The Dynamics of Pricing Points*

ATTILA RATFAI†

Central European University

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Abstract

This paper documents the distribution of pricing points in Hungarian retail stores. Psychological pricing points of 9 and 99 are rare; other attractive price endings are common elements of price setting. Nominal price changes tend to take the form of multiples of 10.

Key words: Retail Price Endings, Microeconomic Evidence

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† Department of Economics, Central European University, Nador u 9, Budapest 1051, Hungary, Email: ratfaia@ceu.hu

1 INTRODUCTION

A large number of empirical studies have documented long periods of inaction followed by intermittent adjustment in nominal prices[1]. Indeed, inaction in nominal prices is one of the cornerstones of many monetary models of business cycle fluctuations[2]. As demonstrated by Ratfai (2003b), lumpiness in price setting is also important in accounting for short-run inflation dynamics. One of the unexplored potential explanations for price stickiness in the macroeconomics literature is the presence of pricing points, that is the tendency of retail prices ending in special numbers, such as 0, 5, 9, 90, 99 etc. Though the theme has been popular in the marketing literature, economists have not been able to come up with a convincing and robust explanation relating pricing points to standard notions of price rigidity.[3]

Better understanding the nature of pricing points is important from the perspective of economic policy as well. In particular, the widespread fears that the changeover to the Euro in 2002 in the European Monetary Union would fuel inflation originated from the presumption that psychological and other pricing points could serve as focal points in

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[1] See for example Cecchetti (1986), Dutta *et al* (1999), Kashyap (1995), Ratfai (2003a), Wolman (2000).

[2] See for instance Ball and Mankiw (1994), Rotemberg (1987).

[3] See Huston and Kamdur (1996) and Kashyap (1995). Basu (1997) and Shy (1999) offer game theoretic explanations for the prevalence of pricing points.

resetting prices after the conversion to the new currency.[4] As the accession countries joining the European Union in 2004 are set to join the EMU in the near future, confronting the issue of pricing points will soon become vital for policymakers in these countries as well.

Pricing points are often interpreted as upper limits of price ranges within which consumers fail to react to price changes. Informal theories in which demand is kinked at pricing points, stopping firms from adjusting prices instantaneously when pricing shocks are not too large are summarized in Blinder *et al* (1998). To learn about the extent, to which pricing points are important components of price setting policies at the retail level, this paper examines price endings in a unique store level panel of Hungarian product prices. The data analysis based on a sample of processed meat product prices utilized in Ratfai (2003a), focuses primarily on documenting the distribution of one-digit and two-digit pricing points and price changes. By relating the dynamics in pricing points to calendar time and observable cost shocks, the paper examines dynamic aspects of pricing points as well.

The remainder of the study proceeds as follows. Section 2 summarizes the literature providing the background to the analysis. The data set is described in Section 3. Section 4 presents the results, while Section 5 concludes.

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[4] For evidence on the inflationary effect of the introduction of the Euro, see Folkertsma (2002) and Mostacci and Sabbatini (2003).

2 BACKGROUND

2.1 Theory

There exist a host of related explanations to rationalize the observation that price endings are often concentrated to a small number of digits. Most of these explanations however tend to posit some form of irrational behavior on the part of consumers, typically their inability to read or understand the last digits of prices, perceiving them as being zero.

The economic argument for the presence of pricing points starts out from the presumption that demand fails to react to a price change when the latter does not exceed a certain range.[5] One of the few formal economic explanations for the presence of psychological price endings such as 9 or 99 is offered in Basu (1997). In his model, consumers ignore the last two digits of the price when purchasing goods and services; instead, they associate the last two digits of the price with the mean cent component of all goods in the marketplace. Demand is then determined by the integer dollar component of the price. Given this characterization of demand and the assumption of a large number of goods supplied by a large number of monopolists, an individual seller may change the cent component of its total price without affecting the average of cent components. Thus in the unique Nash equilibrium, all sellers add the maximum number of cents to the integer component of the price. As all goods are priced at exactly 99 cents, consumers are

[5] Notice that the explanation is complementary to the spirit of (S,s) pricing models in which stores alter their nominal price and pay the fixed cost of adjustment only when the difference between the target and the actual price level is sufficiently large by exceeding some threshold values.

correct not only on average but they have rational expectations in each individual case as well.[6]

2.2 Empirics

The presence of psychological and other pricing points has been documented earlier in other related studies. In the economics literature, early studies highlighting the importance of pricing points are Friedman (1968) and Ginzberg (1936). The idea was emphasized again in an influential paper by Kashyap (1995), focusing on the characterization of various aspects of the pricing policies of mail-order catalogue companies, and relating the empirical findings to leading theories of price stickiness. After concluding that none of the standard models of price setting provide an adequate explanation of pricing patterns in the data, based on his conversions to store managers, Kashyap argues and presents some evidence for pricing points being part of the explanation for microeconomic price rigidities.

Examining the incidence of price endings in a large Mid-Western supermarket chain, Levy, Bergen and Chen (2003) find that retail price endings of 9-cent *and* price changes of multiples of 10 cents are absolutely dominant. They argue that the findings are consistent with a theory of rational price setting based on consumers' reluctance to gather and process all the costly information on prices available. If it is more costly to process multi-digit numerical information, such as price tags from left to right, and if the benefit of processing price information declines from left to right, people may rationally ignore the last digits in prices. Consequently, stores have an incentive to set the last digits

[6] See Shy (2000) for a related model.

of prices as high as possible, typically making it equal to 9 or 99. The reasoning results in two specific predictions. First, price endings of 9 should be dominant among all one-digit price endings, and price endings of 99 should be dominant among all two-digit price endings. Second, price changes of multiples of 10 such as 10, 20, 30 etc. should be dominant among all nominal price changes.

While the early literature on pricing points has focused mostly on US retail price data, more recently evidence from other countries has started to accumulate. First, Fengler and Winter (2001) study the incidence of psychological pricing in a sample of retail prices collected in Germany in 1995. In a set of fast-moving consumer goods belonging to 79 different product categories, they document that price endings are distributed highly unevenly; indeed, 80 to 95 percent of the observations feature psychological price endings. In a detailed analysis of a particular product, vacuum-packed ground coffee, they also document the time variation in the various price endings.

Mostacci and Sabbatini (2003) examine the inflationary impact of the changeover to the Euro in Italy, as associated with price ending effects. They distinguish two categories of 'attractive prices' to which rounding off takes place. They define 'psychological' prices as ones ending with 9, 90 or 95 cents, and 'exact prices' as ones with any one-digit endings of 0 or 5 cents below 5 Euro, or two-digit endings of 00 or 50 cents above 5 Euro. Mostacci and Sabbatini find that the adjustment to the new rounded Euro prices was gradual. Initially, in January 2002 attractive prices were only 20 percent of all prices. However, by the end of the sample period, October 2002 the frequency of attractive prices increased to 52 percent. The share of psychological pricing points remained relatively constant over time, while exact prices became prevalent. Mostacci

and Sabbatini also show that the inflationary impact of price rounding was especially pronounced in services, at more traditional outlets, and in relatively more developed regions of the country.

Examining survey evidence of price endings of retail prices before and after January 2002 in the Netherlands, Folkertsma (2002) finds a muted impact of the introduction of Euro through price endings on inflation. He also documents that at the beginning of the Euro era, inflation as perceived by consumers was significantly higher than actual inflation.

3 DATA

The focus of the current study is on a detailed panel data set of store level consumer prices of various processed meat products first explored in Ratfai (2003a). The sample includes monthly frequency observations of prices of fourteen processed meat products[7] observed in nine continuously operating, distinct and geographically dispersed stores in Budapest, Hungary. Out of the nine stores six are larger department stores and three are smaller grocery stores, called Közért. Stores sell many other products besides the ones considered here. Importantly, whenever data collectors visit a particular store, all the fourteen prices are available and recorded.

[7] The items are listed in Table I.

The sample period runs from the beginning of 1993 until the end of 1996 and splits into two parts due to a five-month long intermission in data collection in 1995. The first part of the sample (referred to as *Period 1*) starts in 1993:1 and lasts until 1995:3, thus covers a total of 27 months. The second part (*Period 2*) starts in 1995:9, lasts until 1996:12 and covers a total of 16 months. The sample is unbalanced: the number of months with non-missing observations for a particular store ranges from 31 to 43 with an average of 38.22. The average number of stores actually observed in a month is 8.01. The total number of store-product-month specific observations is 4816, 2968 in Period 1 and 1848 in Period 2.

The market structure of stores in the sample was relatively stable and their identity did not change over time. Stores can be best thought of as operating in a monopolistically competitive market environment. First, they tend to serve customers living in their geographical proximity. Persistency in price dispersion indicates that the market power of stores is not threatened by deviating from the price set by potential competitors. Second, this monopoly power is far from absolute as the size of an individual store is small compared to the total size of the market.

The specific products involved constitute an especially attractive object of examination. First, they are important[8], well-identifiable, homogeneous food products with insignificant variation in non-price characteristics across stores and over time. Therefore, actual pricing actions (or the lack of them) do not reflect changes in

[8] Being standard food items in Hungary, processed meat product purchases constitute a significant portion of aggregate spending. The Central CSO uses a 5.69% weight for processed meat items in computing the CPI.

underlying product attributes. Second, throughout the sample period there was no government control of the product prices involved. Third, price stickiness in processed meat product prices is unlikely to overestimate the degree of economy-wide stickiness. As the products involved tend to have a relatively low value added in production, their prices can *a priori* be thought of as being highly dependent on raw material prices and thus relatively more volatile. Fourth, artificially induced price rigidities such the ones present in catalogue prices are unlikely to contaminate the data (cf. Kashyap (1995)).

4 RESULTS

Nominal prices are measured in Hungarian Forints. Price levels in the sample range from 133 to 1479, with a mean of 431.5, a median of 395 and a standard deviation of 190. Ratfai (2003a) provides a detailed non-parametric descriptive analysis of the data, here it is instructive to briefly highlight some basic findings therein. First, nominal prices remain constant in 58 percent of the cases and the average duration of price quotations is about three months with the longest spell being 17 months. With the exception of months in the third quarter when the relevant raw material prices happen to spike, spells of adjustment are spaced irregularly across stores. The duration of price changes within stores is fairly dispersed over time, while contemporaneously it tends to be more synchronized.

The size of price changes is relatively homogenous across stores and products. The average size of non-zero price changes is about 9 percent in the whole sample, with the largest size being about 63 percent. The average size of positive changes is 10.85

percent in period 1 and 11.73 percent in period 2. Average negative changes are smaller: -8.24 percent in period 1 and -7.32 percent in period 2.

The frequency of pricing points in nominal price levels is documented separately for one-digit and two-digit price endings. First, Figure 1 shows the distribution of one-digit price endings for all products and stores in the sample. The results indicate that 45.1 percent of the prices end by 0, 11.7 percent end by 5 and only 19.6 percent end by 9. If pricing points are restricted to the psychological price endings of 9, one can conclude that the concept of pricing point is hardly present in the sample. If pricing points are however defined more broadly, including the 'exact' price endings of 0 and 5 as well, then 'attractive' price endings become dominant, constituting a total of 76.4 percent of observations. While the distribution of one-digit price endings is highly uneven, the findings stand in stark contrast of results documenting the absence of 'exact' and the prominence of psychological price endings of in Levy, Bergen and Chen (2003) and Fengler and Winter (2001). At the same time, they are analogous to the results reported in Mostacci and Sabbatini (2003).

To summarize the dynamics in one-digit price endings, Figure 2 plots the time series of the price endings of 0, 1, … and 9. The graph demonstrates the prominence of the price endings of 0, 5 and 9 again. At the same time, it shows that price endings of 0 are losing importance over time. Peaking in May 1996, they steadily decline over time to reach the bottom by the end of the sample, December 1996. In contrast, the incidence of price endings of 5 gradually increases, while price endings of 9 gain substantial ground over time. Indeed, by the end of the sample period, price endings of 9 outnumber price endings of 0. Given the accelerating economic growth in the mid-1990s in Hungary, after

the transformational recession in the early years of the decade, this is not so surprising. Higher income is likely to reduce the net benefits of processing the last digits of prices for consumers, thus giving rise to more frequent price endings of 9.

To provide evidence on their relative incidence, Figure 3 plots the frequency distribution of two-digit price endings. As expected from the findings on one-digit price endings, the dominant two-digit pricing points are of multiples of 10. Price endings of 00 are the most frequent ones; they take place in about 16 percent of the cases. What is surprising is that the next two most frequent two-digit price endings are 09 and 05, taking place in 10.4 and percent of the cases, respectively. These are followed by the nine multiples of 10 (10, 20, …, 90, in no systematic order) with relative frequencies distributed relatively evenly between 2.85 and 4 percents. Then the number of 08 is ranked at thirteen, just preceding 99, the latter being at fourteen! Overall, and this is really puzzling, price endings from 01 to 09 are much more frequent, comprising of 41.03 percent of two-digit price endings than the ones will all the 9 endings of 19, 29, …, 99, making up only 9.12 percent of the cases.

The final set of evidence concerns the last digits in nominal price changes. The size of price changes ranges from –346 to 227, with a mean of 9.31. Figure 4 depicts the frequency distribution of the last digit of non-zero nominal price changes. First, price endings of multiples of 10 (10, 20, …, 90) stand out as the most common price change endings, taking place in 51.9 percent of the cases. The other digits are about equally frequent, with endings of 5 being slightly more common (10.86 percent) than the other ones. These findings are consistent with prior evidence reported in Levy, Bergen and

Chen (2003): by representing 35.1 percent of all cases, price change endings of multiples of 10 are actually less common in their sample than here.

Finally, it is instructive to compare the temporal evolution of the most frequent price endings of 0 to the in-sample monthly inflation rate. To do so, Figure 5 plots the time series of both variables. Visualizing the resulting graph suggests that the two variables be strongly positively correlated, especially in Period 1. The corresponding partial correlation coefficient of 0.58 indeed confirms this presumption.

5 CONCLUSION

One of the unexplored explanations for price stickiness is the presence of pricing points, that is the tendency of retail prices ending in 5, 0 or 9. This study explores the nature of pricing points in nominal price levels and price changes, and relates the dynamics in them to time and observable cost shocks in a panel of retail prices in Hungary. While it finds some evidence for the presence of psychological price endings traditionally defined as 9 or 99, the paper shows that 'exact' prices, especially multiples of 10 are particularly important components of nominal price levels *and* nominal price changes. Though the latter finding gives support to a bounded rationality type explanation of price endings, the first one clearly constitutes a puzzle.[9] At the same time, if they are interpreted broadly as including all price endings with last digits of 9, 5 and 0, 'attractive' pricing points are

fundamental elements of nominal price levels in Hungary. To quantify additional implications of pricing points for aggregate inflation, further research is needed in a richer sample of prices with a broader set of product categories and more stores involved.

[9] Notice however the current results are based on retails prices observed in a relatively small number of stores of relatively small number of products.

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Table I

Products in the Sample

Abbreviation	Name
rk	Boneless Chop
hk	Center Chop
sc	Leg
so	Back Ribs
sd	Thin Flank
mf	Round
mr	Roast
msz	Brisket
vi	Hot Dog
lk	Sausage for Boiling
sl	Shoulder
st	Spare Ribs
esz	Fat Bacon
fft	Smoked Loin/Ham

Note: Products are narrowly defined items according to size, brand, type and flavor.

Figure 1 - Frequency Distribution of Price Endings – 1 digit

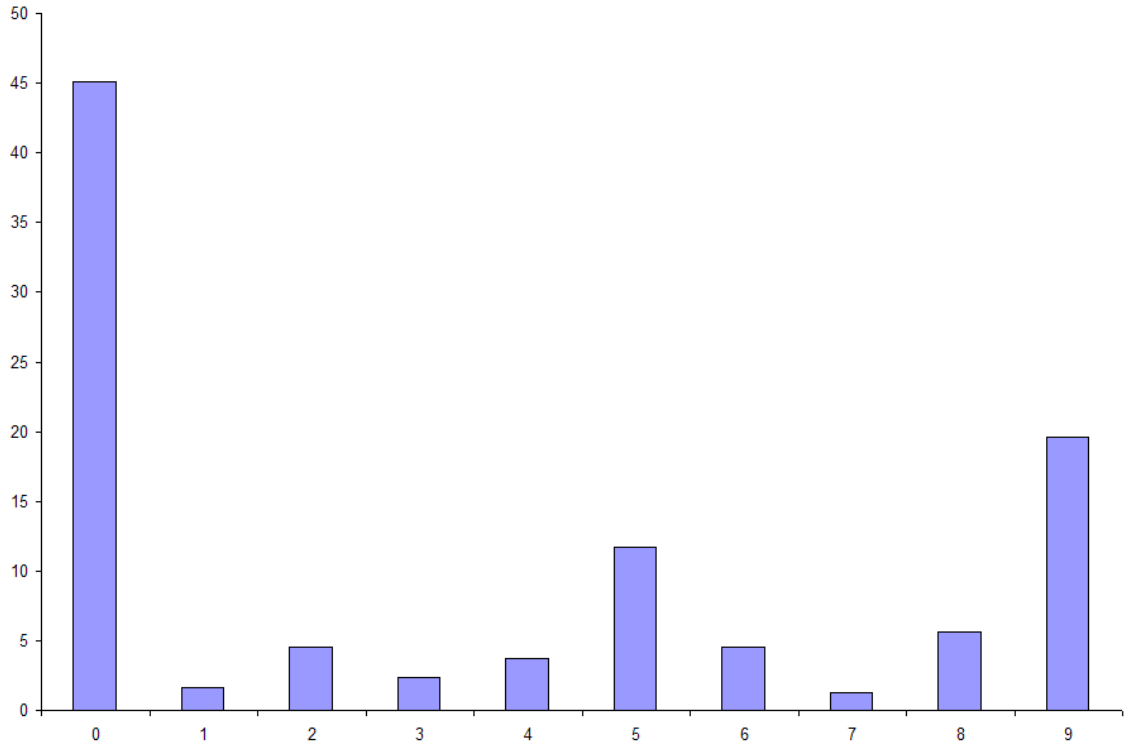
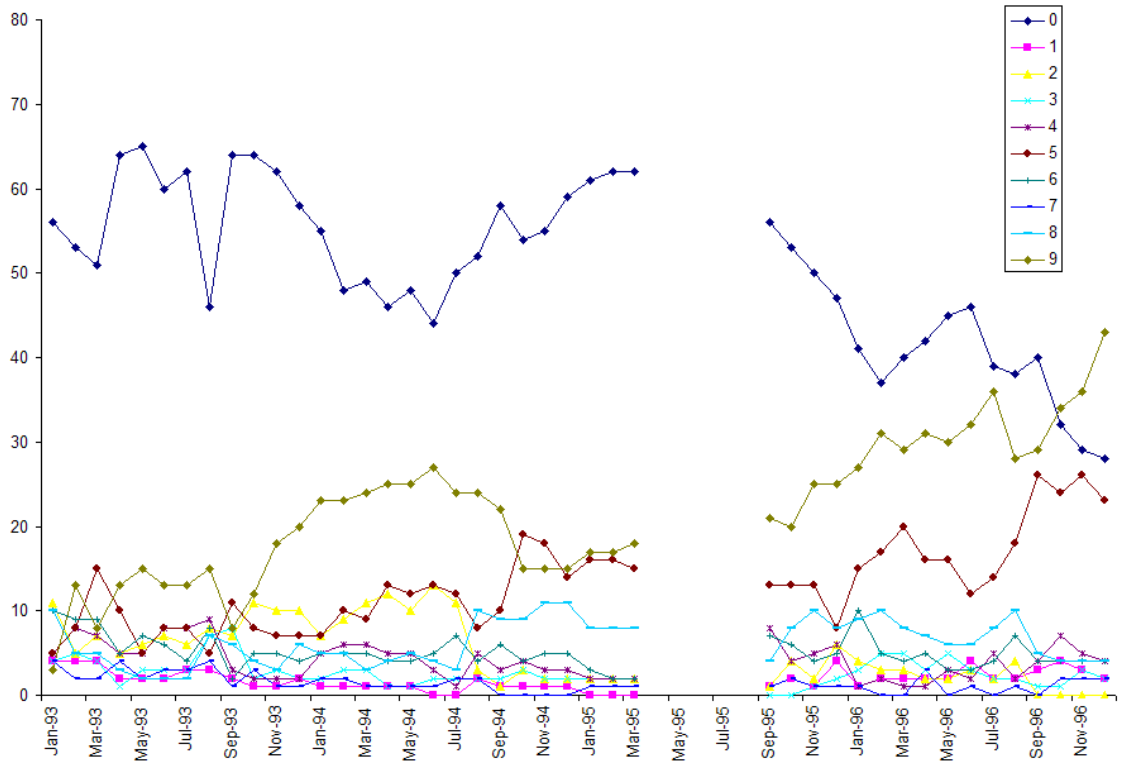


Figure 2 – The Time Path of Price Endings – 1 digit



Note: The number of particular price ending in a given month is on the vertical axis.

Figure 3 – Frequency of Nominal Price Endings – 2 digits

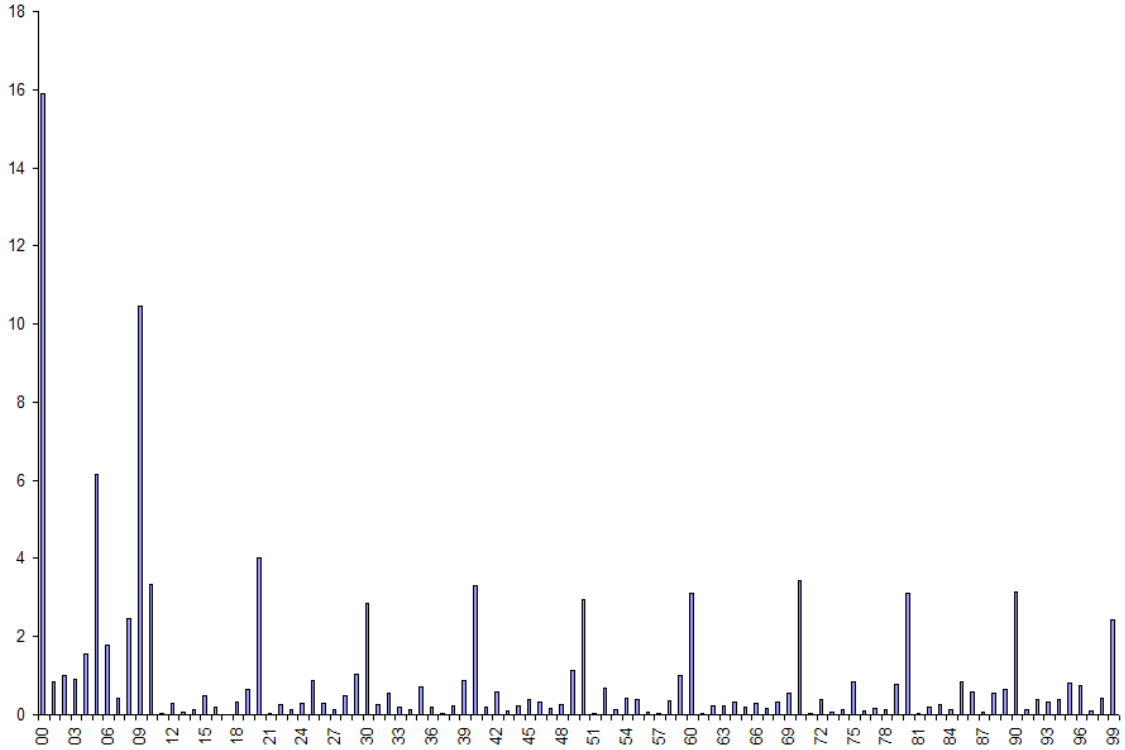


Figure 4 - Frequency Distribution of Nominal Price Changes

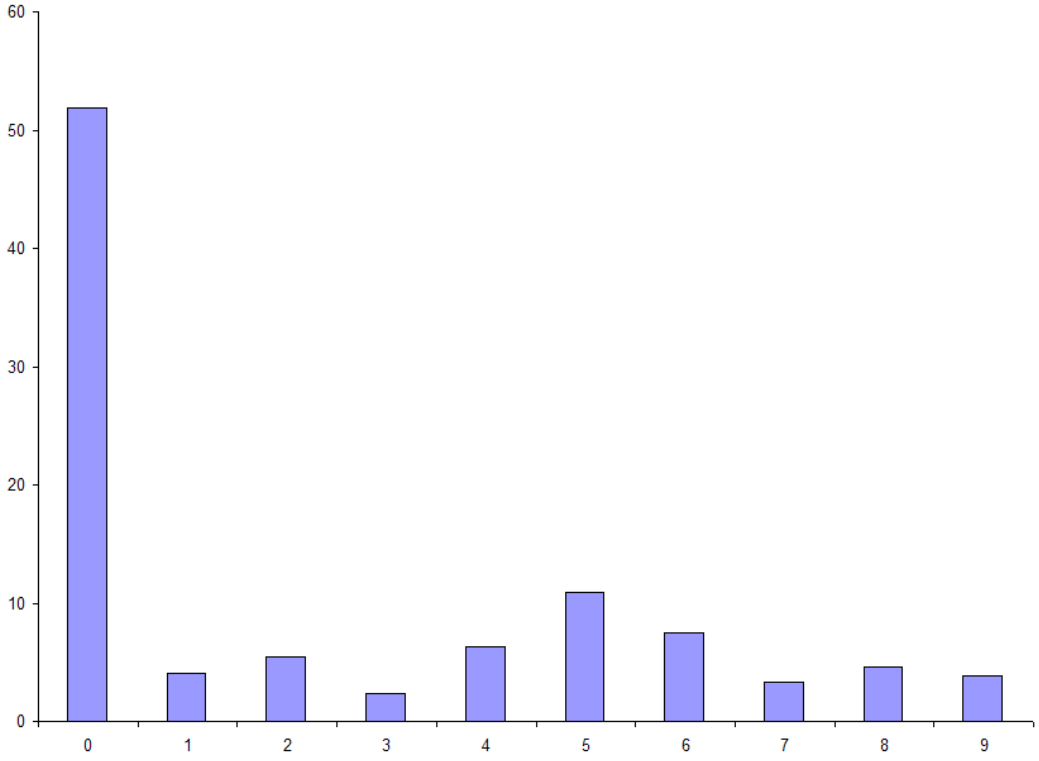
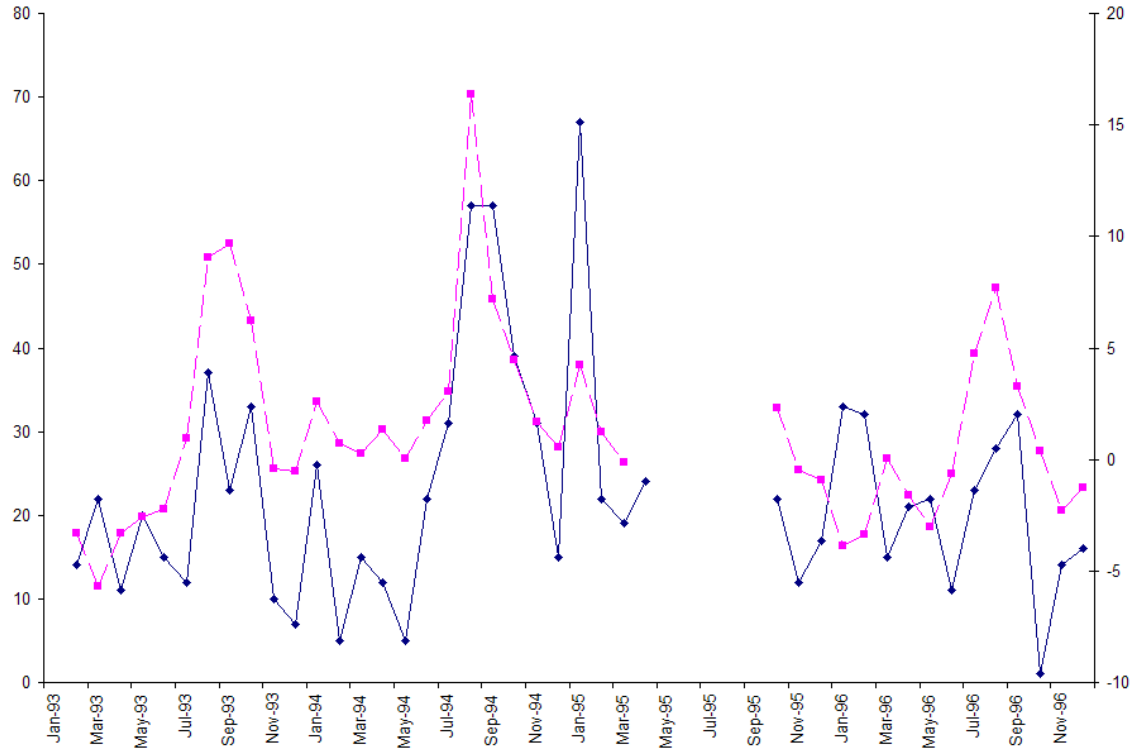


Figure 5 - Nominal Price Changes of Multiples of 10



Note: The solid line represents monthly sample inflation (right axis). The dashed line represents the number of price changes of multiples of 10 such as 10, 20, 30 etc (left axis).