Price Setting in Hungary – A Store-Level Analysis

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Abstract

This paper uses Hungarian micro CPI data between December 2001 and June 2007 to provide descriptive statistics of store-level pricing practices in Hungary. First we present the frequency and average size of price changes, the duration distribution of price spells and calculate mean durations for different product categories. Then we decompose the observed variations in the inflation rate to variations in frequencies and sizes. Finally we estimate the inflation effects of three general VAT-rate changes during our sample period.

1 Introduction

This paper uses Hungarian micro CPI data between December 2001 and June 2007 to provide descriptive statistics of store-level pricing practices in Hungary. In particular, our focus is on the main conclusions of the Inflation Persistence Network (IPN) of the European Central Bank, as summarized by Dhyne et al. (2005): in the Euro area

- prices change rarely (the frequency of price change is 15.1%);
- there is huge sectoral heterogeneity;
- sectoral heterogeneity is more pronounced than heterogeneity across countries;
- prices are flexible downwards;
- the average size of price changes are large (relative to the inflation rate);

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- there is no evidence of synchronization of price changes among price setters.

Our contribution is that we provide further empirical evidence on these issues from Hungary, where the inflation rate was somewhat higher and also more volatile during the sample period: from 6.8 percent in December 2001 and 7.6 percent in May 2004, it decreased to 2.3 percent in March-April 2006, but soon went back to 9.0 percent in March 2007 (see Figure 1 in the *Appendix*).

In terms of frequencies, sizes and mean durations, we find that

- the overall frequency of price change in Hungary is 21.5%, higher than in the Euro area (but still lower than in the US, where Bils-Klenow, 2004 report 26.1%, and Klenow-Kryvtsov, 2007 report 36.2%);[1]
- there is indeed huge sectoral heterogeneity;
- prices are indeed flexible downwards, since the frequency of price decreases (8.8%) is only slightly smaller than the frequency of price increases (12.8%);
- the average size of all price changes is 12.3 percent, out of which the average size of increases is 11.2 percent, and the average size of decreases is 13.6 percent, which is larger than 8 percent and 10 percent in the Euro area (Dhyne et al., 2005), but smaller than 14 percent in the US (Klenow-Kryvtsov, 2007);
- the mean duration of prices is 8.03 months, somewhat smaller than the implied mean duration in the Euro area, and similar to mean duration estimates in the US.

In addition, we also decompose the variation in observed inflation rates to variations of frequencies and sizes. The relatively volatile nature of the Hungarian inflation rate makes this exercise more interesting. We find that

- variations in inflation rate are more strongly correlated with variations in the average size of price changes, seemingly indicating that it is mostly the average size of price changes that drives inflation;
- but a more precise decomposition of the inflation rate (into frequencies and sizes of price increases and decreases separately) reveals that in fact variations in price increase and decrease frequencies are the most important driving forces of inflation.

Finally, we investigate the effects of three general VAT-changes during the sample period:

[1] Note, however, that price change frequencies in different countries are difficult to compare, as the consumer baskets they are based on may contain different goods and services. The only exception is IPN-studies, where statistics were reported to a standardized sample of 50 products.

- In January 2004, the middle VAT-rate increased from 12 percent to 15 percent.
- In January 2006, the top VAT-rate decreased from 25 percent to 20 percent.
- In September 2006, the middle VAT-rate increased from 15 percent to 20 percent.

We find that the effects of the VAT-increase and the VAT-decrease are not symmetric: while the 3 percentage point VAT-increase in January 2004 and a similar 5 percentage point VAT-increase in September 2006 increased the price level of the affected products by approximately 2.05 percent and 3.73 percent on average in the first month after the change, the 5 percentage point VAT-decrease in January 2006 reduced the price level of the affected products by a mere 1.24 percent on average. Moreover, VAT-changes also had significant effects on the prices of those products that were not directly affected; this may indicate that stores do synchronize their price changes (or at least a VAT-change is a natural device for the synchronization).

The remaining of the paper is organized as follows. After describing the data set in section 2, sections 3-4 present simple statistics about the frequency and average size of price changes. Then we discuss overall and sectoral duration distributions, and direct and indirect mean duration estimates in section 5. In section 6 we decompose the inflation variation into frequency and size effects. Section 7 analyzes how the above-mentioned VAT-changes affected the stores' pricing practices and the CPI. Section 8 concludes.

2 Data

The analysis is carried out on a data set containing store-level price quotes, which is originally used for the Consumer Price Index (CPI) calculation by the Hungarian Central Statistical Office (CSO). Field agents of the CSO collect price quotes about several hundred narrowly defined products in various outlets.

The time span of the data set is between December 2001 and June 2007, which means that we have price observations for 67 consecutive months, and price *changes* for 66 consecutive months.

As far as the cross-sectional coverage is concerned, the best coverage is achieved in 2006 (when representative items were selected into the sample). In this year, we have data about 770 representative items of 896 on the item list. This data construction method also implies that representative items disappearing before 2006 are not in the data set, and therefore the coverage in earlier years is weaker (see Table 1). Then the data set was updated in 2007, when the CSO added 17 new representative items to the item list, and discontinued data collection of 40 representative items.[2] Therefore the total number of representative items is 787, but the maximum number in any year is 770.

[2]This would imply 770+17-40=747 representative items in 2007, but prices are not gath-

Table 1: Coverage of the data set by years

year	**no. of items**	**CPI-weight**	**no. of observations**
2002	718	66.855	805,630
2003	732	69.148	828,152
2004	739	69.087	841,282
2005	769	70.735	848,188
2006	770	70.122	879,561
2007	742	68.991	415,479
TOTAL	**787**	–	**4,618,292**

In 2006, the total weight of our 770 representative items in the consumer basket is 70.122%. The missing items have either regulated prices (e.g. kindergarten and school catering, electric energy, pipeline gas, highway toll stickers) or the data collection methodology of the CSO makes it impossible to investigate price quotes of identical products over time (e.g. new and used cars). Table 2 contains the 2006 coverage of the data set by CPI- and COICOP-categories. In terms of CPI-categories, mainly consumer durable goods, services and regulated prices (from the "electricity, gas, other fuels and other goods" category) are missing. In terms of COICOP-categories, we have (almost) full coverage of foods, alcohol/tobacco, clothing, furnishing, restaurants and miscellaneous goods and services, while the coverage is the weakest for transport and communication.

We can look at the data set as 787 mini "panels" about 787 representative items. For example, for the representative item "bony pork rib with tenderloin" there are 8,667 observations from 162 different outlets. Accordingly, in case of this representative item the data set contains (8,667/162=) 53.5 price quotes per outlet on average, but for 95 of the 162 stores we have data from each month (i.e. in all 67 months in the data set). It is true for most of the representative items in the data set that the list of observed outlets is typically unchanged, therefore the store-level developments in the prices and the pricing behavior of different stores can be investigated.

On average, there are approximately 5,952 observations per representative item in the data set, which means that the total number of observations is close to 4.7 million (4,684,289).[3] For each observation, the data set contains the following information:

- price;
- month of observation;
- product code: 5-digit representative item code;

ered at all between January and June each year for five representative items (peach, grapes, plums, and two types of theater season tickets), so in fact we only have price data about 742 representative items in 2007.

[3]In Table 1, 65,997 observations from 2001 December are not reported.

Table 2: Coverage of the data set by CPI- and COICOP-categories in 2006

	CPI basket		Sample	
CPI category	**Weight**	**Items**	**Weight**	**Items**
Food, alcohol, tobacco	31.842	222	31.322	220
Unprocessed food	5.665	53	5.665	53
Processed food	26.177	169	25.657	167
Proc. food excl. alc, tob	17.427	139	16.907	137
Clothing	5.305	171	5.305	171
Durable goods	9.240	112	4.976	73
Other goods	15.277	214	10.235	192
Energy	13.203	16	6.350	8
Services	25.134	161	11.934	106
COICOP category	**Weight**	**Items**	**Weight**	**Items**
Food, non-alc beverages	18.605	167	18.605	167
Alcohol, tobacco	6.696	22	6.696	22
Clothing	5.255	168	5.255	168
Housing, water, electr, gas	19.646	51	5.762	38
Furnishings, househ equipm	7.411	109	6.752	109
Health	2.917	34	2.083	26
Transport	13.950	98	7.800	39
Communications	4.661	14	0.159	5
Recreation, culture	8.831	135	5.858	102
Education	0.947	3	0.632	2
Restaurants, hotels	6.761	35	6.241	33
Miscellaneous	4.321	60	4.279	59
TOTAL	**100.000**	**896**	**70.122**	**770**

- store code (makes possible to identify location in terms of county);
- "change code", indicating sales, normal price increases/decreases, price imputations, forced store and/or product replacements, changes of suppliers, changes in product outfits, and mistakes in previous months' quotes.

Unfortunately, we do not have information about store characteristics (e.g. type of outlet, size, whether the store is operated in a city or not etc). The only thing we can do is to proxy the store size with the number of representative items in our data set sold in the particular stores.

Following Baudry et al. (2004), we call an uninterrupted sequence of price quotes of the same product in the same outlet as a **price trajectory**.[4] Within price trajectories, uninterrupted *sequences of price quotes with the same price* are called **price spells**.

The first step of the data manipulation was to determine the number of price trajectories. We sorted the data set according to product identifiers, store identifiers and months, so that price quotes of the same products from the

[4] Klenow-Kryvtsov (2007) call the price trajectories as quote-lines.

same stores were after each other. Then we determined the consecutive price trajectories. In doing so, we assumed that the following events led to a beginning of a new price trajectory:

- change in the 5-digit representative item identifier (*change of product*);
- change in the store identifier (*change of store*);
- forced product and/or store replacement (either the specific product is not available in the given store, or the store is not available any more, or both);
- change of supplier;
- change of product outfit.

According to this definition, we found a total of 272,549 different price trajectories in the data set, with an average length of 17.2 months.

2.1 Specific data issues: censoring, sales, imputed prices and VAT-changes

Censoring: for a given product in a given store (i.e. for a given price trajectory), we treat the first observation as left-censored, and the last observation as right-censored. This means that (1) the ages in a price trajectory are unobserved until the first price changes takes place; (2) the duration of the first and last price spell in any price trajectory is unobserved; (3) when estimating frequencies and hazards, the last observation of each price trajectory is not taken into account (as it is unobserved whether the price actually changed or not).

Further, we treat the seasonal products (like gloves) as left- and right-censored in each year. This may be a too restrictive assumption, since it may be that gloves, for example, sell for 0 between May-September each year.

Sales: as mentioned before, there is a change code variable for each price quote, which indicates whether the quoted price was actually a sales price or not. More specifically, if the change code is 1, then it indicates the beginning of a sales, and a change code of 2 means that the sales has ended. In the current version, we treated price changes due to sales as "normal"price changes, which may bias the frequency estimates upward, and the mean duration estimates downwards.

Imputed prices: the "change code"variable also indicates if a specific price was imputed by the field agent of the CSO. According to the guidelines given to these agents, they can impute prices for at most two consecutive months, when for some reason they cannot observe temporarily the price of the required product in the required outlet. If the recording of the price quote is impossible in three consecutive months, then the agent has to replace either the store or the product, and so a new trajectory begins.

It should be clear that these imputed prices are not actually observed prices and should be treated differently. Therefore we replaced all imputed prices with the previous month's price quote. This leads to downward bias in the frequency estimates and upward bias in the mean duration estimates only if there were price changes in both the month of imputation and the month after.

Table 3: VAT rates in Hungary

VAT-rates in Hungary	**Lower**	**Middle**	**Top**
– Dec 31, 2003	0%	12%	25%
Jan 1, 2004 – Dec 31, 2005	5%	**15%**	25%
Jan 1, 2006 – Aug 31, 2006	5%	15%	**20%**
Sep 1, 2006 –	5%	**20%**	20%

VAT-changes: relative to other EU member states, in Hungary there have been quite frequent changes in the general VAT-rates recently (Table 3). In January 2004, the middle and lower rates increased from 12 to 15 percent and from 0 to 5 percent, respectively, while in January 2006 the top rate was reduced from 25 to 20 percent. Finally, from September 2006, the middle rate was again increased to 20 percent, which means that now there are only two different VAT-categories in Hungary.

3 Frequency of price changes

Stores adjust prices only infrequently, but there is substantial variation among products (Figure 2). In the whole sample the (weighted) average frequency of price changes is 21.5 percent, and the (weighted) median is 14.0 percent. The minimum frequency is 0 percent for "acupuncture treatment"and the maximum is 100 percent for "currency exchange". In the Euro area the average frequency is 15.1 percent (Dhyne et al, 2005), smaller than in Hungary. In the US, Bils-Klenow (2004) report an average frequency of 26.1%, while Klenow-Kryvtsov (2007) finds 36.2% (on a different sample).

Product-level frequencies are extremely heterogenous, which is also the case at the level of main product categories (Table 4). Price change frequencies are highest for food and energy items, while the rate of price adjustment is the lowest in case of services. In the whole sample, price decreases are almost as frequent as price increases, so our results - similarly to previous findings - do not support downward nominal rigidity. Also in this respect there is substantial heterogeneity across sectors. Services' prices rarely change downwards, whereas in case of durable goods and clothes price decreases are even more frequent than increases.[5]

There is relatively strong correlation between the frequency of price increases and decreases (Figure 3 in the Appendix). This can be the result of volatile

[5]This result about items in the clothing category is heavily influenced by the seasonal pattern of many of them: end-of-season sales are taken into account, while higher prices of new collections (after several months of missing data) are not.

Table 4: Frequency of price changes by product categories

CPI category	Freq of change Mean	Freq of change Median	Freq of increase Mean	Freq of increase Median	Freq of decrease Mean	Freq of decrease Median
Food, alcohol, tobacco	0.249	0.208	0.144	0.136	0.104	0.079
Unprocessed food	0.504	0.466	0.232	0.222	0.273	0.212
Processed food	0.192	0.176	0.125	0.123	0.067	0.058
Proc. food excl. alc, tob	0.195	0.191	0.124	0.119	0.070	0.075
Clothing	0.116	0.111	0.045	0.044	0.071	0.057
Durable goods	0.122	0.108	0.050	0.048	0.072	0.058
Other goods	0.111	0.089	0.067	0.054	0.045	0.032
Energy	0.630	0.877	0.385	0.524	0.245	0.342
Services	0.080	0.069	0.067	0.062	0.013	0.005
COICOP category	**Mean**	**Median**	**Mean**	**Median**	**Mean**	**Median**
Food, non-alc beverages	0.316	0.282	0.170	0.162	0.146	0.110
Alcohol, tobacco	0.229	0.180	0.152	0.147	0.077	0.047
Clothing	0.116	0.111	0.045	0.044	0.071	0.057
Housing, water, electr, gas	0.103	0.077	0.088	0.067	0.015	0.005
Furnishings, househ equipm	0.106	0.095	0.056	0.050	0.049	0.038
Health	0.074	0.059	0.058	0.051	0.016	0.007
Transport	0.507	0.477	0.308	0.265	0.199	0.213
Communications	0.288	0.294	0.090	0.078	0.198	0.216
Recreation, culture	0.115	0.086	0.064	0.046	0.050	0.025
Education	0.069	0.069	0.061	0.061	0.008	0.008
Restaurants, hotels	0.066	0.063	0.060	0.057	0.006	0.003
Miscellaneous	0.118	0.089	0.074	0.070	0.043	0.019
TOTAL	**0.215**	**0.140**	**0.128**	**0.083**	**0.088**	**0.046**

cost factors or pricing strategies of stores (e.g. price discrimination through randomizing prices).

As the different product categories are heterogenous with respect to their adjustment frequencies, it is interesting to have a look at their adjustment patterns separately. For this reason we prepared the time series of the price change frequencies in the different product categories (Figure 4 in the Appendix). Also, it is worth investigating the time series of price increase and price decrease frequencies in the different product categories, which are Figures 5–11 in the Appendix.[6]

Within the food category, processed and unprocessed food behaves quite differently. In case of processed food (Figure 5), price change frequencies are relatively small, and as there is not much time-series variation in the price decrease frequencies, they are mainly driven by the price increase frequencies. In contrast, unprocessed food prices (Figure 6) change relatively frequently, with significant variation in the price decrease frequencies, and we can also see

[6]In these figures, the vertical lines mark VAT-changes. For an analysis of the effects of the tax changes, see Section 7.

seasonal variation in the adjustment frequencies.

In the clothing category (Figure 7), the frequency of price changes shows an especially strong seasonal pattern. The effect of the two end-of-season sales is very transparent in each year. Prices decrease temporarily in January and February (winter sales) and also in July and August (summer sales).

In contrast, the price change frequencies of durable goods (Figure 8) do not show any seasonality. Both price increases and decreases are relatively uncommon and the monthly increase and decrease frequencies fluctuate around 5 percent.

In the other goods category (Figure 9) the price change frequencies are around 10 percent, with relatively higher variation than in case of durable goods (but the variation does not seem to be seasonal). In this product category, price increases tend to be more frequent than price decreases.

We see extremely high adjustment frequencies in the energy category (Figure 10), which is driven by the frequent price change of the different types of fuels. These price changes are strongly correlated with variations of oil prices in the world market.

The services sector (Figure 11) is characterized with a very strong seasonal pattern in the adjustment frequencies: most price changes take place in the first few months of the year. Moreover, in case of services price changes are almost exclusively price increases: the proportion of price decreases is very low, around 1 percent.

As in some sectors the frequency of price changes follows a seasonal pattern, it may be interesting to look at the average frequencies in the different months of the year for each sector (Figure 12 in the Appendix). According to this, the frequency of price change is strongly seasonal in the food, clothing and services sectors, but does not follow any seasonal pattern in the durable goods and other non-industrial goods categories.[7]

4 Size of price changes

In Hungary, the (weighted) average size of price changes is 12.25 percent, and the (weighted) median is 11.68 percent. The average size of price increases is 11.15 percent (with a median of 10.85 percent), and the average size of price decreases is 13.62 percent (with a median of 12.76 percent). These numbers are somewhat larger than in the Euro area, where the average size of price increase and decrease is 8.2 percent and 10 percent (Dhyne et al., 2005). In the US, the average size of price changes is 14 percent (Klenow-Kryvtsov, 2007).

Similarly to the frequencies, the average size of price changes also differs considerably among products (Figure 13 in the Appendix). While the average size (across items) is 12.25 percent, the maximum is 30.6 percent for "natural medical therapy"and the minimum is 1.4 percent for "currency exchange".[8]

[7]These claims remain valid even if we investigate the seasonal patterns between 2002-2005, which period was less affected by VAT-changes.

[8]We took into account only those products for which we had observations for the whole

Some heterogeneity also prevails at the main product category level (Table 5), but it is less pronounced than in case of frequencies. Although the importance of factors like menu costs, pricing strategies and cost factor volatility may differ for explaining the differences in frequencies and magnitude of price changes, it is natural to assume that the lower is the frequency of price change, the bigger is its magnitude. The size of price changes is the smallest for energy, and the highest is for clothing. Although on average price increases are more frequent than decreases, its effect on inflation is partly offset by the higher magnitude of price decreases.

Table 5: Size of price changes by product categories

	Size of change		**Size of increase**		**Size of decrease**	
CPI category	**Mean**	**Median**	**Mean**	**Median**	**Mean**	**Median**
Food, alcohol, tobacco	12.54	11.56	11.63	10.79	13.64	12.75
Unprocessed food	17.75	13.60	15.39	12.72	18.84	14.33
Processed food	11.39	11.23	10.80	10.58	12.49	12.59
Proc. food excl. alc, tob	12.11	12.13	11.36	11.11	13.39	14.05
Clothing	20.61	21.77	15.71	16.21	24.06	25.36
Durable goods	10.53	10.22	9.07	9.09	11.78	11.34
Other goods	12.39	12.33	11.10	10.83	14.41	14.08
Energy	3.82	2.92	3.81	2.86	3.82	3.02
Services	12.86	12.05	12.68	11.85	14.22	13.12
COICOP category	**Mean**	**Median**	**Mean**	**Median**	**Mean**	**Median**
Food, non-alc beverages	13.94	12.48	12.56	11.62	15.44	14.33
Alcohol, tobacco	9.34	9.18	9.01	8.83	9.91	10.88
Clothing	20.70	21.84	15.79	16.23	24.14	25.42
Housing, water, electr, gas	9.90	10.73	9.77	10.19	10.67	10.91
Furnishings, househ equipm	11.27	11.37	10.10	10.21	13.09	13.07
Health	11.81	11.40	11.27	11.07	13.42	12.03
Transport	6.33	3.25	6.26	3.30	6.54	3.18
Communications	21.00	16.96	9.03	9.12	24.53	19.08
Recreation, culture	13.81	12.89	12.50	11.38	15.67	14.55
Education	11.42	11.42	11.10	11.10	14.17	14.17
Restaurants, hotels	11.82	10.58	11.72	10.58	12.29	12.87
Miscellaneous	13.09	12.88	12.50	12.81	15.10	14.44
TOTAL	**12.25**	**11.68**	**11.15**	**10.85**	**13.62**	**12.76**

The correlation between the magnitude of price increases and decreases is strong (Figure 14 in Appendix), which can be a sign of symmetric product specific menu costs.

Similarly to the frequencies, it is worth examining the time series of the size of price changes in the different product categories. Figure 15 in the Appendix depicts the time series in the different CPI-categories, and Figures 16–22 show

sample period. Figure 13 in the Appendix contains all representative items, irrespective of the periods of observation.

the average price increase and decrease sizes for the different product categories separately.

It is apparent from Figure 15 that the extent of sectoral heterogeneity is much smaller for the size of price changes than for frequencies. Representative items in the Energy category – mostly fuels – experience small price changes, and the price of Clothes change by relatively large amounts, but the average size of price changes in the other CPI-categories mostly fluctuates between 10-15 percent.

In the processed food category (Figure 16) absolute sizes of price decreases are consistently above the sizes of price increases. Both increase and decrease sizes are quite stable over time, with no apparent seasonal variation. It is clear that average sizes of price increases and decreases tend to decrease around and after VAT-changes – a robust observation in all product categories.

In the unprocessed food category (Figure 17) the average size of price changes is relatively large. It also has larger time-series variation, and price decrease sizes are also subject of seasonal variation. These reflect the changes in the availability of fresh fruit and other similar representative items.

The largest price changes can be observed in the Clothing category (Figure 18). Price increases and decreases are both strongly seasonal, reflecting seasonal sales for these types of products.

In case of the durable goods (Figure 19), the size of price increases fluctuates between 8 and 11 percent, with no obvious trend or seasonal pattern. The size of price decreases is generally larger (in absolute terms), and is relatively more volatile. After the 2006 January VAT-decrease the absolute size of price decreases reached a historical low.

For the other goods category (Figure 20), the size of price increases is quite stable over time. In contrast, the size of price decreases is more volatile, and also larger (in absolute terms) than the size of increases.

Representative items (mostly fuels) in the Energy category (Figure 21) are quite specific: they have far the highest frequency of price changes, and far the lowest size. While the average size of price changes is more than 10 percent for the other product categories, it is generally less than 5 percent for the fuels.

In the services category (Figure 22), though price change frequencies were very different from other product categories, sizes are more or less similar: the average size of price increases is between 10 and 15 percent in almost all months. The average size of price decreases has somewhat larger fluctuation, but as price decreases are very rare in this category, these numbers are calculated from small numbers of observations, which may explain the larger variation.

Finally, if we investigate the average sizes of price changes by the months of the year within the different product categories (Figure 23 in the Appendix), we can see that the magnitude of price changes is much less seasonal than the frequency: while we had seasonal variation in almost all product categories in the frequencies, we can see seasonal variation in the sizes only in the clothing and unprocessed food categories.

5 Mean duration of price spells

We begin this section by reporting the duration distribution of observed price spells in all product categories (Figure 24). Similarly to many European countries, the mode of this distribution is at 1 month. However, there are two factors that bias our results towards shorter price spells: one the one hand, in our sample there are more spells from stores with shorter average durations, thus we over-sample shorter spells. On the other hand, due to left and right censoring, we lose longer spells with larger probability, which again biases our observed distribution towards the shorter spells.[9] Overall, the average duration of price spells (when calculated directly from the observed duration distribution) is 6.14 months.[10]

Sectoral duration distributions (Figures 25–26 in the Appendix) are generally quite similar to the overall duration distribution. The directly observed distributions in the clothing, consumer durables and other goods sectors are almost identical, the only difference being perhaps the high frequency of durations of 2 months in case of the clothes. For the unprocessed food items, the proportion of spells with a duration of 1 month is more than 60 percent, while the same number in the processed food category is less than 40 percent. In the energy sector, more than 80 percent of the prices last for only 1 month, reflecting frequent changes in fuel prices. In terms of the shape of the observed duration distribution, the only exception is the services sector, where the mode is at 12 months, reflecting time-dependent pricing with price revisions mostly taking place in January.

The second column of Table 7 contains the means of the observed duration distributions by CPI- and COICOP-categories. However, as we discussed before, these mean duration estimates are biased downwards because of two factors: censoring and heterogeneity.

- If the data is *censored*, then longer price spells are more likely to be censored out, and therefore the average duration estimate will be biased downward.

- If there is *store-level heterogeneity* within the product categories, then we will observe more spells from those stores that change prices more frequently. This means that we will over-sample shorter spells, so the product-level average duration estimates will be again biased downward.

Gabriel-Reiff (2007) discuss many possible ways to eliminate these bias in the direct mean duration estimations. The main result of their paper is that when we weight each spell by the inverse of the number of spells observed at the particular store, then the resulting weighted mean duration estimate will be robust to both censoring and cross-sectional heterogeneity. Without further

[9] If we have $T = 67$ months of observations, then we have 66 "generations"of 1-month long spells, and only 60 "generations"oh 7-month long spells.

[10] This number is calculated by taking the weighted average of product level mean durations, with the weights being the product-specific CPI-weights.

discussing this result, in the fourth column of Table 7 we simply report the preferred mean duration estimates from Gabriel-Reiff (2007). Since Gabriel and Reiff use a restricted sample for their calculations (see this restricted sample in Table 6), for the sake of comparability we also report the direct mean duration estimates (i.e. means of the directly observed duration distributions) for the same restricted sample in the third column of Table 7.

Table 6: Coverage of the data set in mean duration calculations, taken from Gabriel-Reiff (2007)

	CPI basket		Original samp.		Restricted samp.	
CPI category	**Weight**	**Items**	**Weight**	**Items**	**Weight**	**Items**
Food, alcohol, tobacco	31.842	222	31.322	220	28.442	189
Unprocessed food	5.665	53	5.665	53	4.151	34
Processed food	26.177	169	25.657	167	24.291	155
Proc. food excl. alc, tob	17.427	139	16.907	137	16.107	127
Clothing	5.305	171	5.305	171	3.024	98
Durable goods	9.240	112	4.976	73	3.388	47
Other goods	15.277	214	10.235	192	7.852	159
Energy	13.203	16	6.350	8	5.468	5
Services	25.134	161	11.934	106	9.945	82
TOTAL	**100.000**	**896**	**70.122**	**770**	**58.120**	**580**

Note: The restricted sample is the sample of Gabriel-Reiff (2007).

Results in Table 7 indicate that correcting for censoring and cross-sectional heterogeneity indeed increases our mean duration estimates. Column 3 indicates that the restricted sample of Gabriel-Reiff (2007) has somewhat larger mean duration than the whole sample used in this paper: the estimated direct mean duration increases from 6.14 to 6.35 months. The difference between the estimated mean durations in columns 3-4, however, are because of the bias correction: if we account for the downward bias caused by censoring and cross-sectional heterogeneity, then the estimated mean duration increases from 6.35 months to 8.03 months. Note that the bias-corrected mean duration estimates are bigger in all CPI-categories than the direct mean duration estimates, supporting our earlier statement about the downward bias in the latter.

6 Inflation variation: decomposition into frequency and size effects

Given that the inflation rate equals the product of the frequency and the average size of price changes,[11] it is natural to ask whether it is changes in the

[11] A formal proof of this can be found e.g. in the Appendix of Hoffmann–Kurz-Kim (2006).

Table 7: Mean duration of price spells by product categories

CPI category	Whole sample Direct est.	Restricted sample Direct est.	Restricted sample Indirect est.
Food, alcohol, tobacco	5.24	5.44	6.76
Unprocessed food	2.26	2.58	3.29
Processed food	5.90	5.93	7.35
Proc. food excl. alc, tob	5.60	5.59	7.19
Clothing	4.75	6.71	9.59
Durable goods	5.49	5.83	9.18
Other goods	7.08	6.46	9.14
Energy	1.85	1.72	1.78
Services	10.84	11.52	13.35
COICOP category			
Food, non-alc beverages	3.40	3.55	4.77
Alcohol, tobacco	4.22	4.17	4.97
Clothing	4.80	6.83	9.69
Housing, water, electr, gas	8.57	9.66	11.67
Furnishings, househ equipm	6.35	6.53	9.66
Health	12.25	18.30	14.62
Transport	4.70	4.61	5.58
Communications	3.19	–	–
Recreation, culture	7.52	8.07	10.40
Education	7.32	9.68	11.76
Restaurants, hotels	11.87	12.20	14.46
Miscellaneous	8.35	7.93	10.23
TOTAL	**6.14**	**6.35**	**8.03**

Notes: The restricted sample is the sample of Gabriel-Reiff (2007) (see also Table 6). The indirect estimates in column 4 are also taken from Gabriel-Reiff (2007).

frequencies or sizes that is behind the observed variation in the inflation rate.[12] In Hungary, this question is of particular interest, since the inflation variation is much bigger than in other developed countries (see Figure 1 in the Appendix): in our sample period of five and half years, inflation varied between 2.3 percent and 9 percent, including a period (April 2006–March 2007) when the yearly inflation rate increased by 6.7 percentage points within a mere 11 months.

In addition to its empirical relevance, this question is potentially important from a theoretical point of view as well. In the sticky prices literature models distinguish between two types of price rigidities: they assume either time-dependent pricing (TDP) or state-dependent pricing (SDP). In the TDP models, firms are given the opportunity to re-price exogenously, and this opportunity typically depends on the time elapsed from the last price change. In the SDP models, firms' re-pricing decisions are endogenous, and depend on the (either

[12]In the previous section we used the term "average size"for the average *absolute* size of price changes. In this section we use the same term for the average sizes of price changes with negative sign for price decreases, and positive sign for price increases.

firm-specific or aggregate) shocks that hit them. Therefore in time-dependent models the frequency of price change does not vary, even after relatively large shocks. On the other hand, under state-dependent pricing, variation in the frequency of price changes (or the extensive margin) is an important channel of price adjustment after shocks. Therefore, by exploring the source of variation in the inflation rate (i.e. whether it is variation in frequencies or not) we may be able to decide which model family is more relevant empirically.

To judge whether it is volatility in frequencies or averages sizes behind the volatility of inflation rates, first it may be useful to have a look at the time-series of monthly inflation rates, price change frequencies and average sizes. Figure 27 in the Appendix indicates that the average size of price changes exhibits stronger co-movement with the inflation rate than the frequency of price changes; but as we shall see, a deeper analysis is necessary to give a definitive answer to this question.

We use the decomposition of Klenow-Kryvtsov (2007) to more formally analyze the driving forces of the inflation variation. Klenow and Kryvtsov show that if we take the first-order Taylor series expansion of the identity $\pi_t = fr_t \cdot dp_t$ (where π_t, fr_t and dp_t are inflation, frequency and average size of price change at time t) around the sample means $\overline{fr}$ and $\overline{dp}$, then we can express the inflation volatility as

$$var(\pi_t) = var(dp_t) \cdot \overline{fr}^2 + var(fr_t) \cdot \overline{dp}^2 + 2 \cdot \overline{fr} \cdot \overline{dp} \cdot cov\left(fr_t, dp_t\right) + O_t. \quad (1)$$

In the right-hand side, the first term ($var(dp_t) \cdot \overline{fr}^2$) stands for the inflation volatility in the intensive margin (i.e. same frequency, varying size of price adjustments), and captures all the inflation volatility in TDP models (where fr_t is constant over time). So the fraction $var(dp_t) \cdot \overline{fr}^2 / var(\pi_t)$ (the "time-dependent part" of the inflation variation) reflects how closely are the TDP models to empirically observed inflation variations.

Table 8 contains this time-dependent fraction $var(dp_t) \cdot \overline{fr}^2 / var(\pi_t)$ of inflation volatility for each product categories separately. Having seen Figure 27, perhaps it is not surprising that when calculated for all product categories, the time-dependent part accounts for 75.2 percent of all inflation variation. This number is somewhat smaller than what Klenow–Kryvtsov (2007) found for the US: they reported the time-dependent part to be between 86 percent and 113 percent (depending on the sample used).

As Table 8 makes it clear, there is huge sectoral heterogeneity in both the inflation volatility, and the time-dependent part of it. The volatility of inflation itself shows high variation across product categories: the volatility is biggest – perhaps not surprisingly – for unprocessed foods, clothing and energy items. The time-dependent part of the volatility is bigger than average for unprocessed food, durable goods, other goods and energy items, reflecting relatively constant price change frequencies (over time) for these. While this is true, this constant frequency is huge for unprocessed food and energy, and it is relatively low for the durable goods and other non-industrial goods.

Table 8: Decomposition of inflation volatility by main CPI categories

CPI category	$var(\pi_t)$	**Time-dependent part of** $var(\pi_t)$	**TDP %**
Food, alcohol, tobacco	0.636	0.427	67.1%
Unprocessed food	7.858	7.200	91.6%
Processed food	0.330	0.122	37.0%
Proc. food excl. alc, tob	0.459	0.156	34.0%
Clothing	2.380	1.470	61.7%
Durable goods	0.082	0.070	85.1%
Other goods	0.149	0.120	80.7%
Energy	3.950	3.043	77.1%
Services	0.365	0.069	18.9%
TOTAL	**0.235**	**0.177**	**75.2%**

At the other extreme, the time-dependent part of the inflation volatility is relatively low for clothing, and extremely low for processed food and services. This would indicate state-dependence and adjustment to shocks on the extensive margin (i.e. through volatile adjustment frequencies). However – as we discussed previously –, the source of frequency volatility in these categories is mainly seasonal variation. The fact that the decomposition of equation 1 cannot distinguish between state-dependence and simple seasonal variation, is a big drawback of this method.[13]

Results in Table 8 indicate that it is predominantly the size of price changes that drives inflation, and not the frequency. But the fact that the price change frequency is relatively stable and independent from the inflation rate may arise simply because when the inflation rate increases, the increasing price increase frequencies and the decreasing price decrease frequencies offset each other. To investigate this possibility (and still following Klenow–Kryvtsov 2007) we also analyzed a more precise decomposition of the inflation rate:

$$\pi_t = fr_t^+ \cdot dp_t^+ + fr_t^- \cdot dp_t^-, \qquad (2)$$

where fr_t^+ and fr_t^- are the frequencies of price increases and decreases, and dp_t^+ and dp_t^- are the average sizes of price increases and decreases.[14] We also introduce $pos_t = fr_t^+ \cdot dp_t^+$ and $neg_t = fr_t^- \cdot dp_t^-$, which are the contributions of price increases and decreases to the overall inflation rate, respectively.[15]

Having calculated the terms in equation 2, in Table 9 we report the simple correlation coefficients of these terms with the inflation rate. In columns 1-2 of Table 9 we report the correlations between $fr_t = fr_t^+ + fr_t^-$ and π_t, and

[13]Nevertheless, Klenow–Kryvtsov (2007) use this decomposition, without discussing the effects that seasonal variation may have on the results.

[14]Our sign convention is that dp_t^+ is positive by construction, and dp_t^- is negative by construction. Of course, the frequencies of price increases and decreases are always non-negative by definition.

[15]Our sign convention then implies that pos_t is always positive, and neg_t is always negative.

between dp_t and π_t. These correlation coefficients are in line with our previous findings: if we use the simple inflation decomposition of $\pi_t = fr_t \cdot dp_t$, then we find that it is mostly the average size of price changes (and not the frequency) that drives the inflation rate.

Table 9: Correlation of terms in equation 2 with the inflation rate

CPI category	fr_t	dp_t	fr_t^+	fr_t^-	dp_t^+	dp_t^-	pos_t	neg_t
Food, alcohol, tobacco	0.71	0.94	0.81	-0.65	-0.02	0.56	0.89	0.73
Unprocessed food	-0.04	0.99	0.43	-0.77	0.45	0.70	0.67	0.90
Processed food	0.89	0.89	0.95	-0.43	-0.31	0.24	0.96	0.51
Proc. food excl. alc, tob	0.89	0.86	0.94	-0.44	-0.51	0.26	0.96	0.50
Clothing	-0.63	0.96	0.71	-0.88	0.50	0.69	0.68	0.95
Durable goods	-0.39	0.90	0.36	-0.52	-0.22	0.48	0.12	0.86
Other goods	0.15	0.93	0.65	-0.52	0.22	0.35	0.81	0.77
Energy	-0.02	0.99	0.89	-0.90	-0.10	0.10	0.85	0.87
Services	0.91	0.60	0.95	0.19	0.09	-0.22	0.99	-0.34
TOTAL	**0.61**	**0.96**	**0.78**	**-0.30**	**0.04**	**0.16**	**0.88**	**0.60**

In columns 3-6 of Table 9, however, we see that variations in the frequencies *do have* an important role in inflation volatility. The frequency of price increases is always strongly positively correlated with the inflation rate, and the frequency of price decreases is almost always negatively correlated with the inflation rate.[16] Obviously, the overall frequency (in column 1) did not show extraordinarily high correlation with the inflation rate because these two effects indeed offset each other. On the other hand, average size of price increases and decreases do not show strong co-movement with the inflation rate. We may have found strong correlation (in column 2) for the average size of *all* price changes because the size of both increases and decreases tends to have a positive correlation with the overall inflation rate.[17]

Finally, columns 7-8 of Table 9 are informative about the relative importance of price increases ($pos_t = fr_t^+ \cdot dp_t^+$) and decreases ($neg_t = fr_t^- \cdot dp_t^-$) in the inflation variation. According to the results, we can assert that price increases seem to be more important from the point of view of inflation than price decreases. Important exceptions are unprocessed food, clothing and durable goods; these are those product categories in which the measured inflation rate in our data set is negative. Therefore it is more appropriate to say that when the inflation rate is positive (negative), then the price increases (decreases) are the primary sources of inflation variation.

[16]The only exception is services, where price decreases are very rare, and their frequency is apparently independent from the inflation rate.

[17]Again, our sign convention implies that whenever π_t increases, dp_t^- becomes a smaller negative number (in absolute terms), so the correlation between π_t and dp_t^- is in fact positive.

7 Inflation effects of Value Added Tax changes

As we discussed earlier, general VAT-rates changed three times during the sample period (see Table 3 earlier). In January 2004, the middle rate increased from 12 percent to 15 percent. In January 2006, the top rate decreased from 25 percent to 20 percent. In September 2006, the middle rate increased again from 15 percent to 20 percent. In this section we analyze how these changes affected the inflation rates.

7.1 Data

The analysis of the inflation effects of the VAT-changes is carried out on a narrower data set than what was used in the previous sections: out of the 770 representative items with a CPI-weight of 70.122 percent in 2006 (see Table 2 before), we dropped further 220. This way the data set analyzed in this section contains 550 representative items with a CPI-weight of 45.346 percent in 2006. The items that were dropped include fuels, alcoholic beverages and tobacco products, where highly volatile external factors (like world oil prices) or frequent changes in indirect taxes (which are similar in effect to VAT-changes) make it difficult to identify the effects of VAT-changes separately. A second main reason of exclusion was when the maximum length of possible price spells was low: these are the products for which the CSO began data collection towards the end of the sample period,[18] rendering the estimates about the inflation effects of VAT-changes to be unreliable. Finally, we also dropped those representative items from the data set whose price are only observed in certain months of the year:[19] missing data makes it very difficult to estimate VAT-effects (for example because there may not be available price observations in the months of VAT-changes).

The coverage of the data set that is used in this section is illustrated in Table 10.[20] In this restricted data set, the number of price observations is 3,950,962, the number of store-product cells 178,534, so the average length of the price trajectories is 22.1 months. (Similar figures in the original sample are 4,684,289 observations, 272,549 price trajectories with an average length of 17.2 months.)

Admittedly, the sub-sample in which we analyze the inflation effect of the VAT-changes is not representative: the frequency of price increases and decreases in the sub-sample are 10.2 percent and 6.2 percent, lower than what was reported earlier for the original sample (12.8 percent and 8.8 percent). Also, the average size of price increases and decreases is also significantly different: 11.7 percent and 14.2 percent, higher than in the original sample (11.2 percent and 13.6 percent). Nevertheless, dropping some representative items is necessary to obtain reliable estimates for the inflation effects.

[18]Examples are LCD TC-s, MP3 players, memory cards.

[19]Examples of these are gloves, cherries, etc.

[20]There is a single Energy item remaining in the data set (propan butan gas). In this section this will be included into the Other goods category.

Table 10: Coverage of the data set in VAT-effect calculations

CPI category	CPI basket Weight	CPI basket Items	Original sample Weight	Original sample Items	Final sample Weight	Final sample Items
Food, alcohol, tobacco	31.842	222	31.322	220	20.272	162
Unprocessed food	5.665	53	5.665	53	4.151	34
Processed food	26.177	169	25.657	167	16.121	128
Proc. food excl. alc, tob	17.427	139	16.907	137	16.121	128
Clothing	5.305	171	5.305	171	3.147	101
Durable goods	9.240	112	4.976	73	3.562	49
Other goods	15.277	214	10.235	192	7.852	159
Energy	13.203	16	6.350	8	0.723	1
Services	25.134	161	11.934	106	9.789	78
TOTAL	**100.000**	**896**	**70.122**	**770**	**45.346**	**550**

7.2 Methodology

To study the inflation effects of the VAT-changes, we decompose changes in inflation to changes in frequency and average size of price changes. Also, we analyze the effects to both the affected and unaffected representative items.

We analyze the frequency and size effects of VAT-changes in three steps:

- Visual inspection: we prepare the time series of frequencies and average sizes of price changes among the affected and non-affected items.
- We estimate regressions on frequencies and sizes to determine the frequency and size effects of VAT-changes.
- We put together the frequency and size effects to obtain a quantitative estimate for the overall inflation effect.

The second step involves the estimation of some regressions. In case of the frequency of price increases and decreases, we estimate the following linear probability models:

$$INCREASE_{it} = \alpha + \beta_1 VAT04J_t + \beta_2 VAT06S_t + \gamma X_{it} + \varepsilon_{it}, \quad (3)$$

$$DECREASE_{it} = \alpha + \beta_1 VAT04J_t + \beta_2 VAT06S_t + \gamma X_{it} + \varepsilon_{it}, \quad (4)$$

where $INCREASE_{it}$ and $DECREASE_{it}$ are dummies for price increases and decreases for store i at time t, $VAT04J_t$ and $VAT06S_t$ are the VAT-increase dummies,[21] and X_{it} are other store- and time-dependent explanatory variables. (In our baseline specification X_{it} contains seasonal and year dummies.)

For the average size of price increases and decreases, we estimate similar regressions on sizes. More precisely, we first calculate the time series of the

[21] $VAT04J_t$ is 1 in 2004 January, and 0 otherwise, and $VAT06S_t$ is 1 in 2006 September and 0 otherwise.

average size of price increases and decreases, and then estimate the following regressions:

$$AVGINCR_t = \alpha + \beta_1 VAT04J_t + \beta_2 VAT06S_t + \gamma X_t + \varepsilon_t, \quad (5)$$

$$AVGDECR_t = \alpha + \beta_1 VAT04J_t + \beta_2 VAT06S_t + \gamma X_t + \varepsilon_t, \quad (6)$$

where $AVGINCR_t$ and $AVGDECR_t$ are the time series of the average sizes of price increases and decreases, and X_t are other explanatory variables (seasonal and year dummies).

To put together the frequency and size effects of VAT-changes into a quantitative estimate of the inflation effect, we depart from the following inflation decomposition equation (for a deeper discussion of this accounting identity, see Hoffmann–Kurz-Kim, 2006):

Average price change = Inflation =

= (Proportion of price increasing stores) * (Average size of price increases)

– (Proportion of price decreasing stores) * (Average size of price decreases)

Formally:

$$\pi = p^+\mu^+ - p^-\mu^-, \quad (7)$$

where π denotes inflation, p^+ and p^- are the proportions of price increasing and decreasing firms, and μ^+ and μ^- are the average sizes of price increases and decreases.

To quantify the inflation effect of a specific VAT-increase, suppose that price increase and decrease frequencies are p^{+V} and p^{-V} when there is VAT-increase, and p^+ and p^- would be the same frequencies in the absence of any VAT-change. Similarly, with the VAT-increase the average size of price increases and decreases are μ^{+V} and μ^{-V}, otherwise they are μ^+ and μ^-. Then if there is a VAT-increase, the inflation rate is $p^{+V}\mu^{+V} - p^{-V}\mu^{-V}$, whereas it would be $p^+\mu^+ - p^-\mu^-$ in the absence of the VAT-increase. So the overall inflation effect of the VAT-increase is

$$\left(p^{+V}\mu^{+V} - p^+\mu^+\right) - \left(p^{-V}\mu^{-V} - p^-\mu^-\right). \quad (8)$$

In this expression the first term is the inflation effect due to higher willingness to increase prices, and the second term is the inflation effect due to lower willingness to decrease prices.[22] We use this equation 8 to quantitatively estimate the inflation effects of VAT-changes, using two alternative methodologies. The first one is based on regressions 3–6 above, while the second one uses a latent-variable selection model on the sizes of store-level price increases and decreases.

[22]Note that if the frequency of price decreases declines when there is a VAT-increase (and the average size of decreases does not change), then the second term is negative, meaning a positive inflation effect.

In the first methodology, we use equations 3–6 to estimate the different terms in equation 8. The term in the first bracket (i.e. the inflation effect of VAT-increase due to higher willingness to increase prices) can be estimated with the following identity:

$$p^{+V}\mu^{+V} - p^{+}\mu^{+} = p^{+}\Delta\mu^{+} + \Delta p^{+}\Delta\mu^{+} + \Delta p^{+}\mu^{+}, \tag{9}$$

where $\Delta p^{+} = p^{+V} - p^{+}$ and $\Delta\mu^{+} = \mu^{+V} - \mu^{+}$ are changes in the frequency and average size of price increases because of the VAT-increase. This formulation is convenient, as its terms can be all estimated from equations 3–6: from equation 3 and 5 we can estimate Δp^{+} and $\Delta\mu^{+}$, and also we have lots of observations to estimate p^{+} and μ^{+} (i.e. the frequency and average size of price increases in "normal"months, when there is no VAT-increase).[23]

The second term in equation 8 can be estimated with a similar decomposition:

$$p^{-V}\mu^{-V} - p^{-}\mu^{-} = p^{-}\Delta\mu^{-} + \Delta p^{-}\Delta\mu^{-} + \Delta p^{-}\mu^{-}, \tag{10}$$

where $\Delta p^{-} = p^{-V} - p^{-}$ and $\Delta\mu^{-} = \mu^{-V} - \mu^{-}$ are the changes in frequency and average size of price decreases because of the VAT-increase. Again, in this equation Δp^{-} and $\Delta\mu^{-}$ can be estimated from equation 4 and 6, and p^{-} and μ^{-} (i.e. price decrease frequencies and sizes in "normal"months) are also easy to estimate.

To sum up, the overall inflation effect of a VAT-increase is estimated as

$$\left(p^{+}\Delta\mu^{+} + \Delta p^{+}\Delta\mu^{+} + \Delta p^{+}\mu^{+}\right) - \left(p^{-}\Delta\mu^{-} + \Delta p^{-}\Delta\mu^{-} + \Delta p^{-}\mu^{-}\right), \tag{11}$$

where Δp^{+}, Δp^{-}, $\Delta\mu^{+}$ and $\Delta\mu^{-}$ are estimated from regressions 3–6, and p^{+}, p^{-}, μ^{+} and μ^{-} are also estimated from these regressions as counterfactual (i.e. fitted values of) frequencies and sizes for the month of the VAT-increase.

In the second methodology to estimate equation 8, we set up a latent variable selection model. The advantage of this method is that it can be estimated on the full panel (while the previous size equations are only estimated in time series). Suppose we would like to estimate the first term of equation 8 (i.e. the inflation effect through price increases). Then we would like to estimate a regression on the size of price increases, and evaluate the marginal effect of various VAT-change dummies on the expected value of the size of price increases. Let us denote the size of the desired price increase by $Y_{1,it}$, and the explanatory variables of this by X_{it}. The regression that we want to estimate is

$$Y_{1,it} = \beta' X_{it} + U_{1,it}. \tag{12}$$

[23] This way we do not have to estimate p^{+V} and μ^{+V}, i.e. the frequency and average size of price increases *in the month of the VAT-increase*, for which we would only have 1 month of data. Technically, we estimate p^{+} and μ^{+} as fitted values for the months of VAT-changes in regressions 3 and 5, without the VAT-dummies.

The problem is, however, that we do not always observe $Y_{1,it}$: menu costs prevent stores from always adjusting, and in fact we only observe the desired size of price increases whenever there is a price increase. If we define the latent variable $Y_{2,it}$ as the variable that determines whether there is price increase or decrease, then we can write

$$Y_{2,it} = \gamma' Z_{it} + U_{2,it}, \tag{13}$$

where Z_{it} are the determining factors of whether there is a price increase or not. We can then say that $Y_{1,it}$ in equation 12 is observed whenever $Y_{2,it} > 0$ in equation 13.

With appropriate distributional assumptions on $U_{1,it}$ and $U_{2,it}$,[24] we can estimate these equations with the well-known Heckman-procedure, using maximum likelihood estimation. In particular, we can express the conditional expected value of price increases by

$$E(Y_{1,it} \mid Y_{2,it} > 0, X_{it}) = \beta' X_{it} + \sigma\rho E\left[\frac{f(\gamma' Z_{it})}{F(\gamma' Z_{it})} \mid X_{it}\right], \tag{14}$$

where $f(\cdot)$ and $F(\cdot)$ are the pdf and cdf of a standard normally distributed random variable. Then we can directly estimate p^{+V} and p^{+} in equation 8 from equation 13, and μ^{+V} and μ^{+} from equation 12, using equation 14. Of course, a similar model can be estimated for the average size of price decreases (to estimate the terms in the second bracket in equation 8).

Finally, we obtain the aggregate inflation effect by aggregating sectoral inflation effects over sectors. Specifically, we use the decomposition in equation 8 to estimate the inflation effects of the VAT-increases in our sample *at the sectoral level*[25]. This means that first we estimate regressions 3–6 and regressions 12–13 separately for each sector, and then calculate the sectoral inflation effects. Finally we use the CPI-weights to calculate inflation effects for higher levels of aggregation (at the whole CPI-level, or at the level of CPI-categories).

7.3 Inflation effects of the 2004 January and 2006 September VAT-increases

Effective from January 2004, the middle VAT rate of 12 percent increased to 15 percent, and from September 2006, the same middle VAT rate further increased to 20 percent. These measures affected 213 representative items in our (restricted) data set, with an overall CPI-weight of 21.250 percent. These items mostly belong to the Food category (132 representative items with a total CPI-weight of 16.855 percent, see Table 11).

The first step in the analysis of the inflation effect of the VAT-increases was a visual inspection: we prepared the time series of frequencies and sizes of

[24]More precisely, the distributional assumption is $\binom{U_1}{U_2} \sim N\left[\binom{0}{0}, \Sigma\right]$, with $\Sigma = \begin{bmatrix} \sigma^2 & \rho\sigma \\ \rho\sigma & 1 \end{bmatrix}$.

[25]Sectors are defined as representative items at the three-digit level.

Table 11: Products affected by the 2004 January and 2006 September VAT-increases

CPI category	Affected items		Not affected items	
	CPI-Weight	**Items**	**CPI-Weight**	**Items**
Food, alcohol, tobacco	16.855	132	3.416	30
Unprocessed food	4.151	34	0.000	0
Processed food	12.704	98	3.416	30
Clothing	0.033	2	3.114	99
Durable goods	0.000	0	3.562	49
Other goods	1.528	15	7.047	145
Services	2.834	21	6.955	57
TOTAL	**21.250**	**170**	**24.096**	**380**

price changes among the affected and non-affected items (Figures 28-29 in the Appendix). It is apparent from Figure 28 that the frequency of price changes increased substantially for the affected sub-group in January 2004 and September 2006: from the usual 20-30 percent, it jumped to approximately 60 and 66 percent. Also, for the non-affected products there is a slight indication of increasing frequencies: apart from 2006 Jan-Feb, when there was a VAT-decrease mostly affecting these items, their frequency also reached an all-time high (though the increase in frequencies is not so dramatic as for the affected products). In terms of the average size of price changes (Figure 29), sizes decline in the months of the VAT-increases for the affected items, but there is no obvious change in the sizes for the non-affected products.

If we decompose price increase and decrease frequencies for the affected and non-affected products (Figures 30-31), it becomes apparent that the main reason behind the increase in price *change* frequencies for the affected items (Figure 30) is a substantial increase in price *increase* frequencies. Interestingly, price decrease frequencies of affected items do not seem to decline around VAT-increases. The same is true for the non-affected items (Figure 31): price increase frequencies tend to increase around VAT-increases, while price decrease frequencies do not change.

We made a similar decomposition for the size of price changes as well (Figures 32-33). For the affected products, changes in the price *change* sizes are mostly driven by changes in the price *increase* sizes (Figure 32), while for the non-affected products, it is the price *decrease* sizes that seems to be slightly smaller than normally (Figure 33).

As a second step, to obtain numerical estimates about the frequency and size effects of the VAT-increases, we estimated regressions 3–6. In equation 3, the estimated β_1 and β_2 for the affected sub-sample of products is 0.2953 and 0.3449 (with standard errors 0.0038 and 0.0038), while in equation 4 we have $\widehat{\beta}_1 = 0.0003$ and $\widehat{\beta}_2 = 0.0021$ (with standard errors 0.0023 and 0.0024). This means that because of the VAT-increases, the frequency of price increases increased by 29.5 and 34.5 percentage points in 2004 January and 2006 September, while the frequency of price decreases did not change significantly.

For the size effects, we estimated equations 5–6. The main parameters of interest are again $\widehat{\beta}_1$ and $\widehat{\beta}_2$. For equation 5 in the affected sub-sample, we estimated $\widehat{\beta}_1 = -6.7168$ and $\widehat{\beta}_2 = -4.1613$ (with standard errors of 1.2241 and 1.2471), while for equation 6 the same estimates were $\widehat{\beta}_1 = -0.9483$ and $\widehat{\beta}_2 = 2.3520$ (with standard errors of 1.2322 and 1.2553). Thus when the VAT-rate increased in 2004 January, the average size of price increases of the affected items decreased by 6.7 percentage points, while the average size of price decreases remained more or less the same. Further, at the 2006 September VAT-increase, the average size of price decreases of the affected items went down by 4.2 percentage points, and the average size of price decreases also declined somewhat, 2.4 percentage points (in absolute terms).

The bottom line is that VAT-increases led to increases in the price change frequencies, but decreased the average size of price changes. Therefore the overall price effect of the VAT-changes is unambiguous.

Now we turn to the estimation of the overall inflation effects of the VAT-increases. As explained earlier, this is done by putting together the frequency and size effects.

Tables 12–13 report the estimated inflation effects of the 2004 January and the 2006 September VAT-increases by main CPI-categories in the affected sub-sample of products. The overall inflation effect of the 3 percentage point increase in 2004 January is 2.05 percent, and of the 5 percentage point increase in 2006 September is 3.73 percent. These are smaller than what would be implied by "automatic"pass-through: 2.68 percent (115/112-1) in 2004 January and 4.35 percent (120/115-1) in 2006 September.

Table 12: Inflation effect of the 2004 January VAT-increase by main CPI categories, affected products

			Through	
CPI category	**Weight**	**Inflation effect**	**increase**	**decrease**
Food, alcohol, tobacco	16.854	2.38	2.25	0.13
Unprocessed food	4.151	2.12	1.93	0.19
Processed food	12.704	2.46	2.35	0.12
Clothing	0.033	0.50	0.24	0.25
Durable goods	0.000	–	–	–
Other goods	1.528	1.33	1.57	-0.23
Services	2.834	0.48	0.50	-0.02
TOTAL	**21.250**	**2.05**	**1.96**	**0.09**

For both VAT-increases, the highest inflation effect can be observed in the Food category: in both cases we find almost perfect pass-through of the VAT-increase into the prices. Inflation effects are somewhat smaller for the Other goods category and Services.

Comparing the two VAT-increases, the inflation effect is always bigger for

Table 13: Inflation effect of the 2006 September VAT-increase by main CPI categories, affected products

			Through	
CPI category	**Weight**	**Inflation effect**	**increase**	**decrease**
Food, alcohol, tobacco	16.854	3.99	3.93	0.06
Unprocessed food	4.151	4.37	4.12	0.25
Processed food	12.704	3.86	3.86	0.00
Clothing	0.033	0.72	0.86	-0.14
Durable goods	0.000	–	–	–
Other goods	1.528	2.81	2.81	0.00
Services	2.834	2.73	2.89	-0.16
TOTAL	**21.250**	**3.73**	**3.70**	**0.03**

the 2006 September VAT-increase, when the increase itself was larger. The effects are however highly non-linear for the services, and somewhat non-linear in the other goods category.

If we decompose the overall inflation effect to the inflation effect of higher willingness to increase prices and of lower willingness to decrease prices (as in equation 8), then we can see that the vast majority of the total inflation effect of the VAT-increases is through the higher willingness of stores to increase prices, whereas there is not much effect in the price decrease side. This is in line what we have asserted earlier based on simple visual inspection of the frequency of size effects, and we could refer to this result as most of the inflation effect is through the primary channel.[26]

If there are close substitutes between products affected and not affected by the VAT-increases, we may expect that these tax increases also affect the prices of those products that are not directly affected. We therefore investigated the inflation effect also for the not directly affected (in what follows "not affected") sub-sample. The results of these are summarized in Tables 14–15.

The overall inflation effects among the non-affected items are indeed positive: they are 0.39 percent in 2004 January and 0.72 percent in 2006 September on the aggregate level, and they are almost always positive in the main CPI-categories (the only exception being -0.03 percent for clothing and footwear in 2004 January). Also, we estimate the largest inflation effects in those product categories (food, services) where the distribution of affected and non-affected products is relatively even. This may be consistent with our hypothesis that the relative price of close substitutes may depend on *relative* tax rates, which also change for those products whose *absolute* tax rates did not change.

A further decomposition of this positive overall effects to effects through price increases and decreases reveals that out of the total effect of 0.39 and 0.72 percent, 0.31 and 0.75 percent are through the larger willingness of stores to increase their prices, so again the primary channel seems to be far more

[26]We use the term "primary channel"as the price increase side in case of a VAT-increase, and the price decrease side in case of a VAT-decrease.

Table 14: Inflation effect of the 2004 January VAT-increase by main CPI categories, not affected products

CPI category	Weight	Inflation effect	Through increase	decrease
Food, alcohol, tobacco	3.416	0.72	0.82	-0.10
Unprocessed food	0.000	–	–	–
Processed food	3.416	0.72	0.82	-0.10
Clothing	3.114	0.17	0.05	0.12
Durable goods	3.562	0.35	0.07	0.27
Other goods	7.047	0.26	0.12	0.14
Services	6.955	0.49	0.49	0.00
TOTAL	**24.096**	**0.39**	**0.31**	**0.08**

Table 15: Inflation effect of the 2006 September VAT-increase by main CPI categories, not affected products

CPI category	Weight	Inflation effect	Through increase	decrease
Food, alcohol, tobacco	3.416	1.20	1.30	-0.11
Unprocessed food	0.000	–	–	–
Processed food	3.416	1.20	1.30	-0.11
Clothing	3.114	-0.03	0.05	-0.08
Durable goods	3.562	0.46	0.51	-0.05
Other goods	7.047	0.55	0.58	-0.03
Services	6.955	1.12	1.09	0.03
TOTAL	**24.096**	**0.72**	**0.75**	**-0.03**

important than the secondary channel.

7.4 Inflation effect of the 2006 January VAT-decrease

In January 2006, the top VAT-rate decreased from 25 percent to 20 percent. Though this affected a different set of products than the VAT-increases just discussed, still it may be interesting to compare the inflation effects of this VAT-decrease with the inflation effects of the VAT-increases. The comparison is perhaps better with the 2006 September VAT-increase, since there is only 8 months between the VAT-decrease and the VAT-increase, and the size of the change (5 percentage points in both cases) is also similar.

The main categories affected are clothing and other goods, and there are also many food and services items (with relatively large CPI-weights) in the affected sub-sample (see Table 16).

Similarly to the previous subsection, we first visually inspect the effect of the VAT-decrease to the frequency and average size of price changes, therefore we prepared the time series of frequencies and average sizes for both the affected

Table 16: Products affected by the 2006 January VAT-decrease

	Affected items		Not affected items	
CPI category	**CPI-Weight**	**Items**	**CPI-Weight**	**Items**
Food, alcohol, tobacco	3.416	30	16.855	132
Unprocessed food	0.000	0	4.151	34
Processed food	3.416	30	12.704	98
Clothing	3.114	99	0.033	2
Durable goods	3.562	49	0.000	0
Other goods	7.047	145	1.528	15
Services	5.992	47	3.798	31
TOTAL	**23.132**	**370**	**22.214**	**180**

and non-affected sub-samples.

Figures 34–35 indicate similar patterns in case of a VAT-decrease to what we have seen earlier for the VAT-increases: in the month of the VAT-change, the frequency of price changes goes up and the average size of price changes goes down for the affected items, while frequencies and average sizes are more or less normal in the non-affected sub-sample. According to Figure 36, the increased frequency in the affected sub-sample is due to the increase in the price decrease frequencies, while the price increase frequency is apparently not smaller than in any "normal"January. Figure 37 depicts the time series of the price increase and decrease frequencies in the non-affected sub-sample: according to this, price change frequencies of non-affected items are not much influenced by the general VAT-decrease in January 2006. As far as sizes are concerned, according to Figure 38 the decrease in average size of price changes in the affected sub-sample is caused by a huge decrease in the average size of price decreases, while the average size of price increases does not seem to be different from other months. Finally, Figure 39 about the non-affected items indicates that the average size of price decreases is also somewhat smaller for these products, while the average price of price increases is again "normal".

Turning to a more formal analysis of the inflation effect of the VAT-decrease, we re-estimated equations 3–6 for a sub-sample with the affected items by the 2006 January VAT-decrease, with a VAT-decrease dummy at the right-hand side. The estimated parameter for the VAT-decrease dummy is -0.0179 (standard error: 0.0015) in equation 3, and it is 0.1805 (standard error: 0.0022) in equation 4. This means that in the month of the VAT-decrease, the frequency of price decreases increased by more than 18 percentage points, and the frequency of price increases decreased by approximately 2 percentage points among the affected items. As far as sizes are concerned, in equation 5 the estimated VAT-decrease dummy is 0.7674 (with a standard error of 0.5938), while in equation 6 it is 9.0679 (with a standard error of 1.3931). Thus, among the affected products, while the average size of price increases does not change significantly when there is a VAT-decrease, the average size of price decreases declines by more than 9 percentage points (in absolute terms).

The bottom line in this exercise is quite similar to what we found for VAT-increases: when there is a VAT-decrease, the frequency of price changes increases, and the average size of price changes decreases. Both of these changes come through the "primary"effect: the frequency of price changes increases because of the frequency of price decreases, and the drop in the average size is due to a drop in the average size of price decreases (while the frequency and average size of price increases do not change much).

Finally, we also prepared quantitative estimates of the inflation effect of the VAT-decrease. This estimation was again done at the sectoral level[27] based on a similar decomposition that we presented in equation 11, and the results are reported in Tables 17–18.

Table 17: Inflation effect of the 2006 January VAT-decrease by main CPI categories, affected products

CPI category	**Weight**	**Inflation effect**	**Through** increase	decrease
Food, alcohol, tobacco	3.416	-1.62	-0.66	-0.96
Unprocessed food	0.000	–	–	–
Processed food	3.416	-1.62	-0.66	-0.96
Clothing	3.114	-1.23	-0.08	-1.14
Durable goods	3.562	-1.88	-0.20	-1.68
Other goods	7.047	-1.47	-0.09	-1.39
Services	5.992	-0.36	0.00	-0.37
TOTAL	**23.132**	**-1.24**	**-0.17**	**-1.07**

Table 18: Inflation effect of the 2006 January VAT-decrease by main CPI categories, not affected products

CPI category	**Weight**	**Inflation effect**	**Through** increase	decrease
Food, alcohol, tobacco	16.855	-0.65	-0.35	-0.30
Unprocessed food	4.151	-0.54	-0.21	-0.33
Processed food	12.704	-0.69	-0.40	-0.29
Clothing	0.033	-0.13	0.39	-0.53
Durable goods	0.000	–	–	–
Other goods	1.528	-0.25	0.11	-0.37
Services	3.798	-0.52	-0.53	0.01
TOTAL	**22.214**	**-0.60**	**-0.35**	**-0.25**

For the affected items (Table 17) the overall effect of the VAT-decrease was -1.24 percent. This is much smaller than what the effect would be if all firms automatically decreased their prices according to the tax change, -4 percent

[27]Sectors are again defined at the 3-digit representative item codes.

(120/125-1). Moreover, this inflation effect is also much smaller (in absolute terms) than what we estimated for a similar tax increase: in 2006 September, although on a different set of products, the inflation effect among the affected items was 3.73 percent.

The highest inflation effect is measured in the clothing and food categories, but these are still much smaller (in absolute terms) than the *average* inflation effect in case of a similar VAT-increase.

Decomposing this inflation effect to “primary”and “secondary”sources, i.e. inflation through the increased willingness to decrease prices and through decreased willingness to increase prices, we can see that much of the effect is through the primary channel. This finding seems to be robust for VAT-increases and decreases.

Finally, we estimated the inflation effect of the 2006 January VAT-decrease for those items that were not directly affected by this VAT-change (Table 18). Here the estimated effects are again non-trivial: the average effect is -0.60 percent, with the highest effects again observed in the food and services categories, i.e. where the number of close substitutes across the affected and non-affected sub-samples is the highest. This gives further support to our earlier hypothesis that in this case of close substitutes the relative tax rate may matter (and that relative tax rates can change even if the absolute tax rates does not). Interestingly, in this non-affected sub-sample the secondary channel (now the one through lower willingness to increase prices) seems to be the one that is more important.

8 Summary

The purpose of this paper was to empirically describe the price setting characteristics in Hungary. The main results can be summarized as follows:

- The frequency of price changes is 21.5 percent. This is higher than in the Euro area, but smaller than in the US.
- Sectors are extremely heterogenous in their frequencies of price changes.
- More than 40 percent of all price changes are actually price decreases (8.8 percent out of 21.5 percent). This suggests that prices are not rigid downwards (services prices being an exception).
- The average size of price changes is 12.25 percent. This is larger than in the Euro area, but smaller than in the US.
- The average size of price increases (11.15 percent) is smaller than the average size of price decreases (13.62 percent). Sectoral heterogeneity in average sizes is not as huge as for the frequencies.
- The mean duration of price spells is approximately 8 months.

- A decomposition of the inflation rate to price increase frequencies and price increase sizes, and to price decrease frequencies and price decrease sizes reveals that inflation variation is mostly driven by price increase and price decrease frequencies. This supports the use of state-dependent models in modelling sticky prices.

- Adjustment to VAT-shocks also takes place mostly on the extensive margin (i.e. frequencies). The inflation effect of a 3 percentage point VAT-increase in January 2004 was 2.05 percent, and of a similar 5 percentage point VAT-increase in September 2006 was 3.73 percent among the directly affected products. The inflation effect of a 5 percentage point VAT-decrease in January 2006 was -1.24 percent among those items directly affected.

- VAT-changes also affect the price level of those products which are not directly hit by the VAT-shocks. The inflation effect seems to be bigger for those items which are relatively close substitutes of other, directly affected items.

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9 Appendix: Figures

Figure 1: The Hungarian CPI in the sample period

Figure 2: Distribution of the frequency of price changes across repr. items

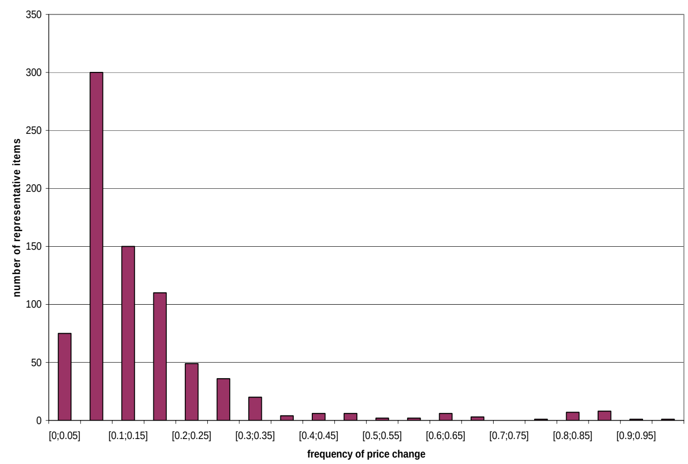

Figure 3: Correlation between frequency of price increase and price decrease

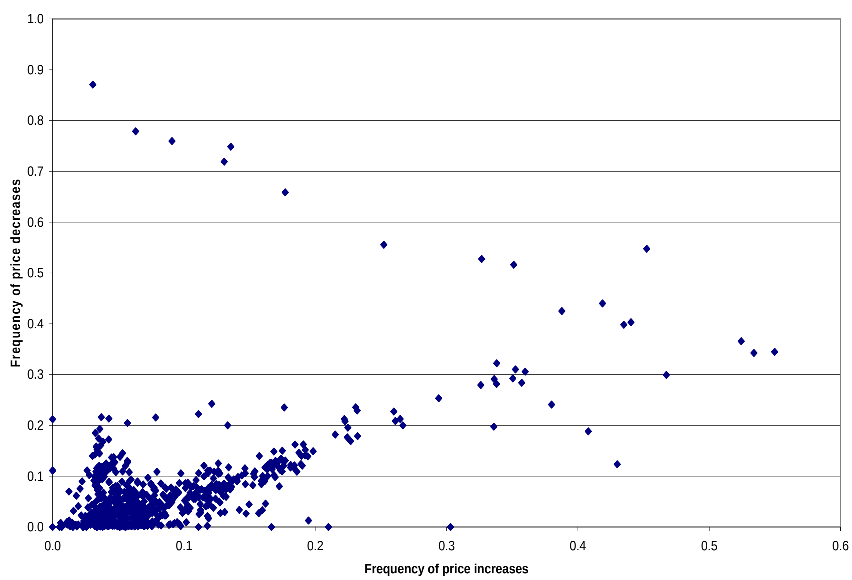

Figure 4: Price change frequencies in the different product categories over time

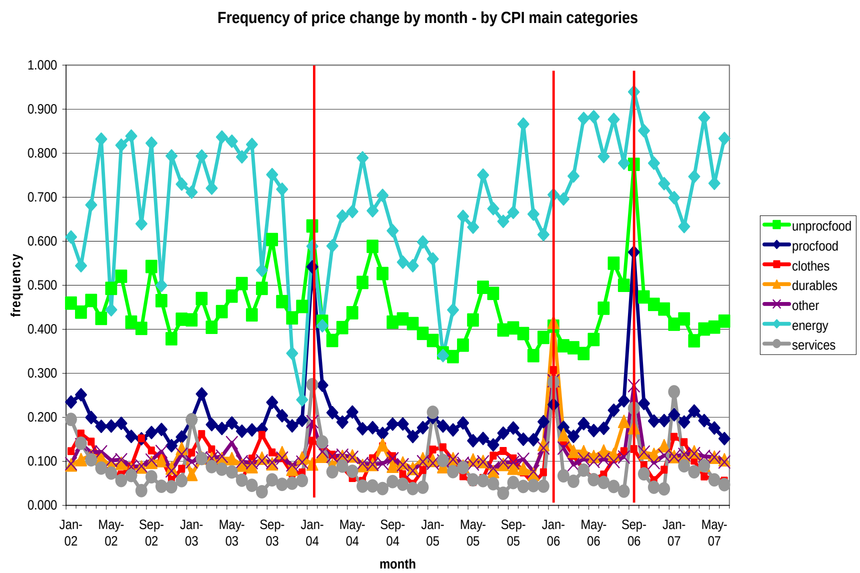

Figure 5: Frequency of price change by month - processed food (excl alc, tob)

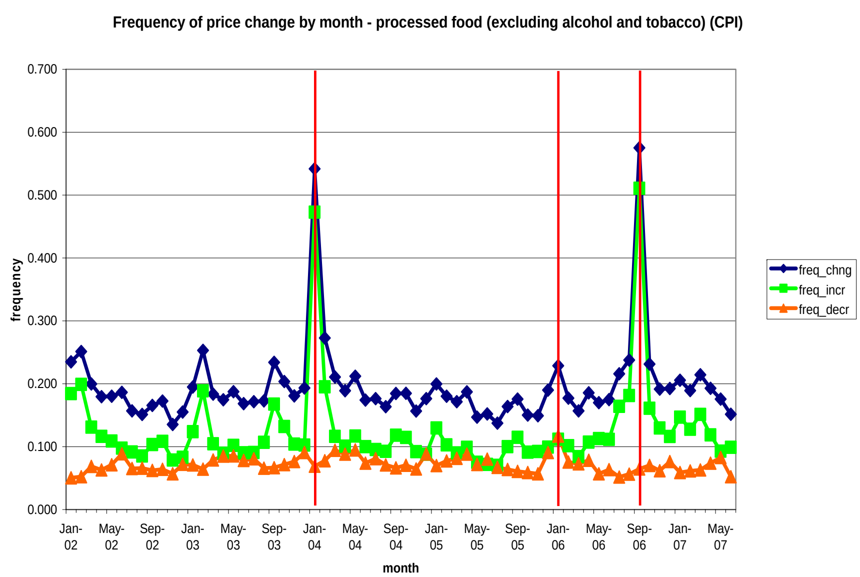

Figure 6: Frequency of price change by month - unprocessed food

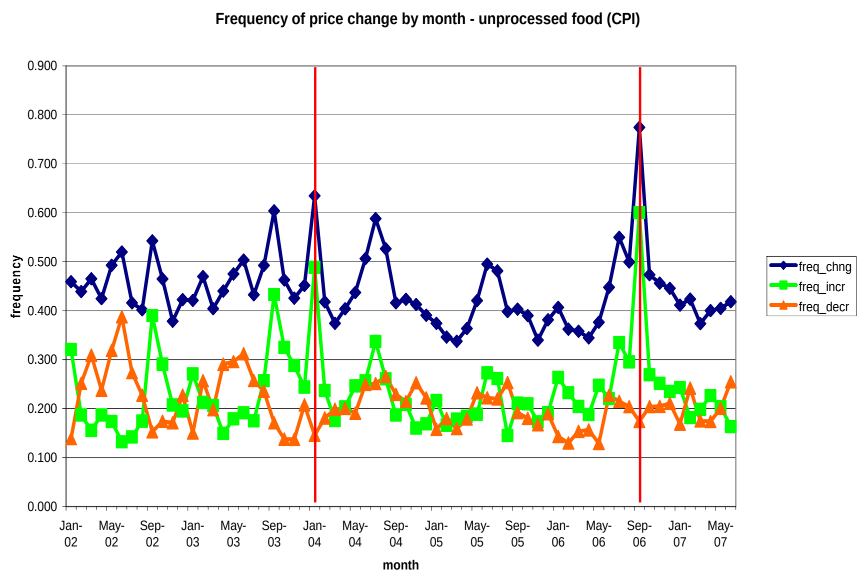

Figure 7: Frequency of price change by month - clothing

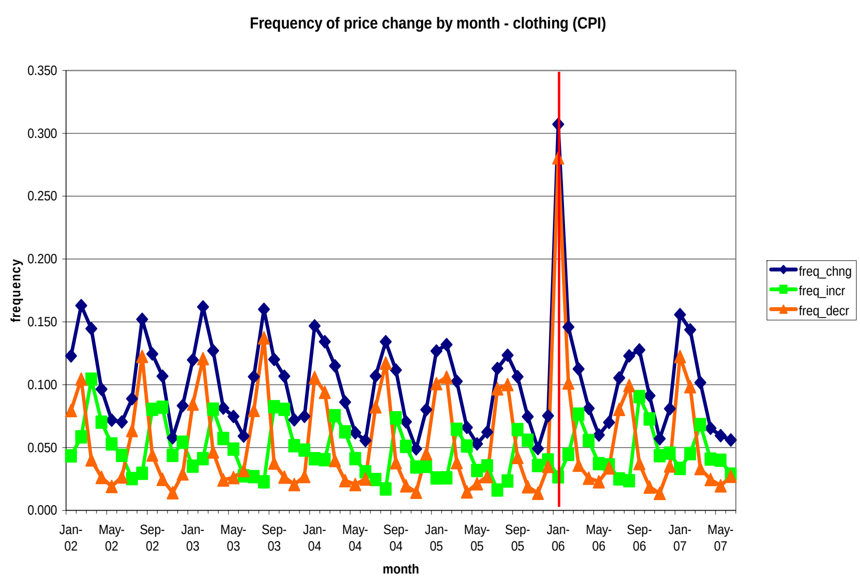

Figure 8: Frequency of price change by month - durable goods

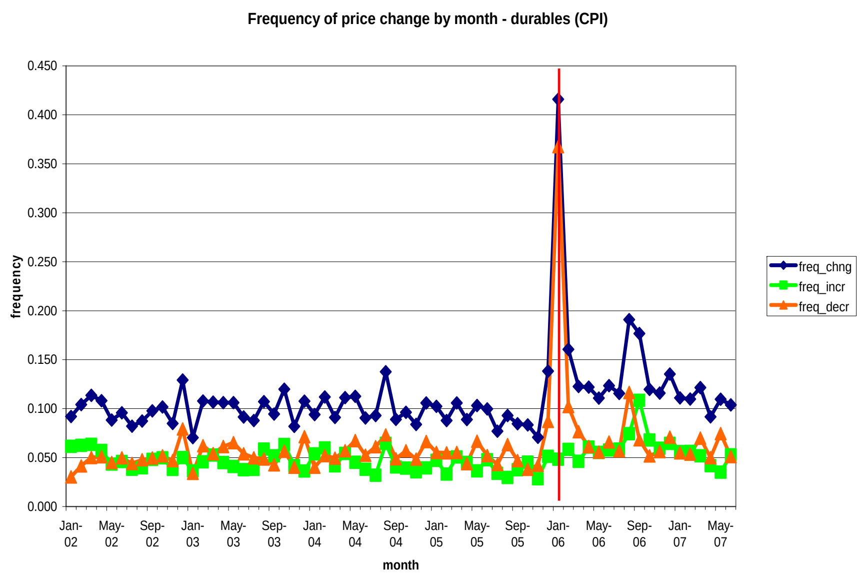

Figure 9: Frequency of price change by month - other goods

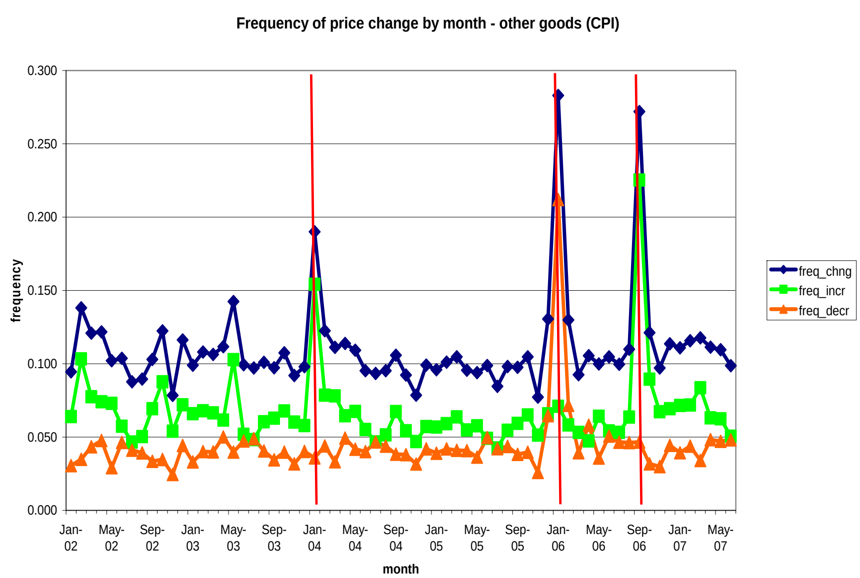

Figure 10: Frequency of price change by month - energy

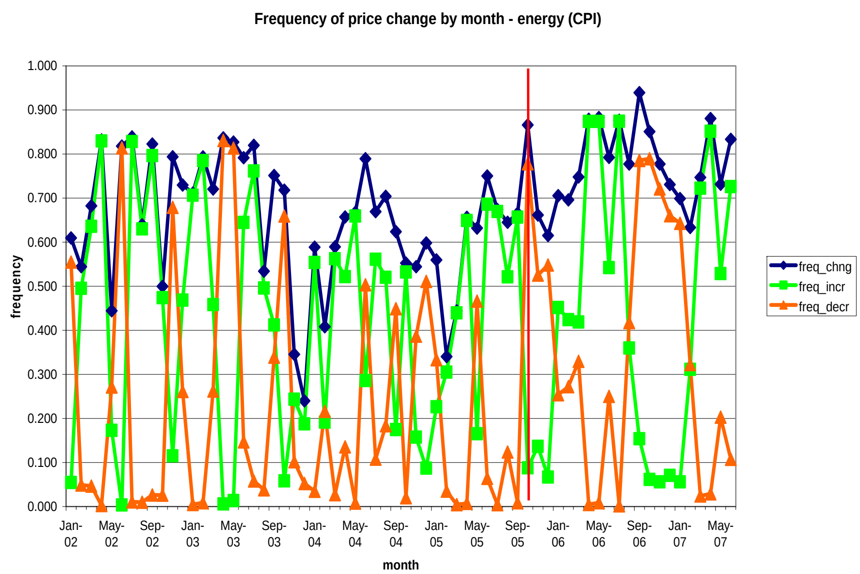

Figure 11: Frequency of price change by month - services

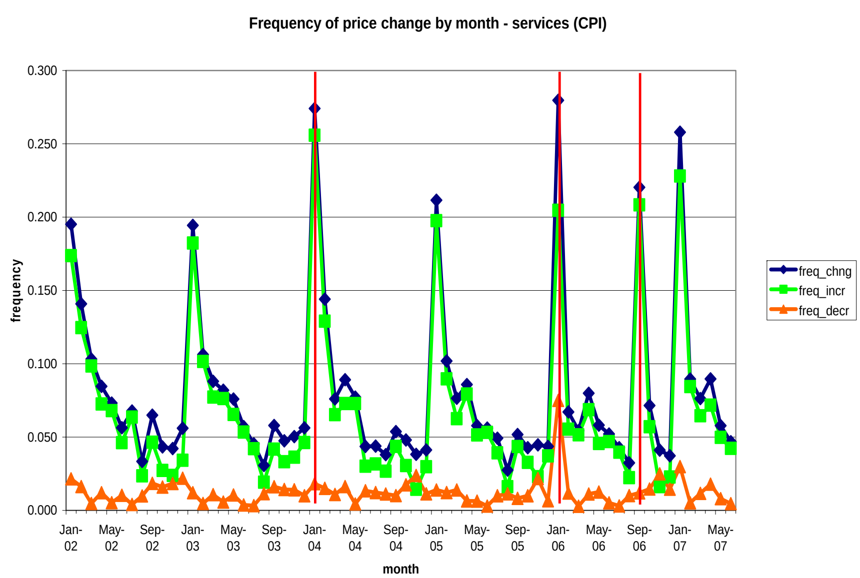

Figure 12: Seasonality in frequencies: frequency of price change by month

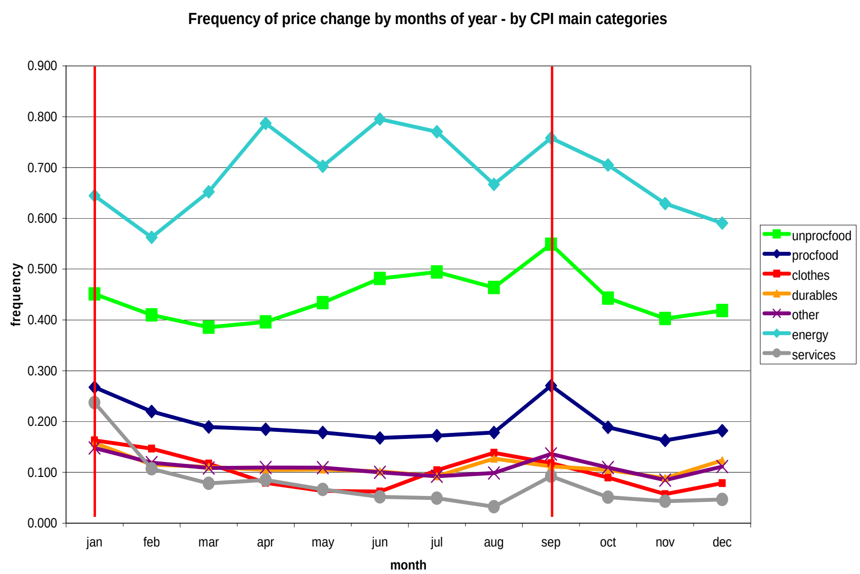

Figure 13: Distribution of the size of price changes across representative items

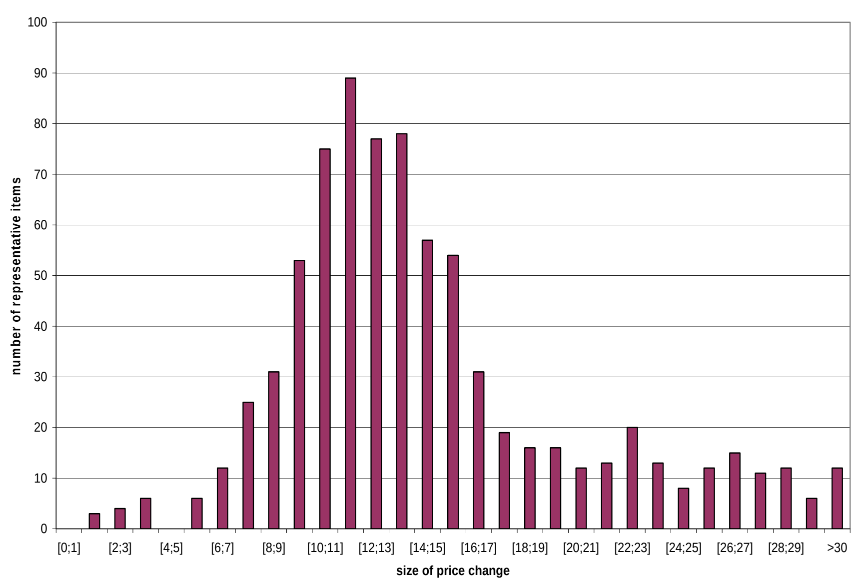

Figure 14: Correlation between size of price increases and price decreases

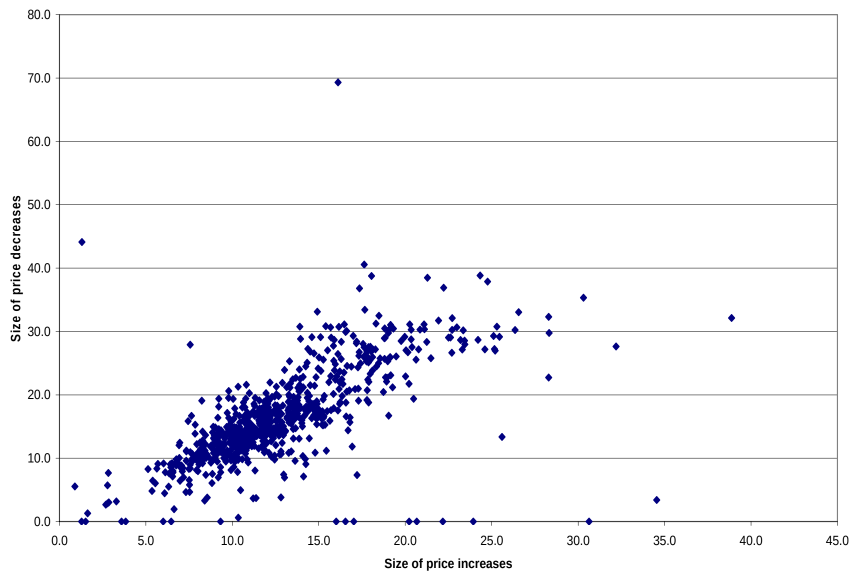

Figure 15: Size of price changes in the different product categories over time

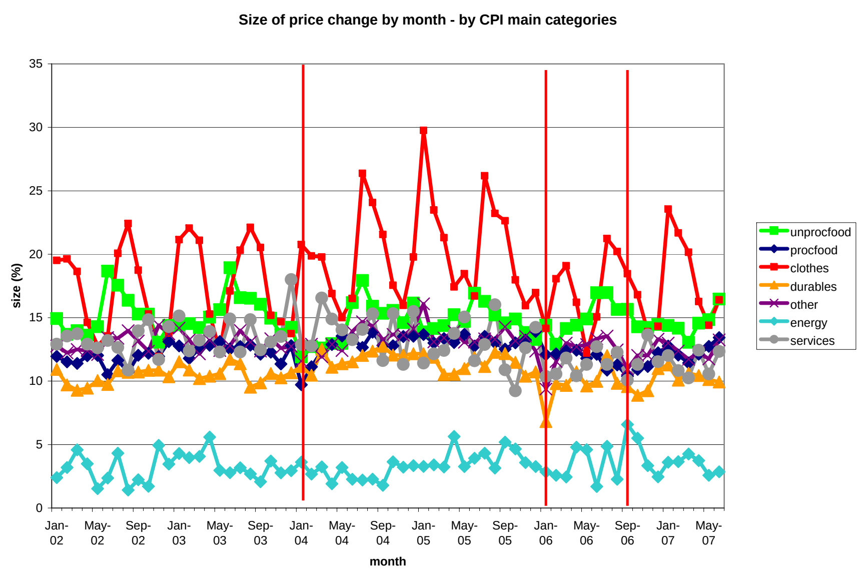

Figure 16: Size of price change by month - processed food (excl alc, tob)

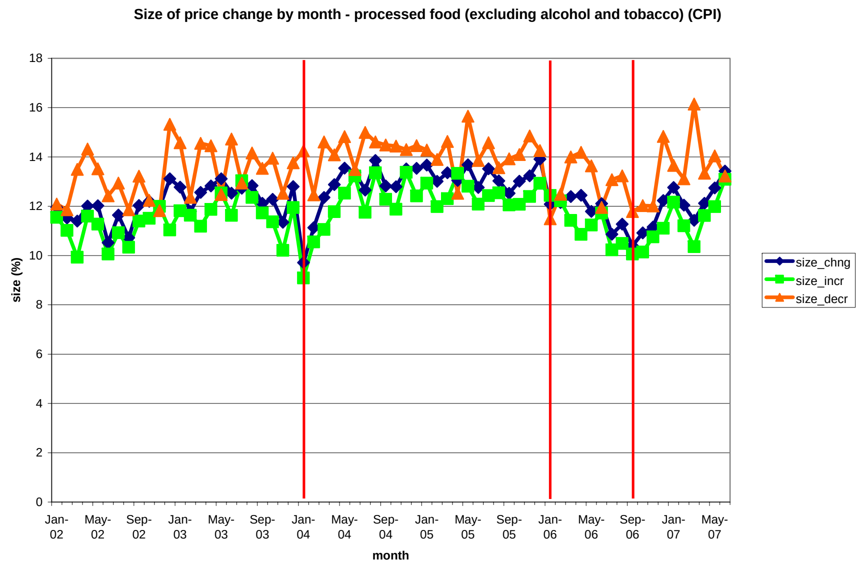

Figure 17: Size of price change by month - unprocessed food

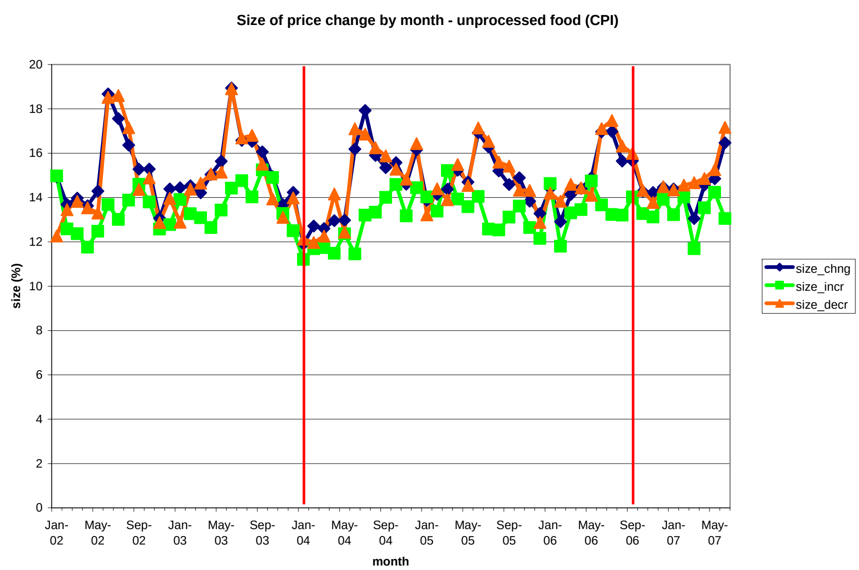

Figure 18: Size of price change by month - clothing

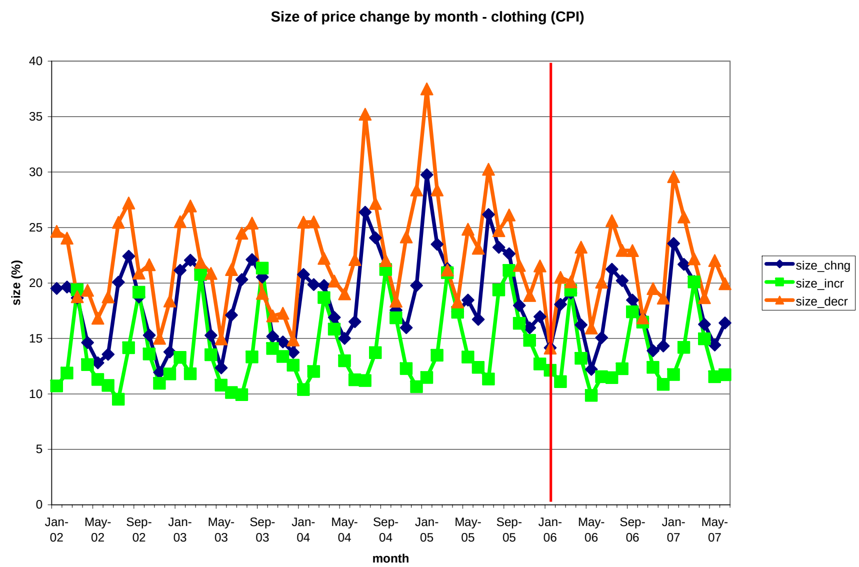

Figure 19: Size of price change by month - durables

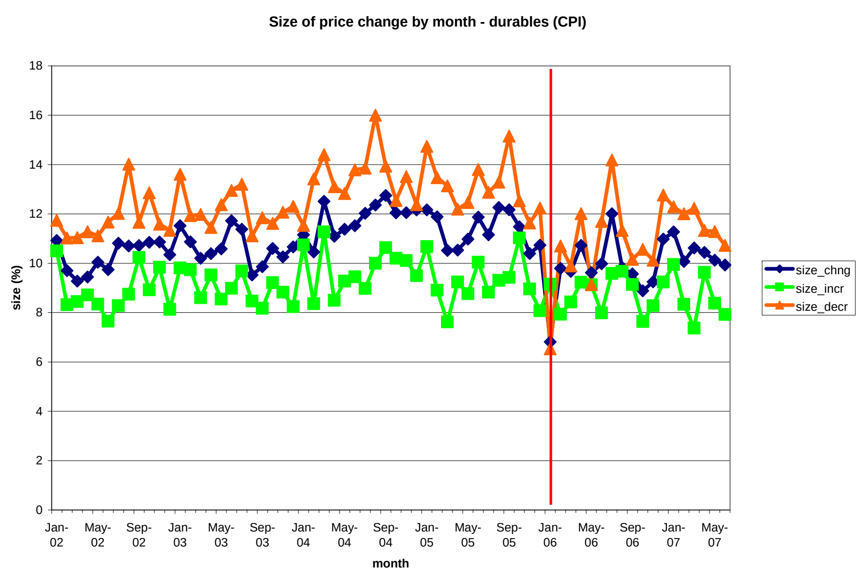

Figure 20: Size of price change by month - other goods

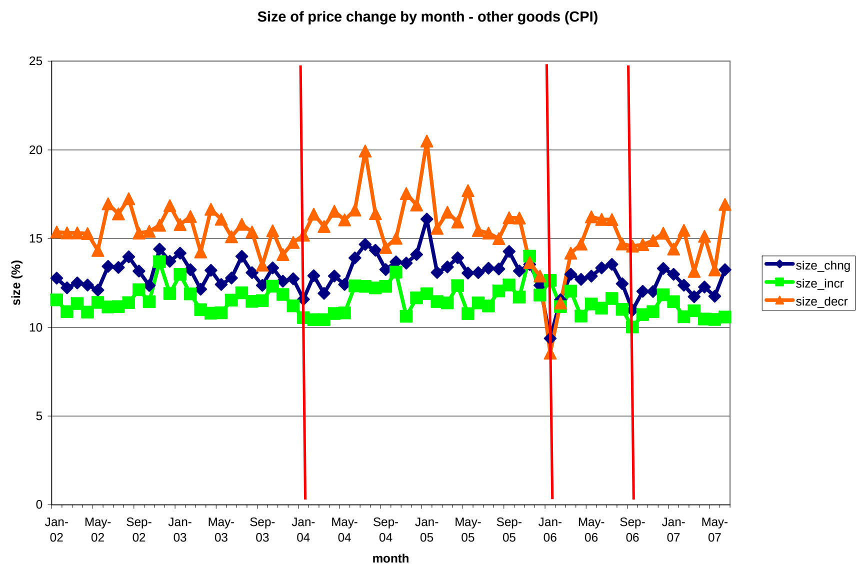

Figure 21: Size of price change by month - energy

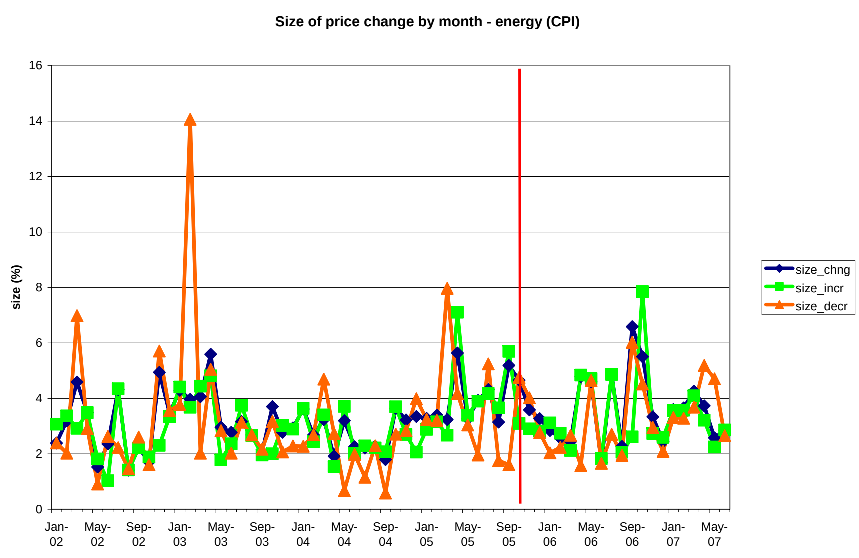

Figure 22: Size of price change by month - services

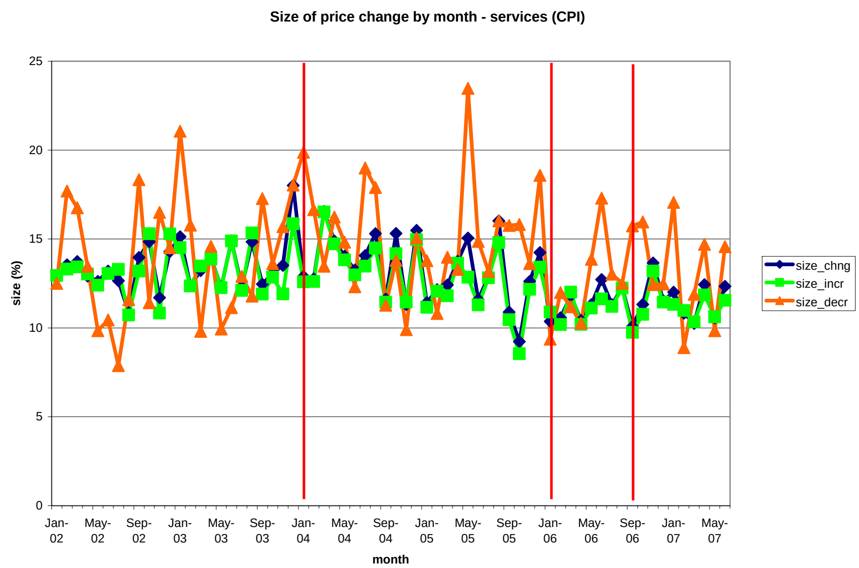

Figure 23: Seasonality in sizes: size of price change by month

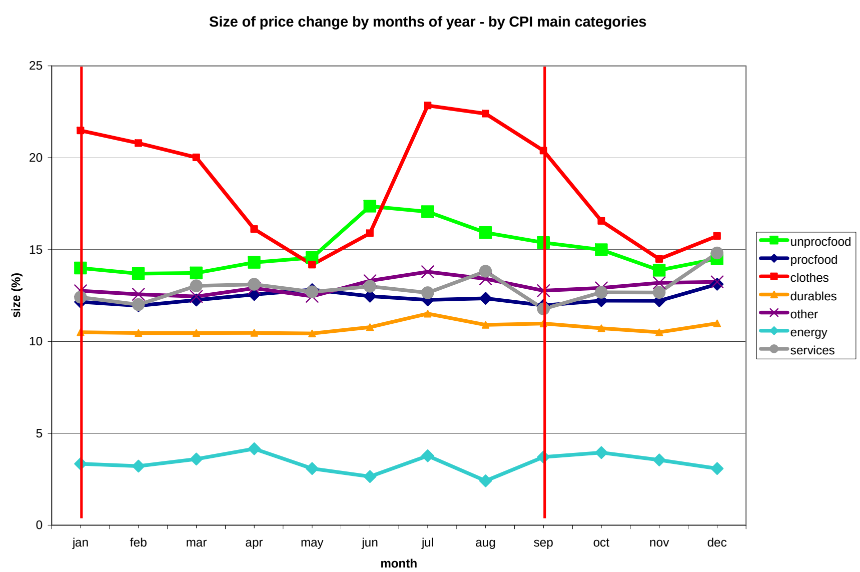

Figure 24: Duration distribution of uncensored spells, whole sample

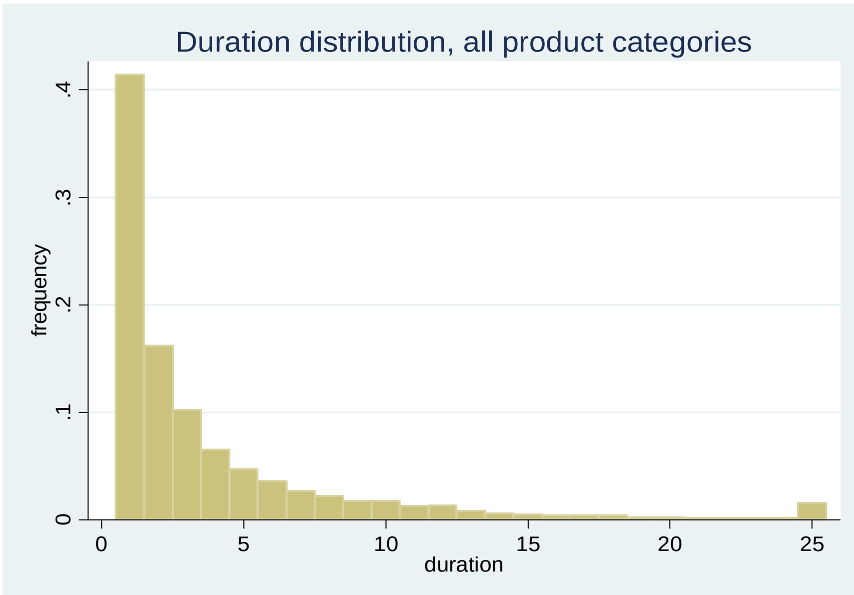

Figure 25: Duration distribution by CPI-categories, part 1

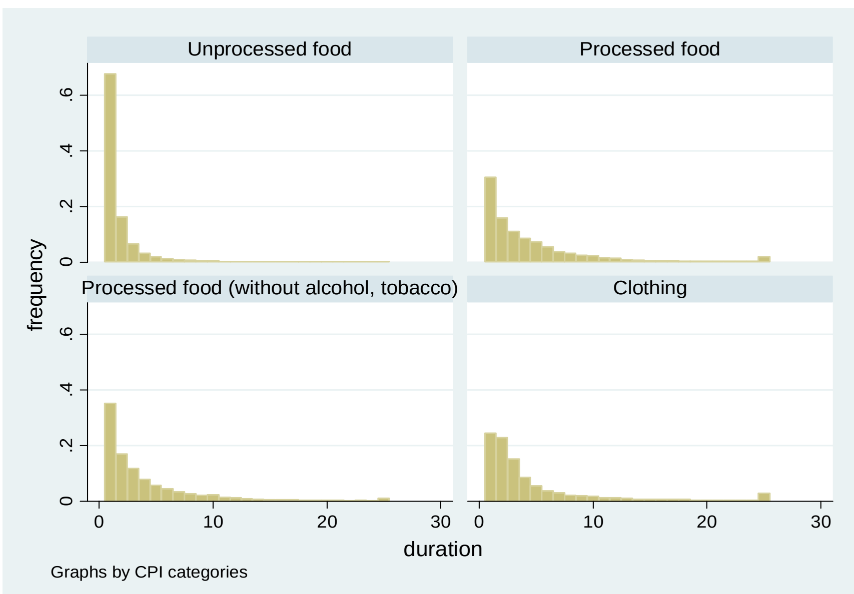

Figure 26: Duration distribution by CPI-categories, part 2

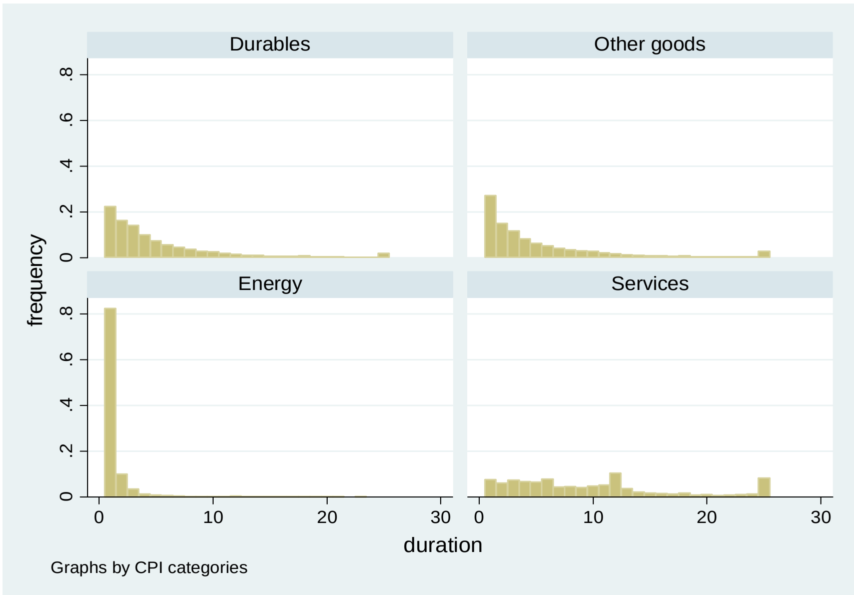

Figure 27: Inflation rate: decomposition to frequency and size effects

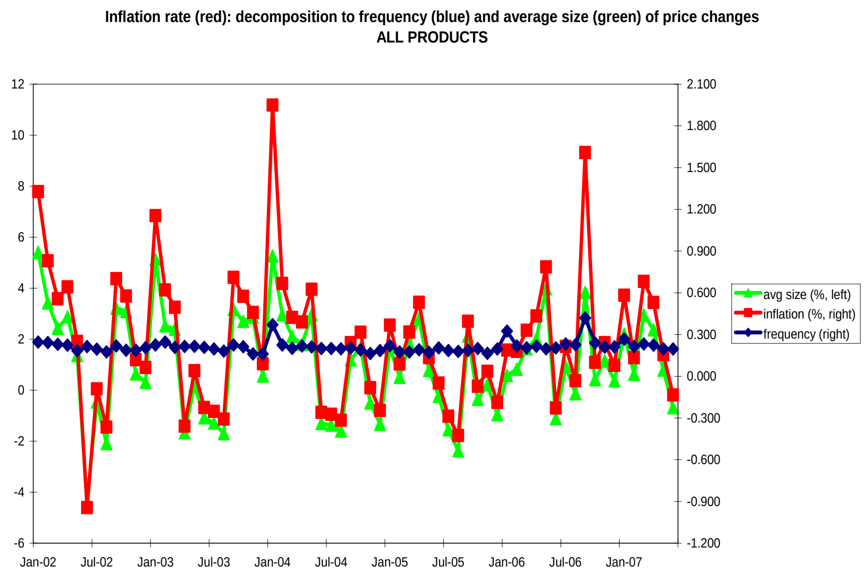

Figure 28: Frequency of price changes – by being affected by VAT-increases

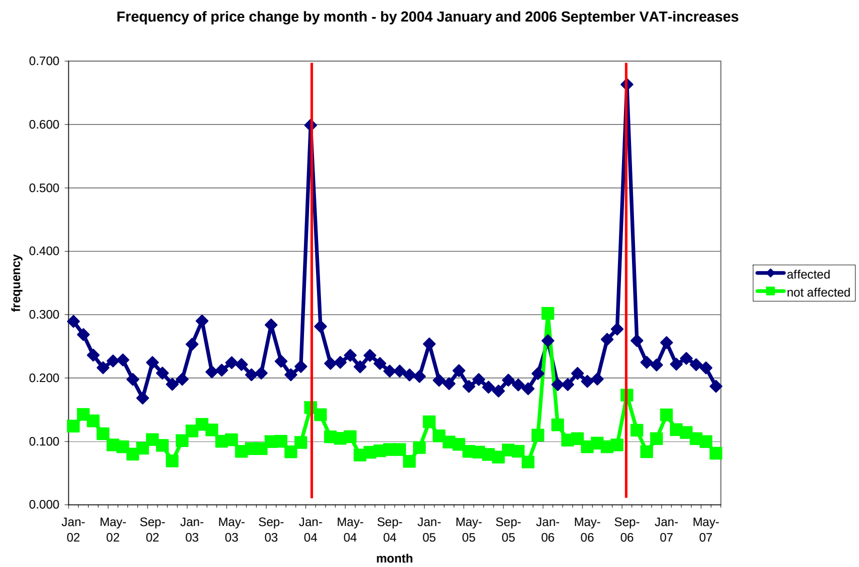

Figure 29: Size of price changes – by being affected by VAT-increases

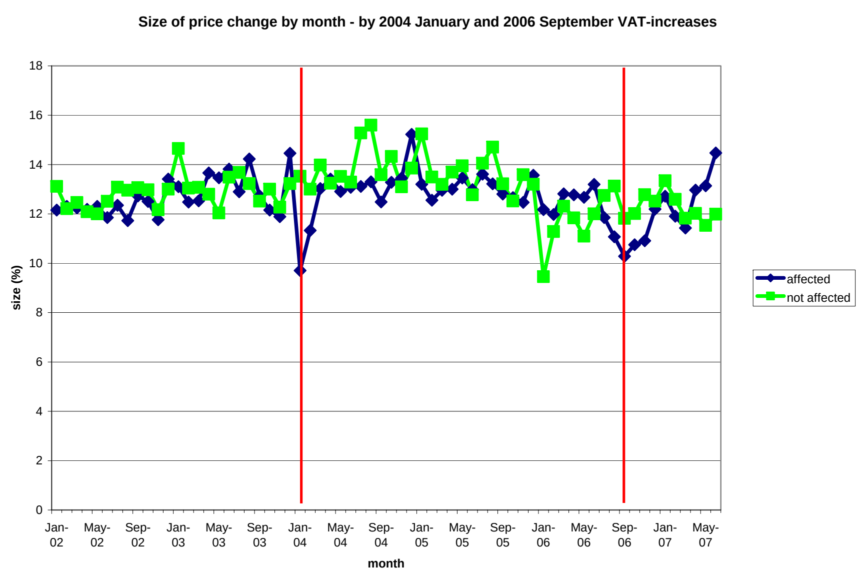

Figure 30: Frequency of price changes – products affected by VAT-increases

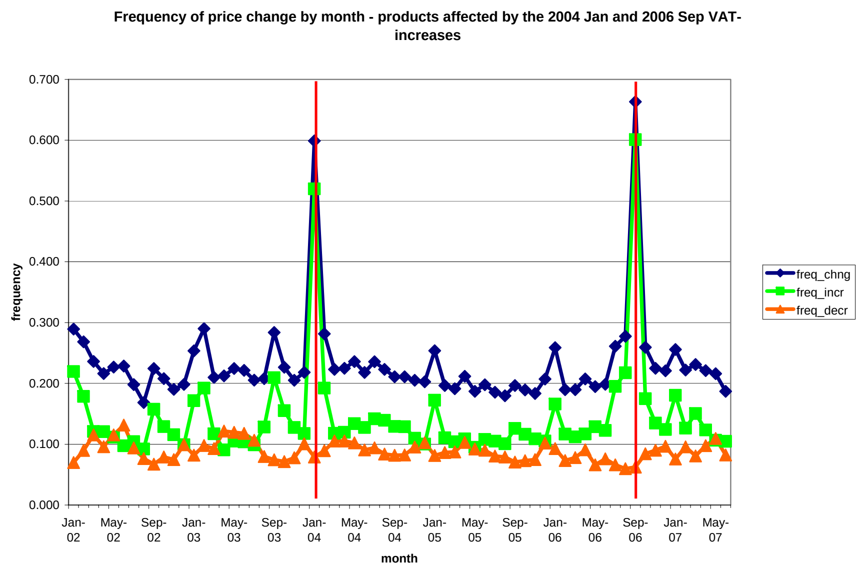

Figure 31: Frequency of price changes – products not affected by VAT-increases

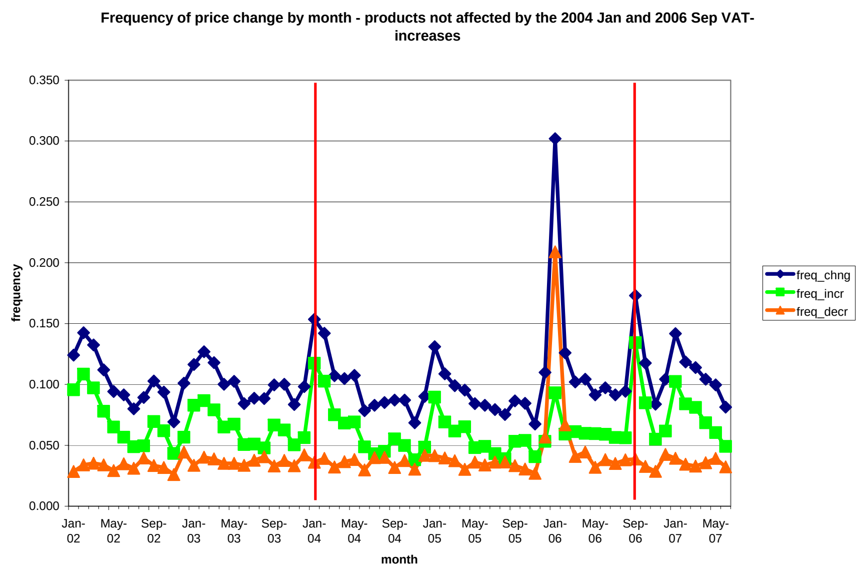

Figure 32: Size of price changes – products affected by VAT-increases

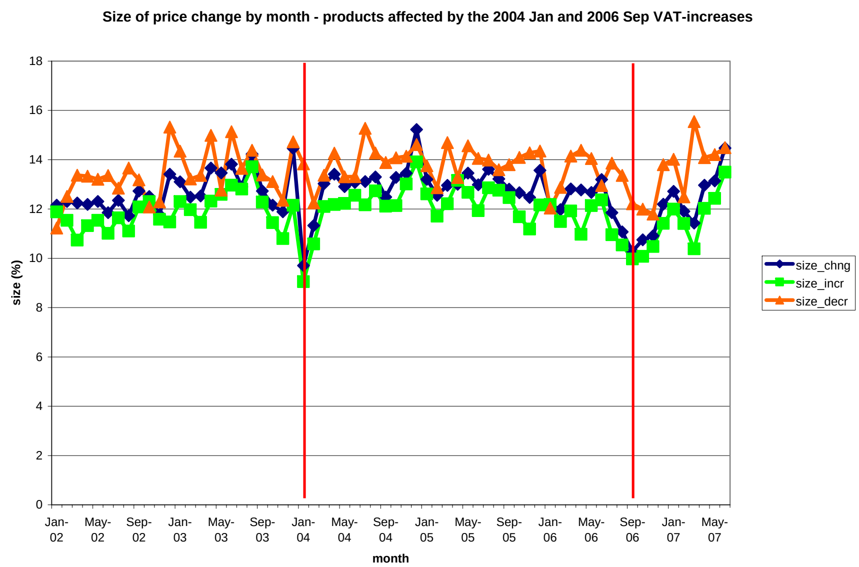

Figure 33: Size of price changes – products not affected by VAT-increases

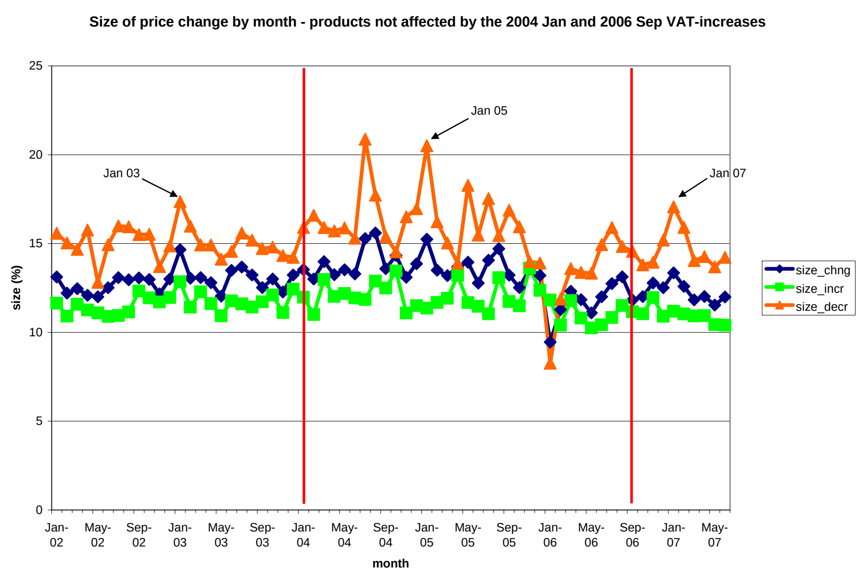

Figure 34: Frequency of price changes – by being affected by VAT-decrease

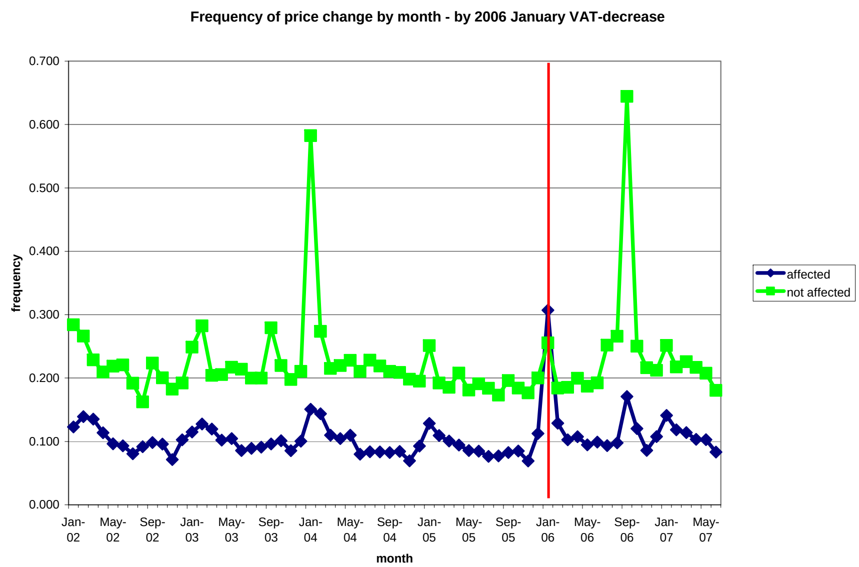

Figure 35: Size of price changes – by being affected by VAT-decrease

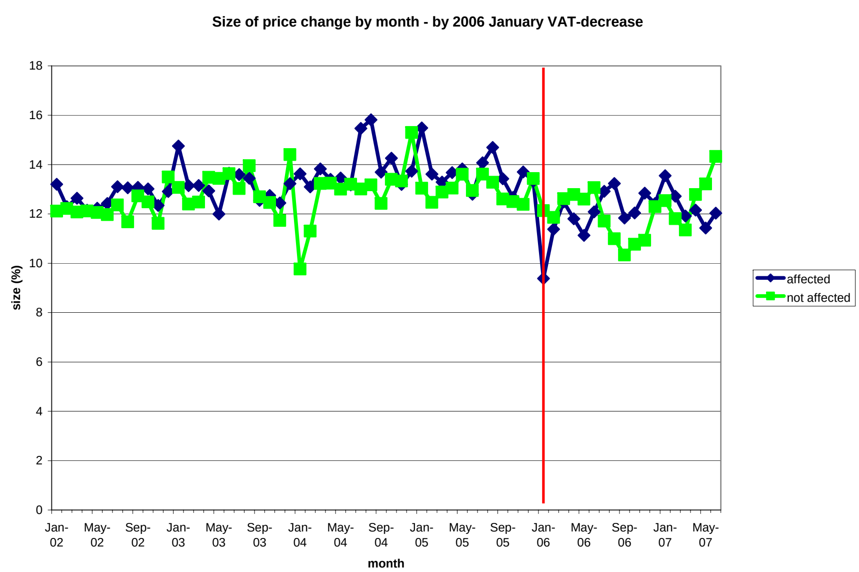

Figure 36: Frequency of price changes – products affected by the VAT-decrease

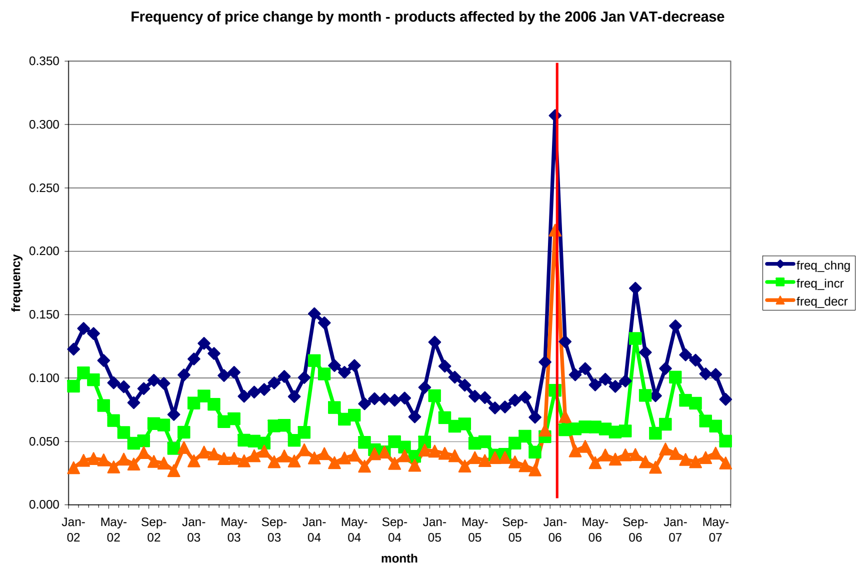

Figure 37: Frequency of price changes – products not affected by VAT-decrease

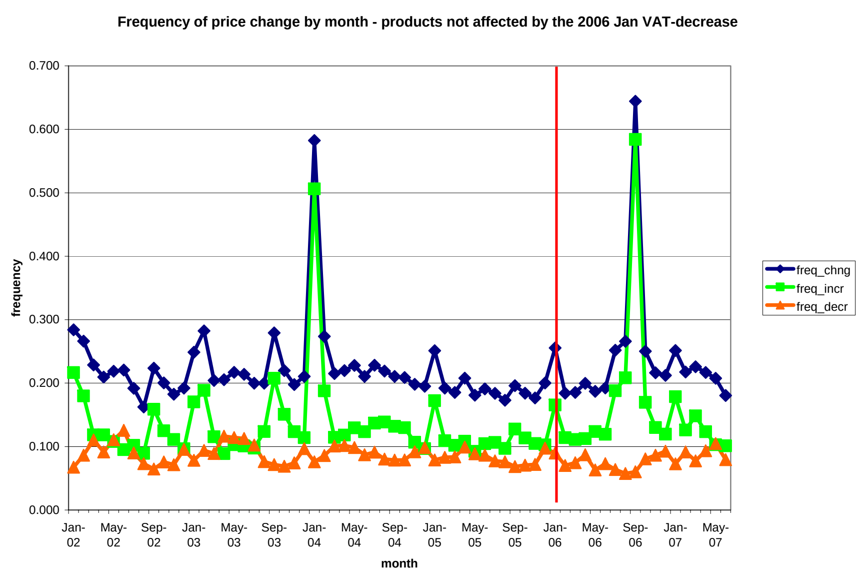

Figure 38: Size of price changes – products affected by VAT-decrease

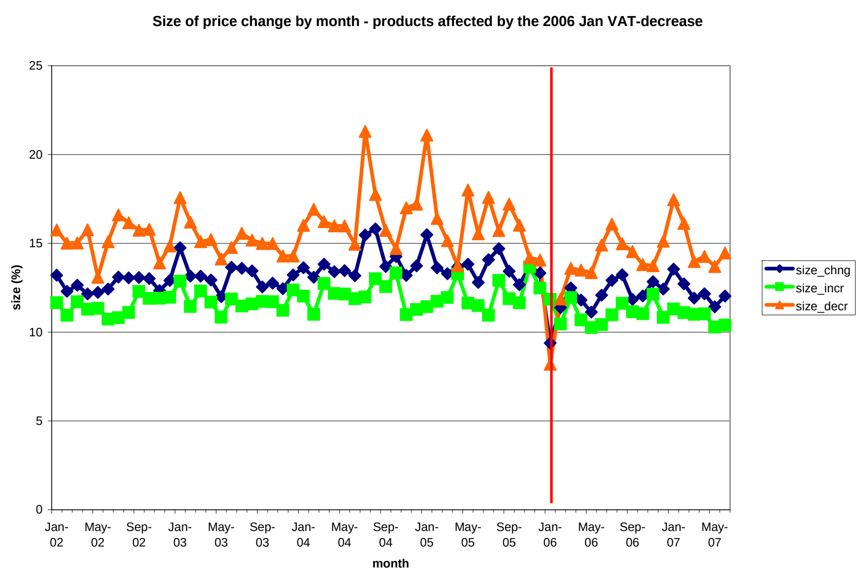

Figure 39: Size of price changes – products not affected by VAT-decrease