price changes are perfectly synchronised the standard deviation is expected to be 0,5. Under perfect synchronisation the standard deviation of the share of price changes depends only on the sluggishness of price adjustment over time. Under perfect staggering, however, we expect the share of price changes to be equal at each point in time. Price changes for the offered products occur purely random. For sufficient large samples at each point in time (many products) the standard deviation converges to zero. In small samples the expected level of the standard deviation depends on the number of observations at each point in time and the general level of price sluggishness. With decreasing number of observations per period the measure converges to the upper limit that is characterised by perfect synchronisation. When observations increase to infinity this measure converges to zero. Within this range the relationship between the frequency of price changes and the expected standard deviation of the frequency can be approximated by a quadratic function. The parameters of this set of functions converges to zero by root of  $m$ .<sup>18</sup>

Figures 4 and 5 report the results for meat products as well as fruits and vegetables.

Insert Figures 4 and 5 about here

In both cases, the results strongly suggest that price changes are staggered almost perfectly within stores even for specific product groups. Thus, the timing of price changes between products within in single stores in most cases is best characterised by a random unique distribution. Even in the case of products groups of close substitutes such as meats, fruits, or vege-

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<sup>18</sup> The number of observations in time also affects the measure, however, as in all cases 295 observations are available, this effect is not considered here.

tables, the stores do not tend to synchronize their own price changes.<sup>19</sup> This result contrasts sharply with the findings of Lach and Tsiddon (1996).

## 6 Conclusions

Only a few studies have analysed staggering and synchronisation in pricing behaviour of multi-product firms. These studies used low-frequency data in an environment of high rates of inflation. This paper investigates staggering and synchronisation of prices for German food stores. Weekly observations on prices of ten products over the period from May 1995 to December 2000 (296 weeks) are analysed for 131 food stores. These stores are all members of six large retailer chains and can further be classified into four different store types.

We go beyond the existing literature by analysing different forms of staggering and synchronisation. More specifically, we test for synchronisation across stores, within specific types of stores, within retailer chains as well as within individual stores (across product synchronisation). Perfect synchronisation of prices is rejected in all cases. Our results do not support the notion that product prices are adjusted at the same time neither across all stores, nor within specific types of stores or retailers nor even within individual stores. Perfect staggering, on the other hand, can only be rejected in very few cases. Our conclusion, that pricing behaviour in German food stores comes very close to perfect staggering contradicts earlier empirical findings, such as Lach and Tsiddon (1996) who report evidence for across-store staggering but within-store synchronisation.

The perceivable lack of synchronisation in pricing behaviour draws into question the significance of fixed, or store specific menu costs. Given that the costs of printing a new menu are shared by all products and possibly by all stores belonging to the same retailer chain, one would expect to find price changes to be synchronised within stores as well as within retailers. In addition, our empirical results do not support the notion of “parallel behaviour” with respect to the timing of price changes. Despite the fact, that the food retail market in Germany is highly concentrated, there is no empirical evidence for a coordination in price changes across retailers. Although macroeconomic textbooks consider staggering unlikely to be a stable equilibrium, the empirical evidence reported here suggests the opposite: staggering is a common phenomenon in German food stores.

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<sup>19</sup> Because the results are very close to perfect staggering we restrain from testing whether there might be a statistically significant deviation. To do this, as for the expected levels of the standard deviation we would have to simulate the expected distribution to derive critical values.

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## 8 Figures and Tables

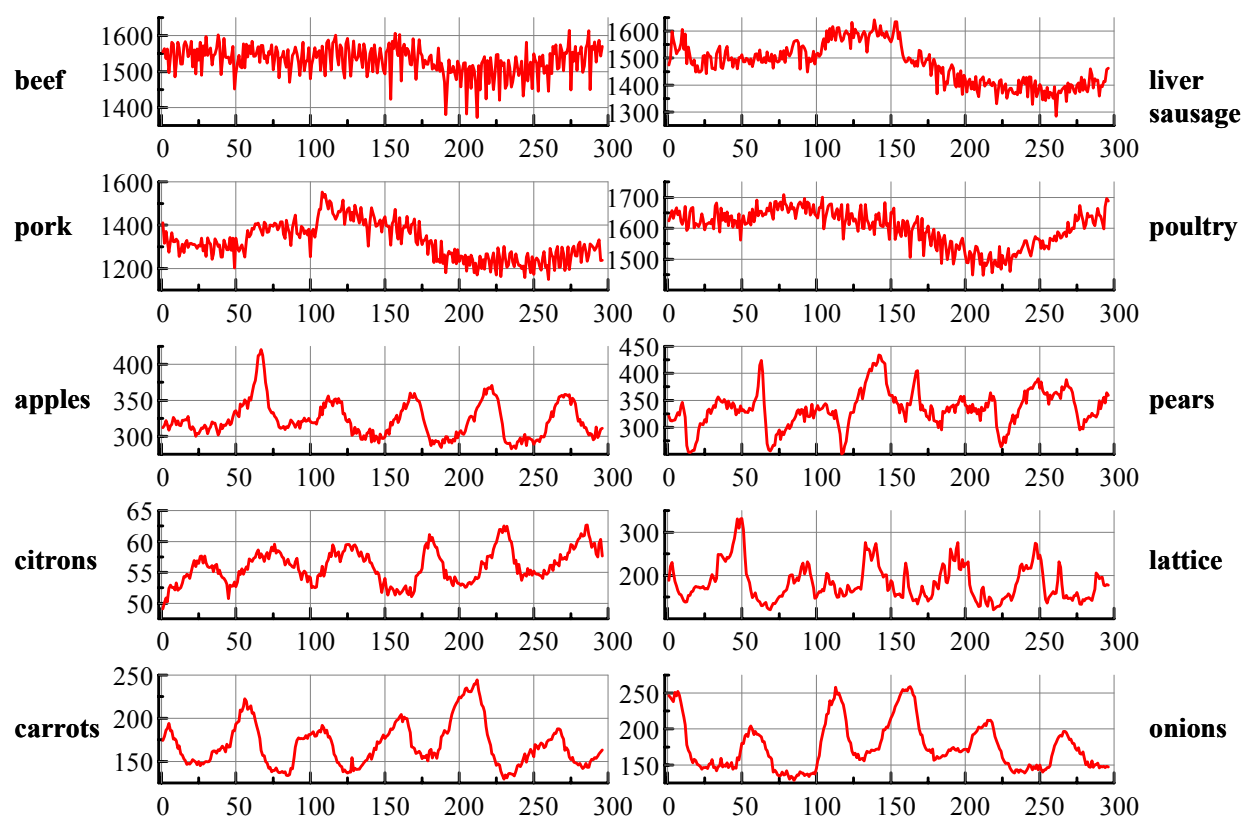
**Tab. 1: Selection of store types and retailer companies in the sample**

	Retailer company							
	Total	A	B	C	D	E	F	Other
SSM	16	5	7	2	1	0	0	1
BSM	43	12	5	11	3	4	0	8
CSM	68	7	4	12	5	20	6	14
DC	4	0	2	0	2	0	0	0
Total	131	24	18	25	11	24	6	23

Notes: SSM: Small supermarkets, BSM: Big supermarkets, CSM: Combined supermarkets, DC: Discounter. A to F: Different retailer companies, such as Edeka or Spar group.

Source: Data by ZMP, 2001.

**Fig. 1: Weekly average food retail prices in Germany from 1995 to 2000 (sample of 131 stores over 296 weeks)**



Legend: All prices in German cent per kg, except the prices of lattice and citrons which are quoted in German cent per piece.

Source: Data by ZMP, 2001.

**Tab. 2: Average and variation of food retail prices in Germany**

		All	Store type				Retailer company					
			SSM	BSM	CSM	DC	A	B	C	D	E	F
<b>Beef</b>	<b>Mean</b>	1531	1662	1634	1439	1482	1581	1582	1513	1726	1421	1333
	<b>Var</b>	299	239	285	277	444	276	317	238	289	291	206
	<b>Var1</b>	98	96	97	96	97	96	96	95	93	90	84
	<b>Var2</b>	54	64	70	61	13	66	49	78	41	62	76
<b>Liver sausage</b>	<b>Mean</b>	1477	1684	1564	1376	1428	1505	1584	1574	1443	1293	1212
	<b>Var</b>	456	427	416	458	480	484	426	411	467	428	393
	<b>Var1</b>	97	95	96	97	91	96	97	97	93	93	75
	<b>Var2</b>	43	46	56	41	30	40	43	49	42	54	77
<b>Pork</b>	<b>Mean</b>	1323	1529	1437	1211	1171	1366	1419	1303	1504	1150	950
	<b>Var</b>	387	372	358	365	399	401	370	349	421	321	230
	<b>Var1</b>	95	94	93	93	94	94	94	93	85	85	56
	<b>Var2</b>	55	67	72	58	19	58	56	70	66	71	91
<b>Poultry</b>	<b>Mean</b>	1602	1700	1679	1539	1435	1601	1644	1628	1710	1516	1441
	<b>Var</b>	306	305	281	298	364	320	307	302	292	284	238
	<b>Var1</b>	96	94	95	94	95	94	92	97	92	90	78
	<b>Var2</b>	58	61	67	63	20	60	62	50	68	65	90
<b>Apples</b>	<b>Mean</b>	322	309	341	315	297	305	326	333	347	315	299
	<b>Var</b>	67	66	68	64	56	68	71	63	69	57	44
	<b>Var1</b>	86	86	83	85	76	81	83	77	85	85	63
	<b>Var2</b>	72	64	78	76	76	74	69	84	75	74	98
<b>Pears</b>	<b>Mean</b>	335	329	351	327	309	326	341	331	354	329	322
	<b>Var</b>	74	71	77	73	58	75	70	72	77	71	68
	<b>Var1</b>	77	71	77	75	70	71	74	72	69	69	63
	<b>Var2</b>	85	85	85	89	82	82	91	92	81	91	97
<b>Citrons</b>	<b>Mean</b>	56	55	59	55	36	58	55	56	52	55	57
	<b>Var</b>	17	14	19	16	7	19	17	18	13	16	14
	<b>Var1</b>	97	95	98	96	81	98	96	95	93	93	88
	<b>Var2</b>	37	31	35	44	73	21	31	41	44	61	49
<b>Lattice</b>	<b>Mean</b>	183	181	194	179	162	183	186	179	194	181	167
	<b>Var</b>	59	54	61	58	46	60	57	56	62	56	57
	<b>Var1</b>	48	49	46	45	55	47	50	37	47	40	31
	<b>Var2</b>	91	93	94	92	78	92	90	97	87	94	98
<b>Carrots</b>	<b>Mean</b>	169	174	180	163	141	168	171	172	182	165	152
	<b>Var</b>	51	45	55	49	42	56	52	50	58	43	44
	<b>Var1</b>	76	75	75	72	75	76	72	78	76	66	58
	<b>Var2</b>	75	78	74	79	60	63	72	75	74	87	94
<b>Onions</b>	<b>Mean</b>	176	179	195	165	137	174	183	179	197	164	129
	<b>Var</b>	64	65	63	61	57	64	67	58	60	58	58
	<b>Var1</b>	73	72	70	69	78	66	79	72	71	66	47
	<b>Var2</b>	75	78	79	80	61	75	75	80	66	85	95

Legend: All prices in German cent per kg, except the prices of lattice and citrons which are quoted in German cent per piece. For definition of Var, Var1 and Var2 see text.

Source: Data by ZMP, 2001.

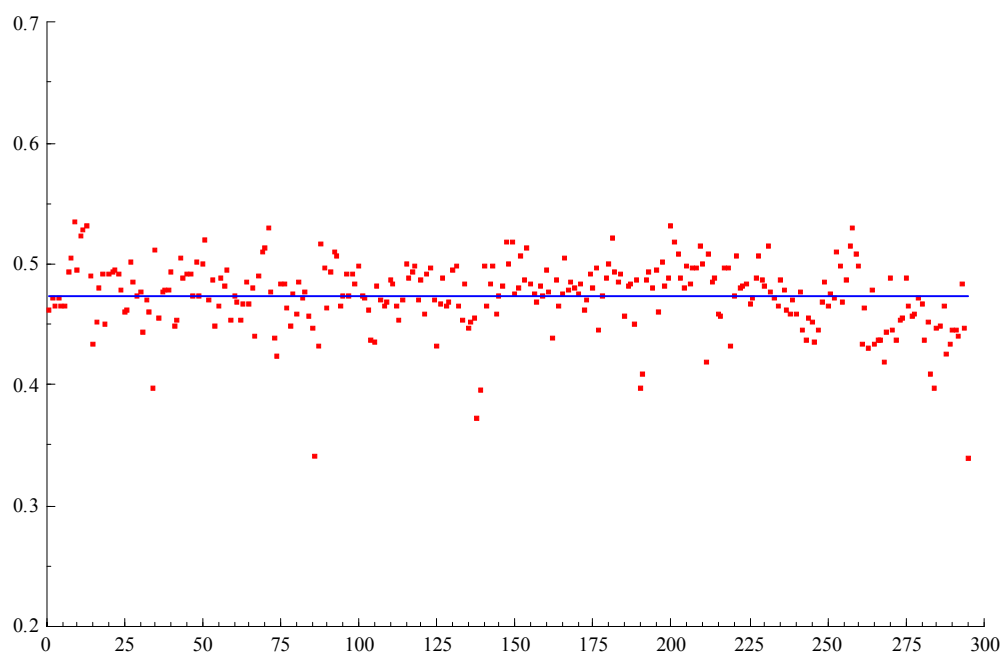
**Tab. 3: The fifteen most frequent prices over all stores**

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Sum %
beef	1699	1399	1799	1499	1299	1690	1498	1899	1599	1598	1798	1290	999	1698	1199	
%	8	4	4	4	4	4	4	4	3	3	3	3	3	3	3	56
liver sausage	1990	1690	1290	1490	990	1790	1590	1390	790	1090	1890	1190	890	2190	2290	
%	10	9	8	8	8	6	4	3	3	3	3	2	2	2	2	72
pork	1499	1299	1399	1590	999	1490	1599	799	899	1699	1790	1799	1690	1290	990	
%	5	4	4	4	4	3	3	3	3	3	3	3	3	2	2	49
poultry	1799	1899	1999	1599	1690	1699	1499	1790	1290	1490	1990	1590	1890	1798	1399	
%	7	6	5	5	5	5	4	4	4	4	4	4	3	3	3	63
apples	299	399	349	199	249	298	499	279	333	259	398	277	379	239	295	
%	39	25	5	5	4	3	2	2	1	1	1	1	1	1	1	90
pears	299	399	349	199	499	249	298	279	379	398	277	297	259	359	198	
%	31	28	6	5	4	4	3	2	2	1	1	1	1	1	1	89
citrons	79	50	69	59	49	40	45	39	35	30	99	25	55	89	33	
%	12	12	12	11	10	5	5	3	3	3	2	2	2	2	1	86
lattice	199	149	179	249	99	299	139	129	159	169	111	198	229	119	279	
%	22	14	8	7	7	6	5	5	5	2	1	1	1	1	1	87
carrots	199	149	99	179	129	249	159	139	169	299	119	198	98	79	189	
%	25	15	10	8	6	5	4	3	3	3	2	2	1	1	1	88
onions	199	149	99	299	129	249	179	159	139	79	198	98	169	119	89	
%	27	12	10	7	6	5	5	3	2	2	2	2	1	1	1	87

Legend: All prices in German cent per kg, except the prices of lattice and citrons which are quoted in German cent per piece.

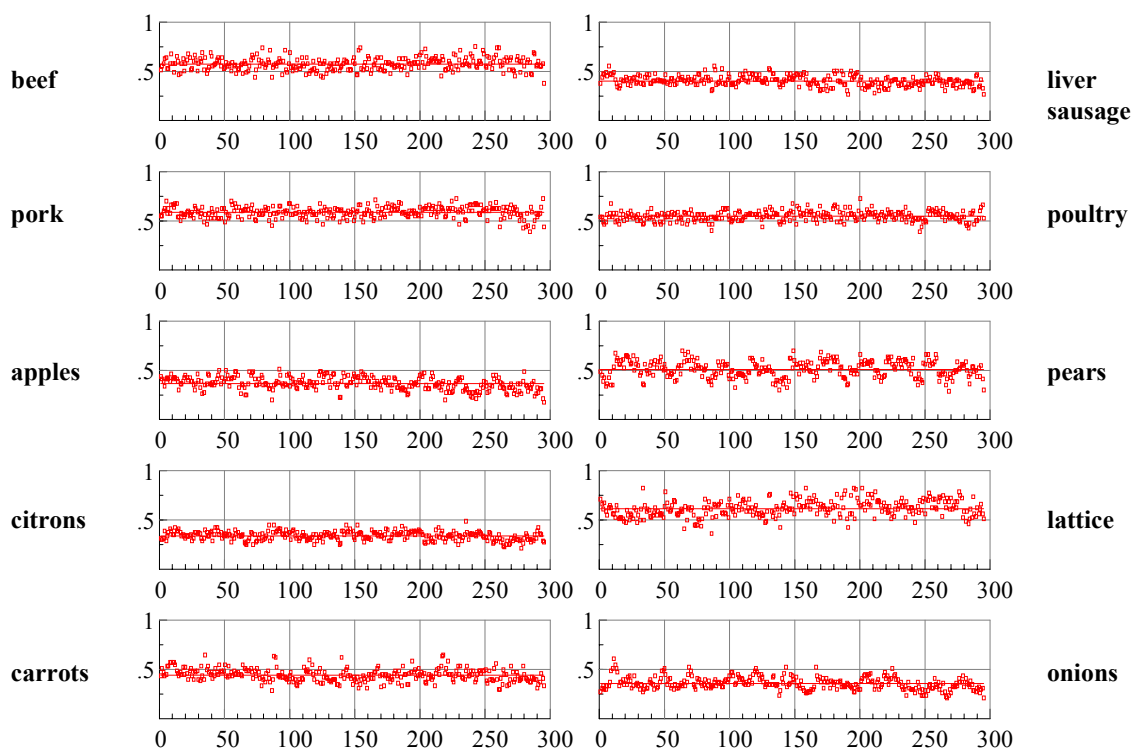
Source: Data by ZMP, 2001.

**Fig. 2: Frequency of price changes per week over all products and stores in percent**  
(sample of 10 food items in 131 stores over 296 weeks)



Source: Data by ZMP, 2001.

**Fig. 3: Frequency of price changes per week over all stores for each food item in percent (sample of 131 stores over 296 weeks)**



Source: Data by ZMP, 2001.

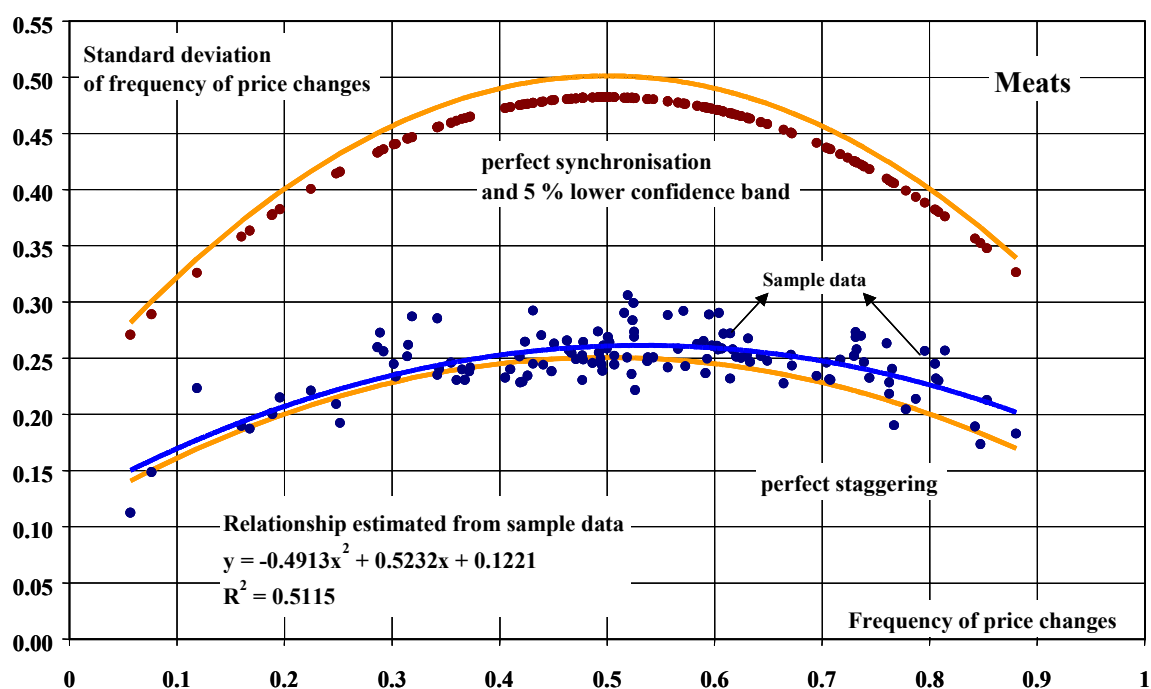
**Tab. 4: Results for the Chi-Square-test with perfect staggering under the  $H_0$ -hypothesis**

	Store type					Retailer company					
	All	SSM	BSM	CSM	DC	A	B	C	D	E	F
<b>All</b>	<b>642</b>	252	<b>342</b>	<b>472</b>	172	283	230	324	277	<b>432</b>	192
<b>Beef</b>	282	87	179	226	85	150	117	112	192	241	110
<b>Liver sausage</b>	256	136	228	206	128	175	150	142	200	240	161
<b>Pork</b>	218	103	155	207	95	115	109	130	160	259	120
<b>Poultry</b>	182	128	142	155	141	142	119	136	171	148	121
<b>Apple</b>	<b>465</b>	182	<b>365</b>	<b>358</b>	152	279	190	<b>371</b>	213	<b>398</b>	233
<b>Pears</b>	<b>563</b>	165	324	<b>401</b>	152	274	172	294	249	328	145
<b>Citrons</b>	232	176	248	184	138	206	167	178	239	232	105
<b>Lattice</b>	<b>435</b>	147	268	288	91	197	134	247	215	267	121
<b>Carrots</b>	<b>378</b>	192	230	276	127	189	160	217	211	301	130
<b>Onions</b>	<b>447</b>	185	301	<b>344</b>	101	263	138	218	200	258	199

Source: Data by ZMP, 2001.

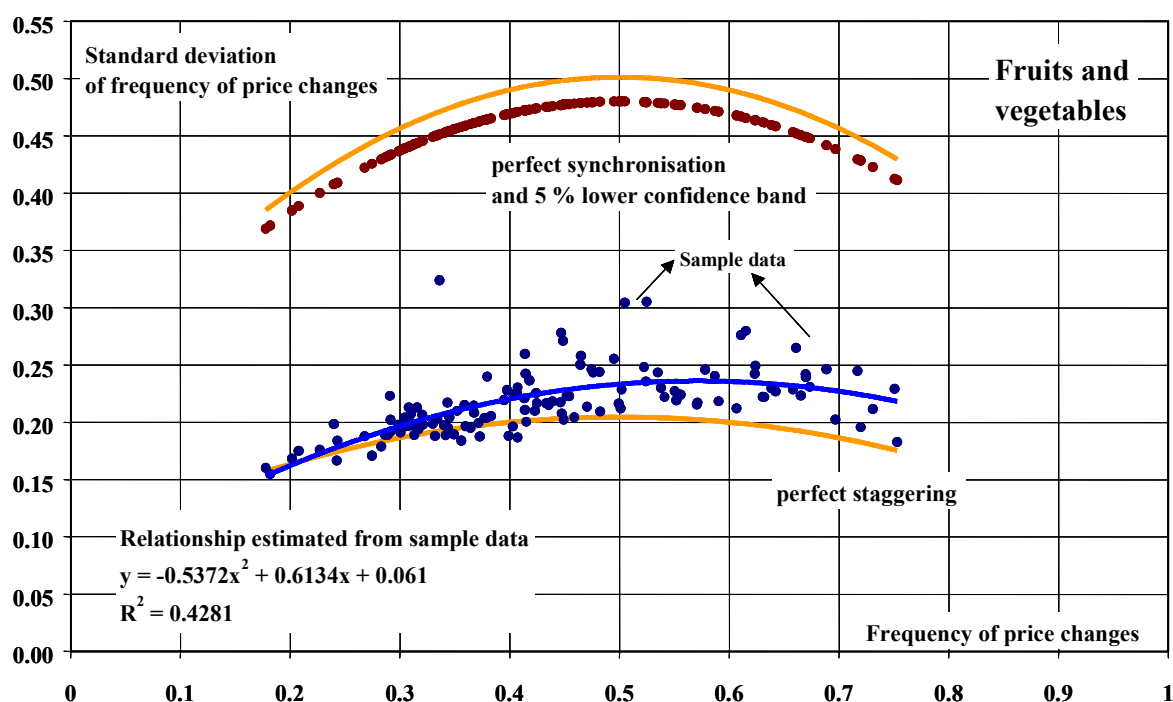
Note: Bold numbers indicate that staggering is rejected at the 95% significance level.

**Fig. 4: The relationship between the average frequency of price changes and the standard deviation of the frequency for meat products**



Source: Data by ZMP, 2001.

**Fig. 5: The relationship between the average frequency of price changes and the standard deviation of the frequency for fruits and vegetables**



Source: Data by ZMP, 2001.