Nominal Rigidities in a Mail Order Company:
Estimation of the Probability of Price Adjustment

by

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Abstract: Nominal price rigidities are analyzed from two different perspectives. From a qualitative point of view - as Kashyap (1995) - we look for coherent signs which confirm the presence of fixed costs of adjustment, and therefore the validity of state-dependent pricing rules. Our data concern a mail order Italian company and confirm that individual prices do not mimic the aggregate price index, as it was already claimed by Kashyap (1995) and Tsiddon (1993) for US and Israeli data. Second, we estimate by ordered probit models the probability to have nominal price adjustments (increase, rigidity or decrease) as a function of last period real price and rivals' price level. Price point strategies are also investigated. We observe a common performance for all brands' prices which supports a (S, s) rule hypothesis.

JEL Classification: C25, D40, D43.

1. Introduction

Our main objective is to verify the consistency of nominal price rigidities with a hypothesis of fixed costs of adjustment by using individual mail order prices. We will present results of an empirical analysis with reference to catalogue prices set by an Italian company of mail order retailing.

Nominal rigidity is an important issue from a theoretical and an empirical perspective. The decision to study optimal pricing rules connected with fixed costs of adjustment has been originated by the observation of empirical works describing aggregate and individual prices behavior. In the former case prices are characterized by smoothness and adjustments are continuous and partial. In individual data set, prices adjust very rarely and the variation is not negligible. From a microeconomic point of view, there are several ways to justify stickiness of prices. In the presence of costs to collect information the optimal pricing rule is *time-dependent*. In the presence of fixed costs of adjustment, i.e. menu costs, the optimal pricing rule is *state-dependent*.

When the observation of the state of the world is costly the optimal firm's decision is to do it at constant intervals of time and therefore the nominal price does not change during these periods. Taylor (1979, 1980) and Fischer (1977) originally proposed models with time-dependent pricing strategies. In order to find evidence confirming the theory, we have analyzed the length of all periods of rigidity[1]. Kashyap (1987) study on mail order prices of 3 different US mail-order companies shows the inconsistency of time-dependent rules even though claiming that these rules are a good justification in case of small price changes. However, a fixed time dependent pricing rule is not sufficiently general. Kashyap (1995) observes that the length of the period of rigidity is related to the information released by the economic system over time. Thus a *variable* time-dependent rule is preferred. If two goods are similar as to demand and costs characteristics, we should find a strong correlation between their timings in the adjustment[2]. In our data set, however, we do not find a high degree of correlation and association. This result is not surprising since they refer to very different

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[1]To check the existence of fixed intervals of rigidity we have determined the average and median rigidity duration and its standard deviation. *We can say that there are no constant intervals of rigidity*. Even taking into account inflation dynamics, we do not find higher of adjustment frequencies in the high inflation period (1973-1984) than in the low inflation one (1985-1995). We instead see that prices were adjusted less frequently in the two-digit inflation regime than in the other one. Therefore we cannot accept a model where prices remains constant for given intervals of time.

[2] To verify if price adjustments of two items are synchronized we calculate a measure of association, using a string of (-1, 0, +1) for each product. This variable indicates with "-1" if a price decreased with respect to the previous semester, "0" if it was unchanged, and "+1" if it increased. We can also determine a correlation index between two goods’ price change rates. In this case, we take into account variations’ magnitude and sign.

items for which it is difficult to admit common features about demand and cost conditions[3]. It is therefore impossible to give a final answer to our question about the importance of time dependent rules. Since our data are not suitable to check the goodness of time dependent rules, we will restrict our attention to state dependent rules and we will try to estimate the probability of adjustment in the hypothesis of this pricing policy.

The optimality of state-dependent rules is demonstrated in dynamic models where a firm pays a menu-cost to adjust nominal prices. The optimal decision establishes the variation of the nominal price when the real price is too far from the optimal real price, whose level refers to an assumption of adjustment at no cost. The state variable - the real price - fluctuates between the optimal price and the upper or the lower limit of a band of oscillation. Menu costs can be interpreted as explicit costs to adjust prices or can represent a good approximation of firms' behavior in models of near rationality, or models with uncertainty and imperfect markets, or in search models[4]. It will be interesting to verify the consistency of our data set with a state dependent rule in the hypothesis of fixed and variable bands. In this framework we will study some phenomena such as downward rigidity and small price adjustments.

Since we are considering all factors influencing the decision to adjust nominal prices, additional stickiness can be introduced if firms have a preference for price points. This idea was suggested by Kashyap (1995) and confirmed by Blinder (1991) in an interview study about price stickiness. In marketing theory a price point is a limit the firm gets over with difficulty and only to reach a new price point. An example of price point in Italian lire is L 19900. The idea is to describe imperfectly rational consumers who have different perception of a price like L 19900 with respect to a little higher price like L 20100. Friedman (1967) gives empirical evidence about a large use of price points in US data. A dummy variable to indicate if a price is a price point or not is important in the

[3] For a few products we obtained a quite large association index. The same result is determined when we consider a correlation index. For example, for the couples bedspring-cover and mattress-cover the association index is 0.79 and the correlation is 0.78. Almost the same result is obtained for the couple plastic boxes and bags-holder. These items are very similar and we can think a common pricing policy is applied since the former group is presented in pair, even though it is possible to buy them separately; the latter couple is produced by the same firm and constructed with the same materials. For other brands, we found a certain degree of association but a negative (and close to zero) correlation. For example, for the couple plastic boxes and electric cables the index of association is 0.24 and the correlation index is -0.04. Other couples with this feature are: blood pressure gauge and electric cables, blanket and plastic boxes. In these cases we run the risk that the correlation index give a greater importance to change rates' magnitude than to their sign.

[4] References are to Barro (1972) for a model of optimal pricing with fixed adjustment costs, and to near rationality model by Akerlof and Yellen (1985). Greenwald and Stiglitz (1993) review theoretical works about uncertain and imperfect capital and labor markets. Sequential search models applied to goods' market theory represent a possible explanation of countercyclical mark-ups (Stiglitz, 1979).

determination of the probability of price adjustment; we will see it in our econometric work in section 6.

The paper is organized as follows. Some considerations about mail order prices are presented in section 2. Then we consider the analysis of nominal prices (section 3) and real prices (section 4) from a qualitative point of view with the main objective to verify the consistency of state-dependent rules with our data set. Last part of the work (section 5 and 6) is devoted to the estimation of the probability of adjustment in the hypothesis of an ordered probit model associated with a state-dependent pricing policy.

2. Mail order prices

In a mail order firm a fixed cost of adjustment is represented by the cost of a catalogue which is uncorrelated with the magnitude of the price adjustment. The first paper where a (S, s) rule has been presented as the optimal rule in the presence of fixed adjustment costs, Sheshinski and Weiss (1977), suggests some examples one of which is the mail order case. Several empirical works point out diverging behavior of individual prices and aggregate price indexes. Microeconomic data are studied in some papers like Mussa (1981), Carlton (1986), and Cecchetti (1986) [5]. As Kashyap (1995), we are concerned with mail order catalogue prices. We are not interested in finding why a price is fixed for six months[6]; on the contrary, our final purpose is to explain why we often have the same price for several semesters even though it would be possible to change it on a new catalogue. Moreover, the price is the only term of exchange between the firm and its customers and there are no additional conditions in the contract to define. Long-term contracts are absent even though the firm is interested to transform occasional buyers into regular customers.

In this section we use prices of 11 goods collected in Postalmarket catalogues from 1970 to 1995. Appendix gives some information about the company and selected brands. All 11 items have some required characteristics. Quality transformations were limited. We avoided goods with a very short business cycle, fashion brands and new items. All goods are also available in other systems of distribution. On May and November, the firm chooses all prices for the new catalogue. In table 1 we

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[5]Mussa (1981) analyzes prices in the hyperinflation period that stroke Germany during the 20s'. Carlton (1986) considers intermediate goods' prices and Cecchetti (1986) studies the prices of the main magazines issued in US.

[6]Some economists give us some useful intuitions about the rigid versus the indexed price issue. Gordon (1990) claims that firms are interested in their demand and cost functions so aggregate demand indexation cannot be acceptable. Weiss (1993) observes that indexation is possible if a lot of firms do the same. This rule has a "public-good"-like nature so multiple equilibria are possible.

can observe some statistics as to sample length, *per* semester average change rates and standard deviations. Moreover, the longest rigidity duration as well as the correspondent date is reported. The number of observations is different product by product. The most complete series is for blanket (1970-1995). The shortest one is for sheet (1980-1994). *Per* semester average change rates - reported in figure 1 - vary from a minimum of 2.15% to a maximum of 6.27%. Blanket, bags-holder and plastic boxes show the highest average change rates with the highest standard deviations. We note that for all brands we have recorded price rigidity for at least 2 semesters. The items with the smallest rigidities are pressure cooker (2 semesters), blanket and beater (3 semesters). At maximum, we observe a period of rigidity of 10 semesters for mattress-cover. The longest periods of rigidity occurred both in the low inflation regime from 1973 to 1984 and in the two-digit inflation period from 1985 to 1995 that have interested the Italian economy over the last 25 years (see figure 2). We point out that prices often were price points during these periods of rigidity. A classification of price change rates in different groups has been given as follows: <0%, =0%, 0-5%, 5-10%, 10-15%, and >15%. We have calculated frequencies for these intervals collected in table 2 and depicted in figure 3. We remark that the magnitude of change rates is variable product by product, as we have already observed in figure 1, and period by period, as we can see in table 2. In table 2 we see that the most important group is 0% for 8 goods (sheet, mattress-cover, bedspring-cover, beater, plastic boxes, bags-holder, blood pressure gauge, and electric cables); only for blanket and pressure cooker is the main frequency group 5-10% even though the 0% frequency is closed to it. We also point out the presence of discount rates whose frequency varies from 2.33% to 22.73%; only a few prices are connected to sales (special offers) which are always valid for 6 months. The 0-5% group is not negligible: 6.52% and 27.27% are minimum and maximum frequencies respectively. Data collected in table 2 were used to depict figure 2 as proposed by Kashyap (1995). Every rectangle represents a product; every area of a given color corresponds to a frequency group. For example, let's consider the mattress-cover item: discounts represent the 2.33% of the entire time series, rigidity represents the 53.49%, 0-3% frequencies are absent, 3-5% group is equal to 13.95%, 5-10% to 11.63%, 10-15% to 13.95%, and variations greater than 15% amount to 4.65%. In figure 2 we can see how important rigidities are (striped area); for the 0% group we have recorded frequencies from a minimum of 18% (blanket) to a maximum of 53.49% (mattress-cover).

A more precise analysis of minimum and maximum prices and of semesters during which they were chosen suggested the presence of the highest price levels in periods of inflation with two digits. Data are reported in table 3. In addition, we calculated median change rates to avoid outlyers. We found that the median change rate is 0% (rigidity) for about a half of the goods. We therefore decided to consider two sub-samples; the first one is relative to catalogues n. 26-49 (spring/summer 1973 - fall/winter 1984), and the second one covers catalogues n. 50-71 (spring/summer 1985 - fall/winter 1995). Detailed statistics for both samples are presented in table 4. As we can see in table 4, at a first sight average change rates are smaller in the low inflation period than in the high inflation one. We have tested the null hypothesis of equal means in the two time periods for all items. We cannot reject it, except for blanket, bedspring cover and beater cases[7]. Median change rates are calculated again with reference to the two sub-samples. The 0% change rate is still the median rate for about a half of the items during both the two-digit inflation regime and low inflation one. This indicates that rigidities concern both periods. Standard deviations are high when inflation is high. Maximum change rates are recorded in the two digits inflation period, all (strictly positive) minimum change rate in the second period. Discounts in the second period are lower than discounts in the first period for 5 items. We notice however the presence of discounts in the high inflation regime too. Discounts are even higher in the latter period than in the low inflation period for 6 brands.

3. Consistency of nominal prices and *state-dependent rules*

In a one-sided (S, s) rule model the nominal price varies only when the real price reaches the lower limit s[8]. In a situation of steady stochastic processes of costs, demand, and competition conditions, the target price S and the lower bound s do not change; therefore we should always observe the same real price adjustment, that is a real change of magnitude (S - s). We will check this proposition in next section. Since the nominal adjustment should be optimal only when the real price decreases of a certain amount, we could not observe small nominal variations. So it is difficult to justify the presence of them. In our data set we observe that the frequency of nominal prices in the 0-5% nominal change rates interval is not negligible (from 6.52% to 27.27%). See table 2. Thus, data appear to be in contrast with theoretical implications of fixed (S, s) rules. However, in a more detailed analysis of state-dependent rules, we can show that small changes are still possible. If a non-steady stochastic process describes inflation, demand, and cost conditions, the optimal rule is to fix a

[7] We cannot refuse a hypothesis of different variances in the sub-samples for two items, beater and plastic boxes. For the other products, we can accept an equal variance assumption.

[8] A one-sided rule is optimal if the inflation process is monotone and stochastic (Sheshinski and Weiss 1977, 1983). If the monotonicity hypothesis cannot be satisfied, a firm optimally chooses a two-sided pricing rule (Caplin and Spulber, 1987).

variable band within which the real price fluctuates and the nominal price does not change[9]. More specifically, if the expected inflation rate increases, the bandwidth becomes larger; *viceversa*, if it decreases, the bandwidth gets smaller. Demand and cost shocks are very important in the determination of this interval. In the latter situation, small nominal changes are admitted.

Another issue we are interested in is the (positive) correlation between the magnitude of nominal change rates and rigidity duration, as suggested by Carlton (1986). This is a useful way to check if an adjustment cost exists. For those goods whose price is very rigid we should find high opportunity costs in case of adjustment, then we should observe only large variation of nominal prices. In table 5, we observe high average change rates if the interval of rigidity is higher than one semester ($n \geq 2$). In the case of maximum flexibility (the nominal price changes in every catalogue), the average change rate is low for all goods, except for sheet and blood pressure gauge.

Another phenomenon we have checked, whose validity is commonly accepted in real experience, is downward rigidity. We have considered two different explanations. First, Carlton (1986) explains downward rigidity with the presence of asymmetric costs of adjustment. The cost is higher for decreases than for positive changes of nominal prices. In this case we should observe smaller minimum strictly positive change rates than minimum strictly negative change rates (in absolute value). In our sample, 6 items do not satisfy this condition (sheet, blanket, mattress-cover, bedspring-cover, beater, and plastic boxes) as we can observe in table 6; the condition holds for the other 5 goods (pressure cookers 5 and 7 lt., bags-holder, blood pressure gauge, and electric cables). In a different model by Tsiddon (1991, 1993) downward rigidity is admitted with a variable (S, s) rule and a revision of inflation expectations. As a consequence, we do not necessarily have to assume asymmetric costs of adjustment. When expectations are revised, decreases of nominal prices are less frequent than increases since it is easier that the fixed adjustment cost be lower than the opportunity cost of waiting the real price enters inside the band again. Tsiddon showed that if expected inflation rate is high, the firm chooses a large band in the (S, s) approach. If it decreases, the firm shortens the band. If the real price is very low when there is a revision like the latter, the nominal price is adjusted because the real price cannot exogenously enter the new band, independently of the adjustment cost. If the real price is very high, inflation reduces the real price bringing it spontaneously inside the new optimal band. In the latter situation, the nominal price is not adjusted if the adjustment cost is greater

[9] The optimality of a variable (S, s) rule is guaranteed when the firm's choice is related to the expected inflation rate (Tsiddon 1991, 1993); another way to follow such a rule is to assume the presence of strategic complementarities among firms (Caballero and Engel, 1993b).

than the opportunity cost from rigidity. This is the reason decreases are less frequent than increases. These results strictly reflect the behavior of inflation.

In addition we have looked at price setting chosen by a firm. Firms often fix prices at special levels, defined in marketing theory as *price points*; they represent barriers the firm gets over with difficulty. We have checked if in our sample we find some evidence about price points. In figure 4 we see how much these prices (expressed in Italian lire) are important; the 54.44% of prices for all 11 items (245 prices over 450) have the hundreds which belong to the interval 900-1000. Taking into account price points, the average change rate, when a price point changes, is usually bigger than the average rate as a non-price-point varies (except for sheet, pressure cooker 7 lt., beater, plastic boxes, and electric cables; for some of them only one price belongs to the latter group). These results are reported in table 7.

Finally the presence of discounts can be interpreted as expectations' revision; if a (S, s) rule is applied adjustment is not always a convenient decision, depending on the comparison between the (fixed) adjustment cost and the opportunity-cost from rigidity. An alternative explanation of this issue can be related to the adjustment of stocks[10]. We often observe that firms can offer goods at low prices when they buy very big quantities. The idea however cannot find confirmation from our evidence, because we do not have data on stock dynamics.

4. Consistency of real prices and *state-dependent rules*

Nominal changes are strongly influenced by price behavior common to all goods, summarized by the CPI change rate. To construct real prices suitable we have considered the "nominal price/general Consumer Price Index" ratio.

We have calculated *per* semester change rates and correspondent mean, standard deviation, maximum and minimum rates; data are all summarized in table 8. Average change rates of relative prices are depicted in figure 5. We can observe that average real price change rates vary over the sample from -2.60% of electric cables to 1.41% of plastic boxes. An analysis of autocorrelations of real change rates provides evidence in favor of constant rates over time: real rate at time t is equal to a constant plus a (white noise) error term. This result is confirmed by a deeper analysis, which compares two sub-samples related to different inflation regimes observed in Italy: 1970-1984 and 1985-1995. In table 9, we reported summarizing data for both samples. An F-test has been implemented to verify a hypothesis of equal variance over the two periods against one of diverging variability. We cannot reject the former assumption for all items but beater and plastic boxes. Then, two different t-tests have been calculated in order to verify equality of average real rates[11]. We cannot reject an assumption of equal means for all items (in a 99% confidence interval).

We can argue that a constant real price variation emerges, empirically confirming that real changes follows (S - s) rules. However, we cannot justify *fixed* (S, s) rules in the presence of small nominal adjustments and downward rigidity as we have already noted in section 3. We therefore prefer *variable* state-dependent rules, which guarantee more flexibility in the estimation of the probability to adjust nominal prices.

Finally, the mail order firm accepted big real losses related to a decision of "no-adjustment" of the nominal prices for all goods. Kashyap (1987) calculated an average loss of about 10% before the adjustment of a price. In our data set we similarly observe the same behavior, with an average loss of 9.82% for the whole sample. For every single product, we determined average losses (collected in table 10) ranging from a 6.54% rate for pressure cooker to a 16.08% for mattress-cover.

5. Ordered-probit estimation

In this section we want to verify the performance of (S, s) pricing rules in the analysis of nominal rigidity with reference to individual data about the Italian mail order firm we have considered in the qualitative approach[12]. We want to estimate the probability of adjusting a nominal price under the hypothesis of a (S, s) rule, with reference to Kashyap (1995), adding an explicit distinction between decreases and increases of nominal prices. This approach needs variables related to the bandwidth and to the intertemporal change of real prices.

In a general framework, a fixed (S, s) rule is associated to a zero probability to modify a price within a given band and to a probability equal to one when a limit is reached. From an empirical point of view, it is more interesting and more flexible to assume that the probability is increasing with

[10] Aguirregabiria (1995) uses information about stocks to explain downward price changes.

[11] If we accept a hypothesis of equal variances, we refer to Student distribution; otherwise, we consider Behrens distribution for small samples, by exploiting Cochran proxy.

[12] It would be interesting to directly estimate the equilibrium real price and the band within which the nominal price is not modified; however, it is difficult to get data on individual prices, demand and cost values. Few papers have tried to do it. Aguirregabiria (1995) has been able to collect a wide data set from a retailing store chain.

respect to the real price position within the band relative to the long run price. So we prefer to use a variable band approach.

A first question arises about the definition of the real price. We have calculated it as a ratio between the nominal price and the Wholesale Price Index[13] relative to the group that includes each item. This share is a proxy of the gross profit, which is chosen by the seller. The second variable we are interested in gives a measure of other sellers' prices. The idea is to consider strategic complementarities that influence firms' decisions. We refer to Consumer Price Index data, disaggregated for different categories of goods, to have a measure of competitors' prices[14].

We have constructed a multinomial model called *ordered-probit* model to remark that the qualitative variable has an order (Greene, 1993)[15, 16]. The probability to observe state i (where i = {-1, 0, 1}) at time t corresponds to the probability that a given estimated linear function plus an error is between an interval defined by two estimated *cut points* for the same state i

$$\Pr(i) = \Pr(k_{i-1} < \beta' x_i + u_i \leq k_i)$$

where u_i is normally distributed. We will refer to an auxiliary variable, denoted by S_i, such that $y_i = -1$ if $S_i \leq k_1$, $y_i = 0$ if $k_1 < S_i \leq k_2$, $y_i = +1$ if $S_i > k_2$, where we have to estimate S_i as

(1) $S_i = \beta' x_i + u_i$

A maximum likelihood method as been used to estimate β vector and k_1, k_2 cut points. x_i is a vector of explanatory variables including real price level at time (t - 1), called *realp1*, consumer price index change rate at time t with respect to time (t - 1), called *CPIrate*, and a dummy variable indicating if the previous period price is a price point, called *dppoint*. The first variable is a proxy of the real price position within the (S, s) band, the second one gives a measure of rivals' average price. Equation (1) can be rewritten as

(2) $S_i = \beta_1\, realp1 + \beta_2\, CPIrate + \beta_3\, dppoint + u_i$

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[13]Source: Istat, Wholesale Price Index (WPI), 1970-1995.

[14]Source: Istat, Consumer Price Index (CPI), 1970-1995.

[15] At a first stage, we have estimated a probit model given a qualitative variable "adjustment of a nominal price", which takes value 1 if the nominal price is modified at time t and 0 if it is not adjusted at time t with respect to the previous semester. Preliminary results have not been completely satisfactory. A possible explanation has been attributed to the presence of several negative changes in nominal price data (10.59%). Therefore we have adjusted our model. Instead of the binary data set {0, 1} we have taken the set {-1, 0, 1} as a dependent variable correspondent to "reduction", "rigidity", and "increase" of the nominal price at time t, respectively.

[16]Greene (1993) offers some justification for the use of the probit model. First of all, it is not possible to consider the linear regression model because there are problems of eteroscedasticity and it does not guarantee that the estimated probability is between 0 and 1. Another possibility is to consider a logit model where we assume a logistic density function. In an empirical framework, there are no apparent differences so the choice is driven by a criterion of convenience. Greene (1993) however observes that in the literature researchers use more often probit models. In

Any nominal price change rate of our data set will belong to "-1" subset if $S_i \leq k_1$, to "0" subset if $k_1 < S_i \leq k_2$, and to "+1" subset if $S_i > k_2$.

Economic theory about (S, s) rules can help us in determining signs of β_1, β_2 and β_3. If the real price at time (t - 1) is high there is a strictly positive probability that it is near the superior limit of the band, and therefore the nominal price will decrease at time t; in this case we have $S_i \leq k_1$. *Viceversa*, if the real price at time (t - 1) is very low, it is possible that the nominal price at time t will increase, so we need $S_i > k_2$. The probability is decreasing with respect to the real price; the coefficient β_1 should be negative. As to the consumer price index coefficient β_2, there is a high probability to increase (decrease) a nominal price if the general price level increases (decreases). If the general price index is high, we need $S_i > k_2$, if it is low we obtain $S_i \leq k_1$. The coefficient β_2 should be positive. *dpricepoint* is a dummy variable, which takes value 1 at time t to signal if a nominal price was a price point at (t -1); the variable is 0 otherwise. From a theoretical point of view, price points are barriers a firm gets over only to reach a new price point. We can therefore think there is a negative effect on the probability since we strengthen the delay in the adjustment. β_3 is negative if we consider price increases, and positive if we observe price decreases. If we wanted to verify this proposition, it would be necessary to separately estimate the probability of changing the price only i) in increases cases and ii) in decrease cases. We have not enough data to do it.

Next section presents results concerning predicted probabilities as well as estimated parameters.

6. Results

We have considered a pooled-regression of all goods' nominal prices by assuming an ordered-probit model[17]. Our objective has been to find a relation between the probability of adjustment and some explanatory variables (real price at time t-1, and rivals' price level at time t) common to all goods. We have adjusted the model with dummy variables to take into accounts price point strategies

addition, it is not possible to test, i.e. with standard LR test, which model is better because logit and probit models do not come from a common general model.

[17] In order to evaluate the probability to vary prices we will consider the following time periods: pressure cooker (1977-1992), bags-holder (1971-1988), and blood pressure gauge (1978-1995).

and heterogeneity across goods admitting differences in the constant term. The corresponding results are presented in table 11[18].

We cannot reject the hypothesis of coefficients different from zero for β_1 and β_2 with respect to *realp1* (real price at time t-1) and to *CPIrate* (consumer general price index rate of change *per* semester at time t), as suggested by the theory. We observe that β_1 and β_2 negative and positive signs are respectively confirmed by empirical results. The item-specific intercept is significantly different from zero for almost every brand, except for blanket and electrical cables. Table 13 presents predicted probabilities for price increases, decreases, and rigidity, compared with relative frequencies coming from data.

Then, we have repeated the same regression, one for each product. We confirm previous results as to β_1, β_2, β_3, k_1, and k_2 (the same notation used in the pooled regression); the probability of adjustment is negatively related to the previous semester real price and positively related to other firms' price level. However, not all coefficients are significantly different from zero. For those products for which we cannot reject the null hypothesis, we probably have problems of efficiency as to the number of observations; for example, the pressure cooker data set contains only 27 observations. In addition, for some of them we do not have an adequate approximation of rivals' prices. CPI data are published only for large categories with very different goods included so the correspondence with our brands is not always suitable.

Our strategy has been to refer to the general CPI for all items but blood pressure gauge to calculate *CPIrate*. For the blood pressure gauge, a health expenditure CPI index change rate has been considered. In this case, there is an improvement of our results. Moreover, in order to limit efficiency problems new estimation has been implemented by considering cumulated change rates. The idea is that real prices should include all information since last price change and not since last semester because it is essential in the decision to adjust or not. In this hypothesis we have calculated the rivals' price change rate as a cumulated rate since last nominal adjustment. However, we do not obtain better predictions with the exception of the blood pressure gauge. This is why in table 14 we present predicted probabilities calculated in single-product estimations where the general CPI change rate is obtained as a change from time t-1 to time t, except for blood pressure gauge, for which we show a result referred to a cumulated rate.

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[18]The same regression has been calculated with reference to an ordered-logit model. Comparison of the two models has been made using the Akaike criterion, and there is no evidence of preferring one of the two hypotheses.

7. Conclusive remarks

The main objective of this paper has been the empirical analysis of nominal price rigidity for a mail order seller. Our microeconomic perspective has been twofold. First, we have conducted a qualitative analysis of our data - following Kashyap (1987, 1995) - to find some facts coherent with a hypothesis of fixed cost in the adjustment of prices. Apparent rigidities have emerged even though the degree of rigidity varies product by product. There is some evidence connected with real change rates that confirms a (S, s) rule. Moreover, variable state-dependent pricing rules are admitted in order to justify the presence of limited price adjustments and reductions during high inflation periods. The presence of adjustment costs has been confirmed by a positive correlation between rigidity duration and magnitude of change rates for almost all items. Importance of price points has emerged evidently. Price points are barriers that let a firm delay price adjustments if a new price point is too high. This is confirmed by the observation that if a price point is adopted the following change rate is higher than one following another price.

Our second purpose has been the estimation of the probability to modify a nominal price following a state-dependent rule taking into account differences of the decision of reducing prices from one of increasing prices. Therefore ordered probit models have been considered. We have estimated a probability of price increase, decrease, and rigidity, as a function of last semester real price, calculated as a ratio of nominal price and Wholesale Price Index, and of rivals' price change rate, given by the Consumer Price Index.

There is some common behavior for all goods as we have seen in a pooled-regression. In single-product regressions, however, not all coefficients are significantly different from zero. This is probably due to efficiency problems as to small length of time series for some goods, and to the available measure of real prices and rivals' behavior. For some items we can reject the null hypothesis: the probability of adjustment is negatively related to the previous semester real price and positively related to other firms' price level.

Appendix: Some information about data

We have collected prices from Postalmarket catalog issued by Grande Distribuzione Avanzata SpA. The firm was born in 1959 with the first catalog issued for Spring-Summer in 1960. The catalog is issued twice a year, the first one at the beginning of January (spring-summer) and the second one at the beginning of July (fall-winter). The validity is respectively February 1 / July 31 and August 1 / January 31. Dates of printing: December 1 and June 1. Prices are set by the company in these dates. Prices are fixed for six months with no exception and everywhere in Italy. There are a minimal value of ordering (in the last catalog is L. 40,000), handling charges (L.7,900) and postage charges (L.1,850). These costs are not considered in the analysis. Old customers receive the catalog freely and new customers can buy it at L.10,000, paid back with the first order.

The criteria followed for collecting prices are more or less the same suggested by Kashyap (1987). Items have been available and unchanged for long periods of time, with limited quality changes. They are also sold in store and shop channels. Products are both small and big and give high volume revenues. We have selected the following items:

- Sheet: white 100% cotton sheet with two pillowcases
- Blanket: double bed 100% woolen blanket
- Mattress-cover: single bed cotton mattress cover
- Bedspring-cover: single bed polyester bedspring cover
- Pressure cooker 5 lt.: 18/10 steel pressure cooker, capacity of 5 liters
- Pressure cooker 7 lt.: 18/10 steel pressure cooker, capacity of 7 liters
- Beater: two-speed beater to prepare mayonnaise, to beat eggs, …
- Plastic boxes: 3 plastic boxes for blankets
- Bags-holder: plastic box for bags
- Blood pressure gauge: gauge to measure blood pressure
- Electrical cables: cables to connect two car batteries

References

Aguirregabiria, V. (1995) Moment Conditions in Dynamic Decision Models with Corner Solutions: Estimating a Model of Price and Inventory Decisions, University of Western Ontario, mimeo.

Akerlof, George A., and Janet L. Yellen (1985) A Near-Rational Model of the Business Cycle, with Wage and Price Inertia, *Quarterly Journal of Economics*, Supplement, 823-838.

Barro, Robert (1972) A Theory of Monopolistic Price Adjustment, *Review of Economic Studies*, 34, January, 17-26.

Blinder, Alan S. (1991) Why Are Prices Sticky? Preliminary Results from an Interview Study, *American Economic Review, Papers and Proceedings*, 89-96.

Caballero, R.J. e Engel, M.R.A. (1993a) Microeconomics Rigidities and Aggregate Price Dynamics. *European Economic Review*, 37, 697-717.

Caballero, R.J. e Engel, M.R.A. (1993b) Microeconomic Adjustment Hazards and Aggregate Dynamics. *Quarterly Journal of Economics*, 108, 359-383.

Caballero, R.J. e Engel, M.R.A. (1993c) Heterogeneity and Output Fluctuations in a Dynamic Menu-Cost Economy. *Review of Economic Studies*, 60, 95-120.

Caplin, A. e Spulber, D.F. (1987) Menu Costs and the Neutrality of Money. *Quarterly Journal of Economics*, 102,703-725.

Carlton, Dennis (1986) The Rigidity of Prices. *American Economic Review*, 637-658.

Cecchetti, Stephen G. (1986) The Frequency of Price Adjustment: A Study of the Newsstand Prices of Magazines, *Journal of Econometrics*, 255-274.

Fischer, S. (1977) Long-term Contracts, Rational Expectations, and the Optimal Money Supply Rule, *Journal of Political Economy*, 85, 191-205.

Friedman, L. (1967) Psychological Pricing in the Food Industry, in *Prices: Issues in Theory, Practice and Public Policy*, A. Phillips e O.E. Williamson (eds.), Philadelphia: University of Pennsylvania Press.

Gordon, Robert J. (1990) What Is New-Keynesian Economics?, *Journal of Economic Literature*, 1115-1171.

Greene, William H. (1993) *Econometric Analysis*, Prentice Hall.

Greenwald, Bruce e Joseph Stiglitz (1993) New and Old Keynesians, *Journal of Economic Perspectives*, 7, 23-44.

Kashyap, Anil K. (1987) Sticky Prices: New Evidence from Retail Catalogs, mimeo.

Kashyap, Anil K. (1995) Sticky Prices: New Evidence from Retail Catalogs, *Quarterly Journal of Economics*, 245-274.

Mussa (1981) Sticky Prices and Disequilibrium Adjustment in a Rational Model of the Inflationary Process, *American Economic Review*, 71, 1020-1027.

Sheshinski, E. e Weiss, Y. (1977) Inflation and Costs of Price Adjustment. *Review of Economic Studies*, 44, 287-303.

Sheshinski, E. e Weiss, Y. (1983) Optimum Pricing Policy under Stochastic Inflation. *Review of Economic Studies*, 50, 513-529.

Stiglitz, Joseph (1979) Equilibrium in Product Markets with Imperfect Information, *American Economic Review*, 71, 393-410.

Taylor, John B. (1979) Staggered Wage Setting in a Macro Model, *American Economic Review*, 108-113.

Taylor, John B. (1980) Aggregate Dynamics and Staggered Contracts, *Journal of Political Economy*, 1-23.

Tsiddon, D. (1991) On the Stubbornness of Sticky Prices. *International Economic Review*, 32, 69-75.

Tsiddon, D. (1993) The (Mis)Behaviour of the Aggregate Price Level. *Review of Economic Studies*, 60, 889-902.

Weiss, Yoram (1993) Inflation and Price Adjustment: A Survey of Findings from Micro-Data, in *Optimal Pricing, Inflation, and the Cost of Price Adjustment*, E. Sheshinski e Y. Weiss (eds.). Cambridge, MA: MIT Press.

Table 1: Descriptive statistics

Item	Sample	Mean	St. dev.	Longest period of rigidity Dates	Duration (sem)
Sheet	80N-94N	3,28	8,49	84N-87M	6
Blanket	71M-95N	5,43	9,25	80N-81N/91M-92	3
Mattress-cover	74N-95N	4,27	6,66	86N-91M	10
Bedspring-cover	72M-95N	4,51	6,38	87N-91M	8
Pressure cooker 5 lt	77N-90N	4,30	8,21	many	2
Pressure cooker 7 lt	77N-92N	4,26	8,68	many	2
Beater	72M-95N	4,39	8,46	71N-72N	3
Plastic boxes	72M-95N	6,63	13,61	71N-73M	4
Bags-holder	72M-88M	6,14	12,74	71N-73M/77N-79M	4
Blood pressure gauge	79M-95N	3,23	8,18	86M-88N	5
Electrical cables	73M-95N	2,77	7,51	82M-84N	6

Table 2: Distribution of nominal price change rates

Item	< 0	= 0	0%-5%	5%-10%	10%-15%	≥15%
Sheet	10,34%	58,62%	10,34%	3,45%	6,91%	10,34%
Blanket	16%	18%	20%	20%	14%	12%
Mattress-cover	2,33%	53,49%	13,95%	11,63%	13,95%	4,65%
Bedspring-cover	4,35%	47,83%	6,52%	21,74%	13,04%	6,52%
Pressure cooker 5 lt	9,10%	21,21%	27,27%	30,30%	6,06%	6,06%
Pressure cooker 7 lt	9,10%	21,21%	27,27%	33,33%	3,03%	6,06%
Beater	22,73%	22,73%	13,64%	18,17%	13,64%	9,09%
Plastic boxes	5%	40%	22,50%	17,50%	5%	10%
Bags-holder	7,69%	38,47%	12,82%	10,26%	15,38%	15,38%
Blood pressure gauge	17,65%	38,23%	17,65%	14,71%	8,82%	2,94%
Electrical cables	10,87%	47,83%	8,69%	21,74%	4,35%	6,52%

Table 3: Average, maximum and minimum nominal price change rates

Item	Mean	St. dev.	Max	Min	Median
Sheet	3.28	8.49	33.44	-11.56	0.00
Blanket	5.43	9.25	33.47	-18.71	4.90
Mattress-cover	3.47	5.78	27.19	-3.39	0.00
Bedspring-cover	4.05	6.30	19.05	-15.09	0.02
Pressure cooker 5 lt	4.10	7.40	28.54	-12.02	3.75
Pressure cooker 7 lt	3.91	7.90	32.95	-14.31	2.94
Beater	3.56	7.72	24.37	-16.26	0.48
Plastic boxes	6.05	13.72	60.40	-8.11	0.07
Bags-holder	6.27	13.89	60.61	-12.58	0.00
Blood pressure gauge	3.23	8.18	41.13	-5.09	0.00
Electrical cables	2.15	6.43	21.62	-23.33	0.00

Table 4: Analysis of nominal price change rates in high-inflation and low-inflation sub-samples

	Sample: 1973M-1984N					Sample: 1985M-1995N				
Item	Mean	St. dev.	Max	Min	Median	Mean	St. dev.	Max	Min	Median
Sheet	5.51	12.66	33.44	-11.56	0.00	2.27	5.93	19.42	-3.88	0.00
Blanket	8.15	10.13	33.47	-5.27	6.05	2.12	7.48	13.07	-18.71	3.02
Mattress-cover	5.11	7.28	27.19	-3.39	0.25	1.91	3.32	11.15	0.00	0.00
Bedspring-cover	5.86	6.67	19.05	-0.03	2.82	1.68	5.35	10.37	-15.09	0.00
Pressure cooker 5 lt	3.59	9.56	28.54	-12.02	0.11	4.58	4.87	20.04	-0.09	4.09
Pressure cooker 7 lt	3.72	10.59	32.95	-14.31	0.12	4.09	4.47	18.68	-0.08	3.46
Beater	5.79	7.13	24.37	-4.14	4.63	1.45	8.14	21.36	-16.26	0.00
Plastic boxes	5.69	12.72	50.63	0.00	0.00	6.98	15.48	60.40	-8.11	2.86
Bags-holder	8.25	15.38	60.61	-12.20	0.00	1.24	8.03	13.33	-12.58	1.35
Blood pressure gauge	2.42	4.38	9.13	-4.18	0.00	3.68	9.72	41.13	-5.09	0.00
Electrical cables	2.46	8.11	21.62	-23.33	0.00	1.82	4.04	10.10	-5.29	0.00

Table 5: Average change rate (in absolute value) after a period of rigidity of *n semesters*

Item	n=1	n>1 weighted average	n>1 simple average	n=2	n=3	n=4	n=5	n=6	n=8	n=10
Sheet	11.19	9.97	7.90	14.62	/	7.98	-1.09	/	/	/
Blanket	8.62	11.16	8.73	9.01	16.56	/	/	/	/	/
Mattress-cover	7.69	9.115	10.69	12.30	/	27.19	10.03	11.15	/	3.86
Bedspring-cover	8.89	10.93	12.68	8.75	18.52	19.05	/	6.71	10.37	/
Pressure cooker 5 lt.	6.59	13.73	13.73	13.73	/	/	/	/	/	/
Pressure cooker 7 lt.	6.21	13.36	13.36	13.36	/	/	/	/	/	/
Beater	6.95	10.70	8.79	11.34	6.25	/	/	/	/	/
Plastic boxes	7.33	17.19	19.88	30.68	9.09	/	/	/	/	/
Bags-holder	10.29	19.22	16.28	25.09	12.92	10.83	/	/	/	/
Blood pressure gauge	8.96	5.00	4.77	4.76	6.67	/	2.87	/	/	/
Electrical cables	7.15	10.48	8.24	5.06	13.35	9.17	/	5.37	/	/

Table 6: Downward rigidity

Item	Strictly positive minimum change rate	Strictly negative minimum change rate
Sheet	2.11	-1.09
Blanket	1.70	-0.19
Mattress-cover	3.86	-3.39*
Bedspring-cover	4.32	-2.86
Pressure cooker 5 lt.	0.13	-7.42
Pressure cooker 7 lt.	0.12	-6.68
Beater	0.72	-0.52
Plastic boxes	0.85	-0.84
Bags-holder	1.35	-2.16
Blood pressure gauge	2.12	-2.79
Electrical cables	1.27	-2.23

* This is the only negative change rate in the mattress-cover price series.

Table 7: Average nominal price change rates and *price points*

Item	Average change rate after a *price point* is adjusted (n° of changes)	Average change rate after another price is adjusted (n° of changes)	Number of semesters with a 0% change rate	Overall average change rate (n° of changes)
Sheet	6.90% (11)	19.42% (1)	17	3.28% (29)
Blanket	8.40% (30)	1.78% (11)	9	5.43% (50)
Mattress-cover	9.12% (18)	6.81% (2)	23	3.55% (43)
Bedspring-cover	8.63% (18)	6.75% (6)	22	4.26% (46)
Pressure cooker 5 lt.	6.25% (21)	2.72% (5)	7	4.39% (33)
Pressure cooker 7 lt.	5.33% (23)	5.81% (3)	7	4.24% (33)
Beater	4.75% (29)	6.54% (5)	10	3.87% (44)
Plastic boxes	11.20% (22)	21.71% (2)	16	7.24% (40)
Bags-holder	11.73% (18)	10.58% (6)	15	7.04% (39)
Blood pressure gauge	5.23% (21)	/	13	3.23% (34)
Electrical cables	5.22% (23)	7.25% (1)	22	2.77% (46)

Table 8: Mean, maximum, and minimum change rates of real prices

Item	Mean	St. Dev.	Max	Min
Sheet	-0,85	7,40	21,25	-14,91
Blanket	0,24	8,31	25,97	-20,78
Mattress-cover	-0,99	6,00	18,12	-14,24
Bedspring-cover	-0,98	5,22	14,55	-17,34
Pressure cooker 5 lt.	-0,71	7,37	15,98	-16,72
Pressure cooker 7 lt.	-0,76	7,37	19,95	-18,88
Beater	-0,67	7,50	18,12	-18,72
Plastic boxes	0,16	11,20	40,92	-12,77
Bags-holder	-0,12	12,69	54,53	-17,01
Blood pressure gauge	-1,04	8,77	38,28	-12,94
Electrical cables	-2,60	7,02	15,94	-26,96

Table 9: Real price change rates in two different inflation regimes

	Two-digit inflation (1973 - 1983)				**Low inflation (1984 - 1995)**			
Item	**Mean**	**St.Dev.**	**Max**	**Min**	**Mean**	**St.Dev.**	**Max**	**Min**
Sheet	0,60	10,21	21,25	-8,85	-1,31	6,50	16,23	-14,91
Blanket	0,71	9,65	25,97	-10,62	-0,25	6,84	10,78	-20,78
Mattress-cover	-1,02	8,22	18,12	-14,24	-0,97	3,29	9,08	-4,80
Bedspring-cover	-1,17	4,39	6,88	-7,89	-0,79	6,07	14,55	-17,34
Pressure cooker 5 lt.	-2,51	8,96	15,98	-16,72	0,59	5,90	13,96	-11,96
Pressure cooker 7 lt.	-2,26	10,02	19,95	-18,88	0,33	5,44	12,66	-11,00
Beater	-0,45	7,09	12,15	-11,23	-0,91	8,06	18,12	-18,72
Plastic boxes	-2,50	9,86	38,06	-11,23	3.07	12.08	40.92	-12,77
Bags-holder	-1,84	8,14	18,61	-10,07	4,29	20,29	54,53	-17,01
Blood pressure gauge	-6,03	4,19	0,83	-12,94	1,23	9,42	38,28	-6,99
Electrical cables	-3,71	9,17	15,94	-26,96	-1,49	3,76	3,86	-8,07

Table 10: Average real loss when nominal prices are sticky for at least 2 semesters

Item	Average real loss
Sheet	9.47%
Blanket	6.87%
Mattress-cover	16.08%
Bedspring-cover	9.49%
Pressure cooker 5 lt.	6.54%
Beater	6.85%
Plastic boxes	11.13%
Bags-holder	11.74%
Blood pressure gauge	7.65%
Electrical cables	12.42%

Table 11: Ordered-probit model

Explanatory variables	Coefficients	Std. Err.	z	P>|z|	[95% Conf. Interval]	
realp1	-.0058514	.0032105	-1.823	0.068	-.0121438	.0004411
CPIrate	.0382261	.0154026	2.482	0.013	.0080376	.0684147
d1	-2.146494	.7756174	-2.767	0.006	-3.666676	-.6263121
d2	-.4625284	.3043673	-1.520	0.129	-1.059077	.1340204
d3	-1.861539	.7737311	-2.406	0.016	-3.378024	-.3450539
d4	-1.814591	.7850343	-2.311	0.021	-3.35323	-.275952
d5	-.1810895	.3434961	-0.527	0.598	-.8543296	.4921505
d7	-1.61791	.6737057	-2.402	0.016	-2.938349	-.2974713
d8	-1.69395	.7829515	-2.164	0.030	-3.228507	-.1593931
d9	-2.125875	.8415598	-2.526	0.012	-3.775302	-.4764479
d10	-1.359852	.445535	-3.052	0.002	-2.233084	-.4866191
d11	-2.118553	.7881334	-2.688	0.007	-3.663266	-.5738403
k_1	-3.163398	.8517366				
k_2	-1.881343	.8447463				

Table 12: Results in single product probit models

Item	CPI change rate (t -1)			Real price (t -1)		
	Coefficient	St.Dev.	P-value	Coefficient	St.Dev.	P-value
Sheet	0.0637095	0.1248580	0.610	0.0059477	0.0300858	0.843
Blanket	0.2116191	0.0799648	0.008	-0.0159122	0.0058820	0.007
Mattress-cover	-0.0186059	0.0607129	0.759	0.0536038	0.0434952	0.218
Bedspring-cover	0.1244833	0.0662254	0.060	-0.1366657	0.0592385	0.021
Pressure cooker 5 lt.	-0.0863065	0.1133675	0.446	-0.0175080	0.0119326	0.142
Beater	0.0936233	0.0592224	0.114	-0.0249542	0.0242500	0.303
Plastic boxes	0.0506703	0.0513897	0.324	0.0247338	0.0202136	0.221
Bags-holder	0.0098132	0.0514722	0.849	-0.0998430	0.0833861	0.231
Blood pressure gauge	0.0420656	0.0643689	0.513	-0.0115078	0.0098953	0.245
Electrical cables	-0.0035274	0.0311621	0.910	-0.0205131	0.0411381	0.618

Table 13: Predicted probabilities in the pooled estimation

	Pooling model		
	-1	**0**	**+1**
Predicted probability	0.1016	0.3887	0.5097
Relative frequency	0.1059	0.3892	0.5049

Table 14: Predicted probabilities in single-product estimates

	Predicted prob.			*Actual frequency*		
Item	**-1**	**0**	**+1**	**-1**	**0**	**+1**
Sheet	0.1010	0.5881	0.3109	0.1034	0.5862	0.3103
Blanket	0.1519	0.1747	0.6734	0.16	0.18	0.66
Mattress-cover	0.0252	0.5350	0.4398	0.0233	0.5349	0.4419
Bedspring-cover	0.0485	0.4438	0.5077	0.0417	0.4583	0.5
Pressure cooker	0.0937	0.1834	0.7229	0.1111	0.2222	0.6667
Beater	0.2214	0.2035	0.5751	0.2292	0.2083	0.5625
Plastic boxes	0.0437	0.3903	0.5659	0.0417	0.3958	0.5625
Bags-holder	0.0559	0.5258	0.4183	0.0606	0.5152	0.4242
Blood press. gauge	0.1469	0.3989	0.4542	0.1765	0.3824	0.4412
Electrical cables	0.1138	0.4769	0.4093	0.1087	0.4783	0.4130

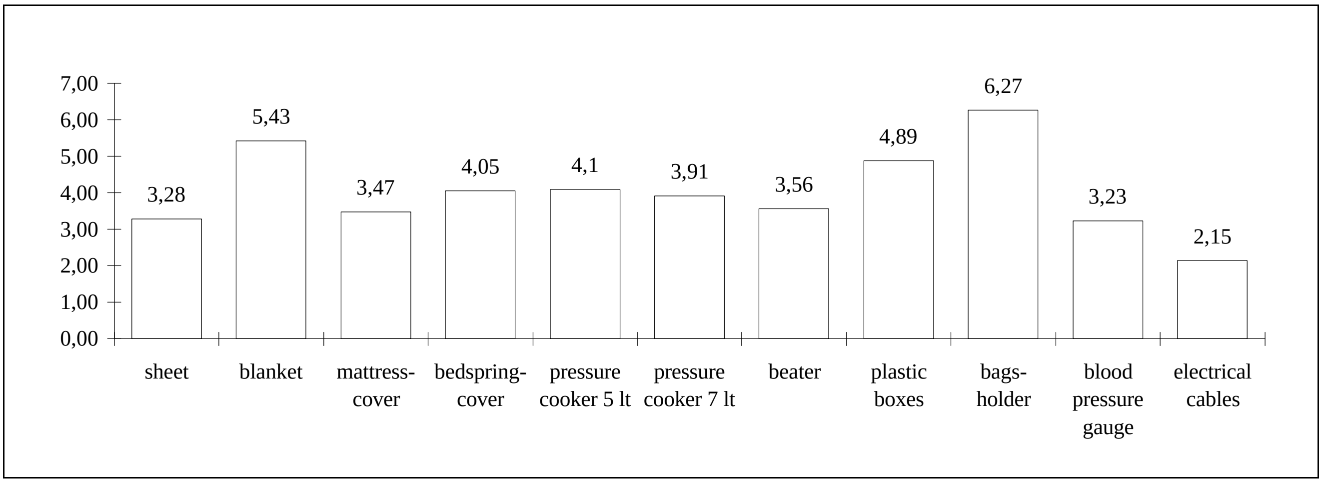

Fig. 1: Average nominal price change rates

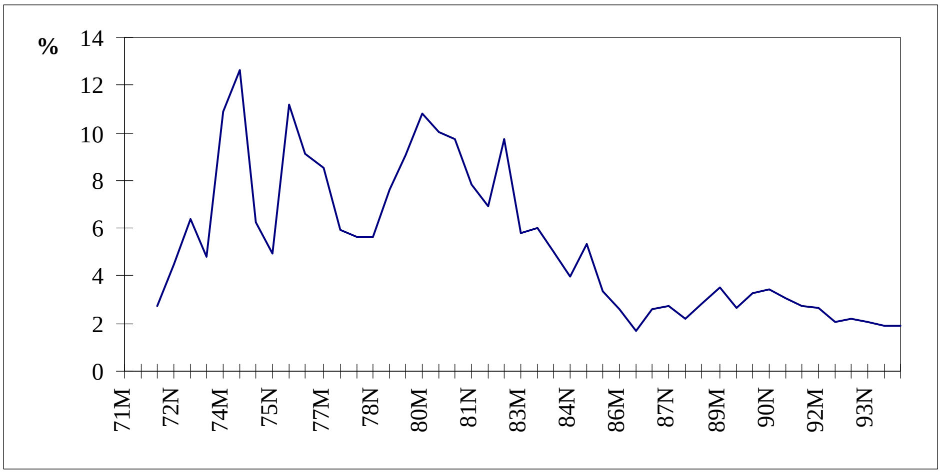

Figure 2: Inflation rate, Italy 1971-1994

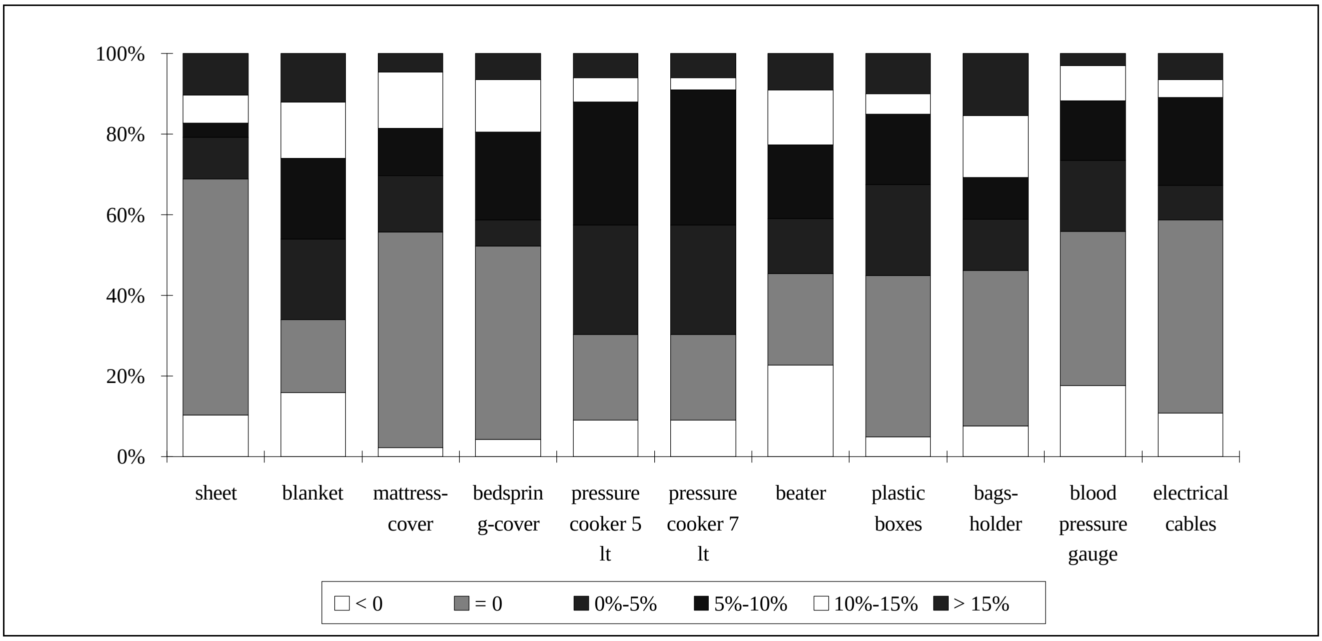

Fig. 3: Price change rate distribution

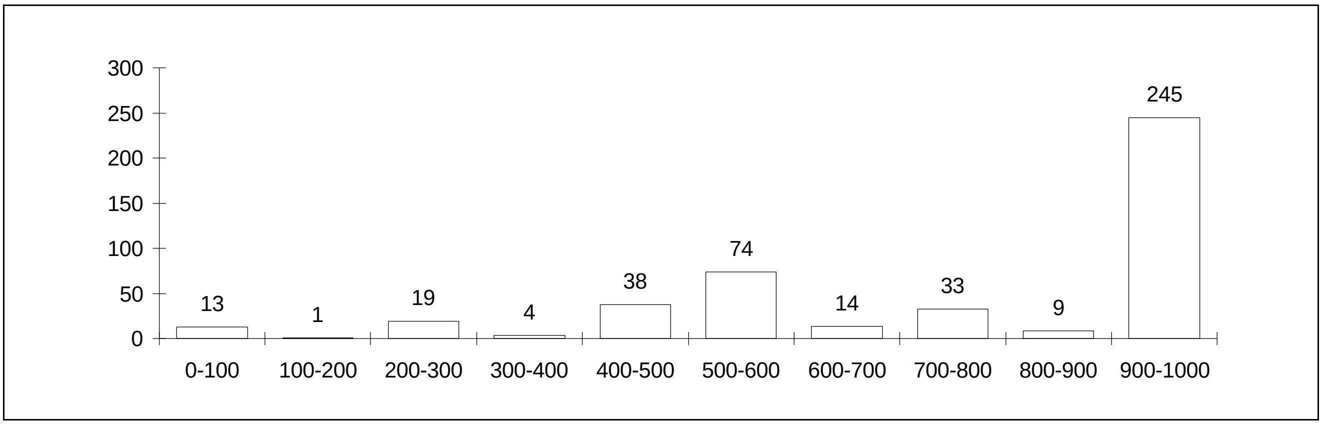

Fig. 4: Frequency of *price points* (Italian Lire)

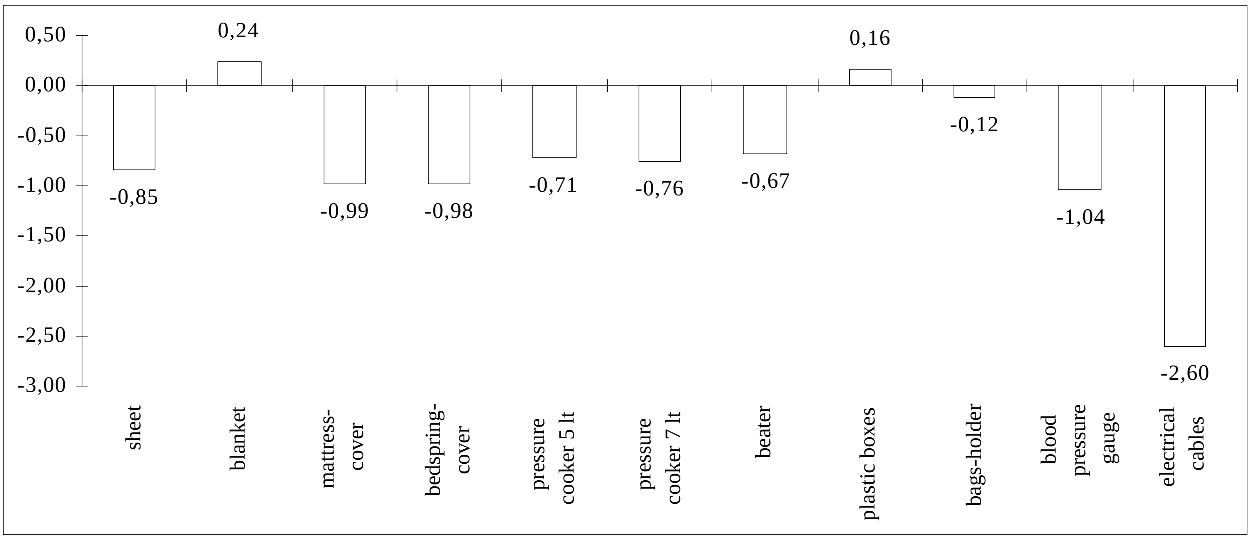

Fig. 5: Average change rates of real prices