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The importance of attractive prices in pricing dynamics

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Suomen Pankki
Bank of Finland
P.O.Box 160
FI-00101 HELSINKI
Finland
☎ + 358 10 8311

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Ville Aalto-Setälä* – Robert M. Schindler**

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* Bank of Finland and National Consumer Research Center
** Rutgers University, Camden

http://www.bof.fi

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Ville Aalto-Setälä – Robert M. Schindler
Monetary Policy and Research Department

Abstract

Nominal rigidities have an important role in macro models used for the analysis of monetary policy. Recently, attractive prices (also known as price points) have often been referred to as one important potential explanation of nominal rigidities. An increased interest on attractive prices as an explanation for price rigidities rests on online pricing, in the context of which it has been shown that prices are rigid also on the internet, where physical costs are not important. Our empirical analyses using micro data on consumer prices in Finland indicate that a specific form of attractive prices – 9-ending prices – have a considerable effect on pricing dynamics. The results of the study show that changes to prices with 9 endings are more often decreases than are changes to prices with other endings. Price changes to 9-ending prices are also of smaller size than are changes to other endings.

Key words: rigidity, price endings, attractive prices, 9-prices

JEL classification numbers: E42, D01

Houkuttelevien hintojen merkitys yritysten hinnoittelustrategiassa

Suomen Pankin tutkimus
Keskustelualoitteita 30/2006

Ville Aalto-Setälä – Robert M. Schindler
Rahapolitiikka- ja tutkimusosasto

Tiivistelmä

Nimelliset jäykkyydet ovat tärkeä tekijä rahapolitiikkaa analysoivissa makrotaloudellisissa malleissa. Houkuttelevien hintojen käyttö on viime vuosina noussut yhdeksi tärkeäksi nimellisiä jäykkyyksiä mahdollisesti selittäväksi taustatekijäksi. Mielenkiinto houkuttelevia hintoja kohtaan on viime aikoina kasvanut lähinnä siksi, että tutkimustulokset viittaavat myös Internetissä käytettävien hintojen olevan jäykkiä, vaikka niiden muuttamiseen ei juuri liity kustannuksia. Suomen kuluttajahintojen mikroaineiston empiiriseen analyysiin perustuvat tulokset osoittavat, että tietyillä houkuttelevilla eli 9-loppuisilla hinnoilla on huomattavia vaikutuksia hinnoitteludynamiikkaan. Hintojen muutokset 9-loppuisiksi ovat useammin hinnanlaskuja kuin muutokset muilla numeroilla loppuviksi hinnoiksi. Hintojen muutokset 9-loppuisiksi ovat myös pienempiä kuin hintojen muutokset keskimäärin.

Avainsanat: hintajäykkyys, houkuttelevat hinnat, 9-loppuiset hinnat

JEL-luokittelu: E42, D01

Contents

1 Introduction

Nominal rigidities play an important role in today's modern macroeconomic models used for the analysis of monetary policy. Nominal rigidities are a crucial element for many mainstream models of business cycle fluctuations, precisely because nominal frictions allow for monetary policy to have an effect on inter-temporal decisions of households and firms, and thus to the short-term fluctuations in aggregate demand and supply. Modern mainstream macroeconomic models are based on the principles of dynamic optimization, so that nominal rigidity must be consistent with an equilibrium outcome for the decision problems of the firms and households. Microeconomic foundations of nominal rigidities are thereby lifted to an integral part of the dynamic optimization problems faced by the agents in these models.

Literature offers several potential theoretical explanations for price rigidities. The most prominent explanations are related to informational frictions (Lucas, 1972), staggering of contracts (Fisher, 1977), costs of price adjustment (Mankiw, 1985), and near-rationality (Åkerlof and Yellen, 1985). In contrast to these more or less traditional sources of price rigidities, attractive prices (aka price points or 9-endings) have recently been referred to as one potential explanation of nominal rigidities (Blinder et al, 1998; Kashyap, 1995)[1]. One reason for the increased interest on attractive prices as an explanation for price rigidities rests on online pricing: it has been shown that prices are rigid also in the internet where physical costs, or menu costs, are not important (Chakrabarti and Scholnick, 2005). Another obvious reason is that certain digits remain over represented in the price data (Friedman, 1967; Anderson and Simister, 2003; Schindler and Kirby, 1997; Aalto-Setälä and Halonen, 2004; Schindler and Bizer, 2005). For example, in grocery retailing in the US, it has been found that as much as 80 per cent of prices end in 9 (Wisniewski and Blattberg, 1983). In Finnish grocery retailing, the number '9' accounted about 70% of all observations as a second last digit of the price in markka era (Aalto-Setälä and Halonen, 2004).

Economic rationale for pricing points typically rests on the assumption that there is some upper limit of price ranges within which consumers do *not* react to price changes. Consumer's inattentiveness in turn can be due to the consumer's limited capacity to process information. For instance, consumers may ignore the

[1] There are also views that pricing dynamics and thus also rigidities may have changed during the couple of last decades. According to Willis (2003) costs of price adjustment have decreased. First, because of scanner technology the costs of implementing new prices are lower. Second, the information and managerial costs associated with pricing decisions are lower due to the development of information technology. Further, global competition has decreased mark-ups and, thus, firms need to be ready to respond faster than earlier to changes in market situation. (Gordon, 1990).

last digits of the prices. This inattentiveness of consumers gives rise to kinked demand curves at pricing points. The natural reaction of firms is to limit the adjustment of prices instantaneously when pricing shocks are not too large.[2] As a result, prices appear unresponsive to changes in the economic environment and thus contribute to price rigidity. Similar kind of behavior can be generated in the (S,s) pricing models,[3] but clearly the economic rationale for price rigidity is very different. In (S,s) pricing models firms face fixed pricing costs. They change the nominal price and pay the fixed cost of adjustment only when the difference between the optimal price and the actual price is sufficiently large.

Basu (1997) provides a rationale for commonly observed 9 or 99 pricing. In his model, all the firms add the maximum number of cents to the integer component of the price in the monopolistically competed markets. This is because consumers simply ignore the last two digits of the price, say, 9 or 99. His model is a specific example where the firms directly exploit the consumer's limited capacity to process information.

This study examines attractive prices and particularly the impact of attractive prices on dynamics of pricing. We also provide some new results about the relationship between price rigidity and attractive prices. The recent conversion in Europe from national currencies to the euro has presented an opportunity to examine attractive prices and pricing dynamics in greater detail. Although the currency change did not immediately affect retail price levels, it entirely disrupted the common patterns previously observed in the use of price points. In this study, we make use of the transition from a national currency to the euro as an opportunity to observe the natural 'evolution' of 9-ending pricing. In an environment where there is fluidity between the use of prices that end in 9s and those that end in other digits, it becomes possible to address the issue of how 9-endings affect price increases and decreases. Indeed, one limitation of the past studies of attractive prices is that they have largely relied on cross-sectional data. With cross-sectional data it is possible to study only the incidence or effects of 9-endings on concentration of prices at a particular point in time. Another shortcoming is that many retail categories or retail outlets have stable or very high proportions of 9-ending prices. The lack of transitions between 9-ending and other-ending prices in such situations makes it difficult to observe the effects of price endings on price changes. The currency change and the time series dimension of the data used in this study provide a unique possibility in this respect.

Our analyses indicate that attractive prices have a considerable effect on pricing dynamics. The results of the study show that changes to prices with 9

[2] See Blinder et al (1998) for a review of different explanation for price rigidities.

[3] Seminal articles on (S,s) pricing include Arrow, Harris and Marschak (1951), Barro (1972), Sheshinski and Weiss (1977, 1983). Extensive research of pricing behavior of firms has been conducted at the European Central Bank within Inflation Persistence Network.

endings are more often decreases than are changes to prices with other endings. Price changes to 9-ending prices are also of smaller size than are changes to other endings. We examine the suggested reasons for over-representation of 9 endings: *sticky-price, just-below-price*, and *attractive-price paths.* The price data do not strongly support any of the suggested reasons for 9 endings.

The rest of the study is organized as follows. Chapter 2 reviews the literature and Chapter 3 describes the data. Chapter 4 presents statistical evidence on over-representation of certain digits and discusses the adjustment of attractive markka prices to attractive euro prices. Chapter 5 examines the impact of attractive prices on pricing dynamics. Chapter 6 concludes.

2 Literature review

Previous empirical studies concerning the importance of nominal values in pricing clearly show that retailers do use certain prices much more frequently than others. This tendency was discovered already a long time ago (Rudolph, 1954; Twedt, 1965; Kreul, 1982). The result was that numbers '0', '5' and '9' were used as the rightmost digit of a price much more often than chance would predict.

More recently Schindler and Kirby (1997) examined price advertisements in 43 US newspapers. They found that the rightmost digit of the prices was far from uniformly distributed. The number '9' occurred as the rightmost digit in 31%, the number '0' in 27%, and the number '5' in 18.5% of all observations. Folkertsma (2002) studied the distribution of prices in the price data used Statistics Netherlands to compute the consumer price index. The sample contains 72 000 prices for 1516 different articles. The number '9' occurred as the rightmost digit in 31% and '0' in 24% of the prices in the data. In addition, 12% of the prices are fractional. Folkertsma defines fractional prices as 'amounts that are convenient to pay', such as 2.50 NLG or 4.75 NLG. Payments of these amounts require few coins and only one coin or none in change.

Aalto-Setälä and Halonen (2004) show that the situation was different in Finland during the markka period. For example, in grocery prices the number '9' was used in some digit of the price (normally as a second last) but not as a last digit. I fact, vast majority (more than 90%) of Finnish grocery prices ended up with the number '0'. Our study shows (see Figure 2) that during the euro period situation in Finland has adjusted to be about the similar as, for example, in the US.

Further, Aalto-Setälä and Halonen (2004) extended the topic of rightmost digit and examined the entire price distribution in the automobile and grocery markets. The data sets are from Finland, Sweden and the Netherlands. They show that prices concentrate heavily to numbers that fall somewhat below round prices. However, prices are not normally set at the smallest possible distance from round

prices. For example, a price like 29 500 in automobiles or 5.90 in groceries is much more common than 29 999 and 5.99, respectively. Another attractive price type includes 5-prices with round endings (like 25 000 in automobiles or 5.50 in groceries). Consequently, these observations do not provide unambiguous support to Basu's (1997) model, according to which monopolistically competitive firms would always add the maximum number of cents to the integer component of the price.

Schindler (2001) carried out an analysis of cross-sectional data on price levels as a function of price ending. He found that, for a given retail item, prices ending in the digit 9 were on the average higher than prices for the same item that ended in digits other than 9. Although this finding could be useful to shoppers, it does not indicate that the difference in the level of prices is due to the use of 9 endings. It could simply be the case that higher-priced retailers are more likely to choose to use 9 endings than are lower-priced retailers.

The question of how the retailer's tendency to favor 9-ending prices affects the level of prices depends on the path by which the price setter arrives at a 9-ending price. One possible path is that 9-ending prices result from price increases tending to stop at 9-ending prices in order to avoid increasing the price's left digits and creating high consumer awareness of and/or response to the price increase. This involves the concept of 'sticky prices'. Blinder et al (1998) expressed this idea as follows:

> 'The idea is that certain prices – such as round numbers – have such psychological significance to consumers that they form a kind of barrier against price increases. So prices get 'stuck' at numbers like $9.99 or $29.95, rather than move up to, say, $10.32 or $31.43. Such barriers can be breached, of course; but it takes more than the usual stimulus to do so. In that sense, pricing points can be a source of price stickiness (Blinder et al, 1998, p. 175).'

In the sticky-price path, 9-ending prices would tend to be lower prices than the retailers would ordinarily charge. The stickiness of the perceived price barrier would hold the 9-ending price back to a level lower than what would otherwise have been charged. In other words, if sticky price path holds, price changes to 9-ending prices are *smaller* than changes to prices ending with other digits. Another implication of sticky price path is that price changes to 9-ending prices come from downwards. We test this in the empirical analysis by calculating the typical size of a price change and change direction to 9-ending prices based on the last digits.

A second possible path is that 9-ending prices are dropped from a higher price, perhaps even the immediately higher 0-ending price, in order to make the price more appealing to the customer. Such greater appeal could be due to the lowering of the leftmost digit (Thomas and Morwitz 2005) or to the possibility that a consumer might perceive a small gain, such as when a price of $29 is

interpreted as involving a $1 discount from $30 (Schindler and Kirby, 1997). This price path involves lowering the price until it is 'just-below' a price threshold. For example, Gedenk and Sattler (1999) have presented an analysis suggesting items priced with 0 endings are likely to become more profitable if lowered to 9-ending prices. Like the sticky-price path, the just-below-price path suggests that a retailer's use of 9-ending prices produces prices that are lower than what the retailer might otherwise charge. Another implication of the just-below prices is that most of the price changes to 9-endings are price decreases.

A third possible path involves the idea that 9-ending prices are 'attractive prices' (Folkertsma, 2002) that can exert their attractive effect in either an upward or downward direction. A savvy retailer might let himself be more susceptible to the allure of a 9-ending price when it involves a price increase than when it involves a price decrease. Or, retailers might let the immediate pricing situation determine whether to reach a 9-ending price by lowering a price to the next lowest 9-ending number or by raising it to the next higher one. In contrast to the sticky-price and just-below-price paths, the attractive-price path suggests that the use of 9 endings would either lead a retailer to set higher prices than would otherwise have been chosen or would have no net effect on a retailer's price levels. Another testable issue is the direction of price changes: if the hypothesis on attractive prices hold, price changes to 9-ending prices come symmetrically from both sides, such that we observe roughly the same amount of decreases and increases to 9 ending prices.

The effect of 9 endings on the level of retail prices is relevant to both the consumer looking for a good bargain as well as to the retail price setter, who must manage prices with very imperfect knowledge about likely consumer response and response of its competitors. To shed light on the relative importance of these three possible price paths, we look empirically at the relations between price endings and the changes that have occurred in a large number of grocery prices over a four-year period.

3 Data

The data were originally collected for calculating the Finnish Consumer Price Index (CPI) by Statistics Finland. These data comprise some 50,000 monthly price observations on individual consumer goods between 1997–2005. In this study, we concentrate only on grocery prices of the CPI data. The data cover the years 2000–2005, and thus include the euro changeover, which took place at the beginning of 2002. The data typically include 150 grocery items and 50 to 200 monthly price observations of each item. Altogether, there are about 16,000 grocery-price observations in each month.

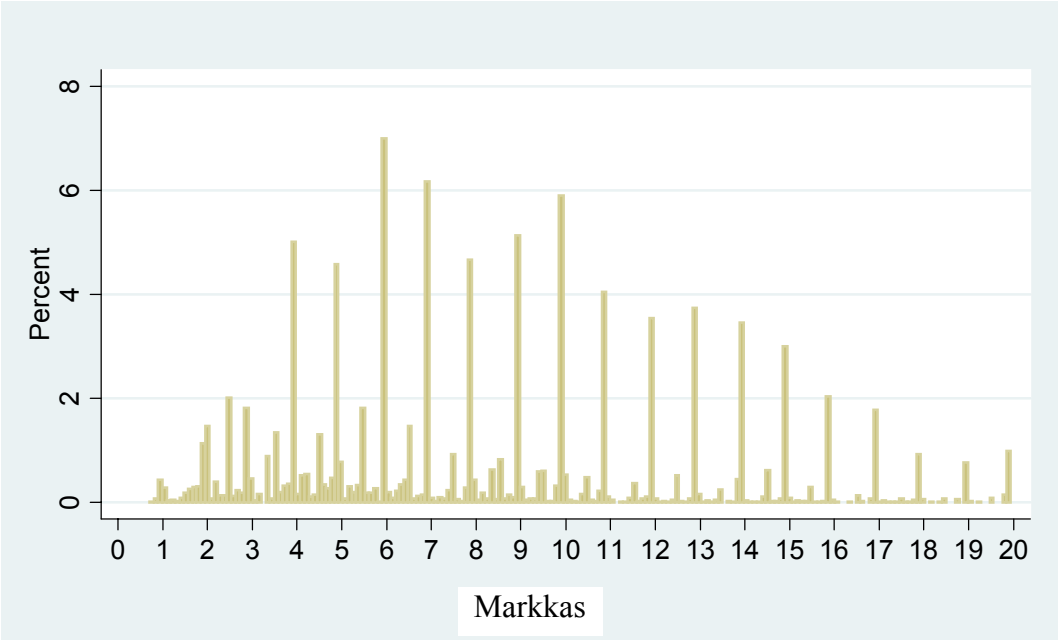
The items are strictly defined in time, but not in cross sections. For example, there are 130 observations of different spaghettis. These 130 observations include different brands (also private labels) and package sizes. However, the same brand and package size is always collected at the same store. The data are thus ideal for examining price changes over time, but it would be problematic for examining price dispersion in cross sections.

Price inspectors visit the stores to collect the data. In addition to noting an item's price, they report if the observed price is a 'normal price' or a 'sale price'. Inspectors also note if the product has been changed. In the case of grocery products the changes are very rare, but in the case of other CPI product groups – like electronics – this would be a very crucial variable.

4 Price distributions and adjustment

Figure 1 shows the marked impact of nominal values on the distribution of prices in markkas one year before the euro changeover in January 2001. The figure is a histogram indicating each 10-penny interval's share of all observations. The high bars in the figure are all prices ending with 90 pennies. For example, the highest bar in the figure indicates that about 7% of all observations were located between 5.90 and 5.99 (it cannot be seen from the figure, but 5.90 markkas was the only price used within this interval). The high concentration of observations at certain prices can be seen also in Figure 2, which shows that the number 9 was used in 70% of all observations and the number 5 in 15% of all observations as a second-to-last price digit throughout the markka period from January 2001 to December 2002.

Figure 1. **Histogram of grocery prices in January 2001 (class interval is 10 pennies)**

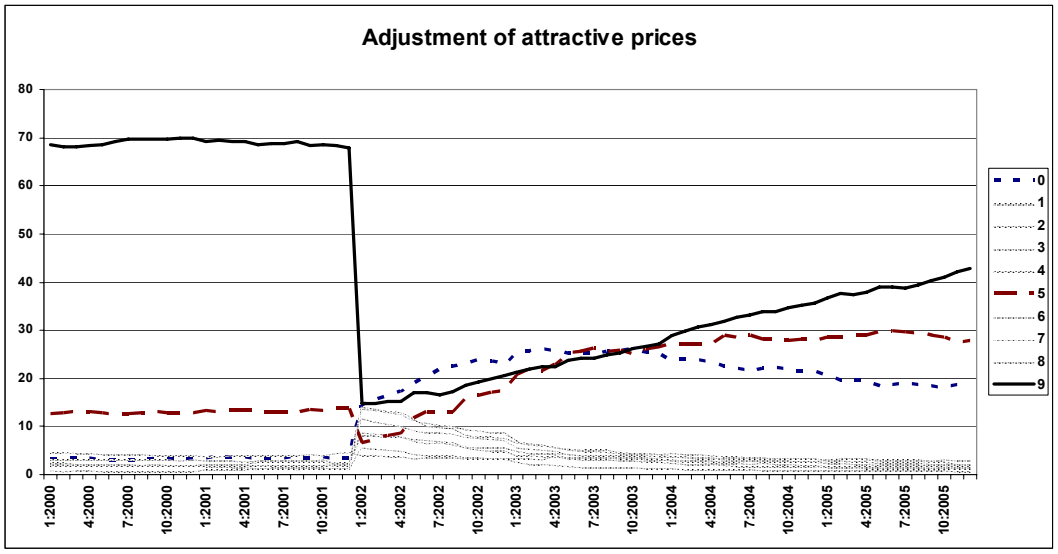


In addition to showing the distribution of second-to-last digits used in the markka period, Figure 2 shows the distribution of last digits used in the euro period. The reason for presenting the second-to-last digit in the markka period and the last digit in the euro period is that the usage of the number 9 moved from the second-to-last to the last digit after the euro changeover. The figure shows the slow progress of adjusting price endings from the markka to the euro period. The prices did not adjust overnight from markka prices with favored price endings (ie, the 90 ending) to euro prices with favored price endings (ie, the 9 ending). Instead, markka prices with 90 endings were converted to euros based on official conversion rate of 5.94573 (for more detail about the adjustment process of pricing after the euro changeover, see Aalto-Setälä (2005). It is interesting to notice that Mostacci and Sabbatini (2005) also find that the adjustment to the new rounded euro prices has been gradual in Italy.

The adjustment process and period of 'not too concentrated prices' provide a unique opportunity for the purposes of this study. The reason is that it is not practical to examine the effect of 9 endings on pricing dynamics if nearly all prices have 9 endings, as was the case in Finnish grocery prices during the markka period. Instead, in the euro period, the concentration of 9 endings has been modest, though steadily increasing. In 2002, the share of 9 endings was 17.2% and share of 0, 5, and 9 together 49.5%. In 2003, the share of 9 was 24.2% and the share of 0, 5, and 9 together 74.1%. In 2004, the share of 9 endings was 32.7%

and the share of 0, 5, and 9 together 74.1%. In 2005, the share of 9 endings was 39.3% and the share of 0, 5, and 9 together 87.0%.

Figure 2. **Share of different numbers as a second-to-last digit in the markka period and as last digit in the euro period**



5 Price paths and nominal values

This study examines monthly price changes of single grocery items in specific stores. We examine only normal prices – not promotional or 'sale' prices. Two measures of price change are used: *average change size*[4] and *net change direction*.

– *Average change size* is simply the average size of price changes that have occurred during a month

$$AV_{m,m-1} = \sum_{s=1}^{S} 100 \times \frac{p_m^{is} - p_{m-1}^{is}}{p_{m-1}^{is}} \times \frac{1}{S_{m,m-1}^{ch}} \qquad (5.1)$$

where p_m^{is} is price of the product i at store s at period (month) m and $S_{m,m-1}^{ch}$ is number of observations if $p_m^{is} \neq p_{m-1}^{is}$.

[4] It should be noted that the average change size is not ideal measure if purpose is to examine how price changes affect price indexes. Arithmetic average of logarithmic changes or geometris mean are better measures for price index comparisons. However, we do not examine the relationship between price changes and development of price index. Thus, we use simple arithmetic mean. We believe that this is the most intuitive measure of price changes.

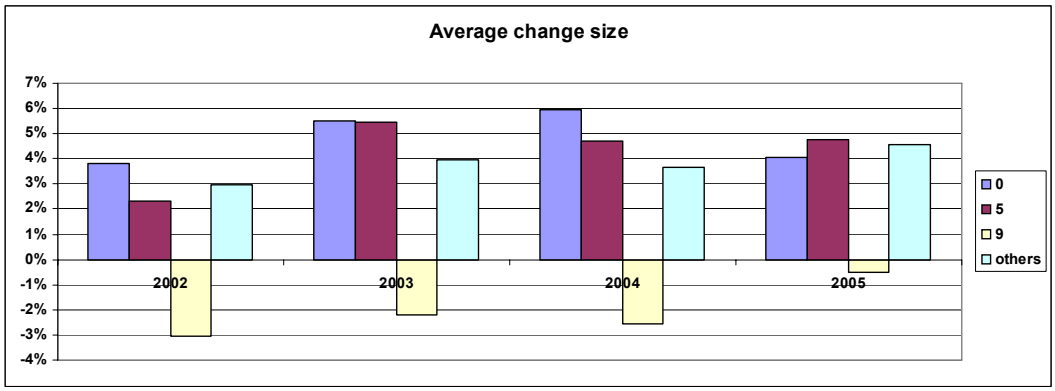
– *Net change direction* is the net proportion of price increases and decreases expressed as a per cent

$$N^{i}_{m,m-1} = 100 \times \sum_{s=1}^{S} \frac{x^{is}_{m,m-1}}{S^{ch}_{m,m-1}}, \text{ where } x^{is}_{m,m-1} = \begin{cases} 1, & \text{if } p^{is}_{m} > p^{is}_{m-1} \\ -1, & \text{if } p^{is}_{m} < p^{is}_{m-1} \end{cases} \quad (5.2)$$

It is important to note that typically 70% to 85% of all price observations do not change between consecutive months at all.[5] Because both of the price-change measures are calculated based on only changed prices, the price changes appear quantitatively rather large. If zero changes would have been included the average change size and net change direction would amount to about one fifth of the values presented below.

Figure 3 presents *average change size* of prices based on the ending of the price that is changing. The figure presents 0-, 5-, and 9-ending prices separately and other endings (1-, 2-, 3-, 4-, 6-, 7- and 8-ending) are aggregated. There are no clear differences in the group of other-ending prices. We present them as one group because these endings have a low share of all observations and because the high number of such endings would make interpretation of the results more difficult. Figure 3 clearly shows that the average size of the price change is smaller if the price is changing to 9-ending price than if the price is changing to any other ending. Furthermore, since the euro change over in 2002, the average size of price chances to 9-ending has decreased over time. This is likely to reflect the gradual adjustment process of attractive prices, as reported in figure 2. Finally, the difference in average price changes between 0-, 5- and other-ending prices is quite small. It is also not possible to detect any consistent pattern in 0-,5-, and other ending prices over time since the euro change over.

Figure 3. **Average change size of prices based on last digit**



[5] According to Dhyne et al (2005) on average 71.7% of prices of unprocessed food and 86.3% of prices of processed food do not change between consecutive months in euro area.

Figure 4. **Net change direction of prices based on last digit**

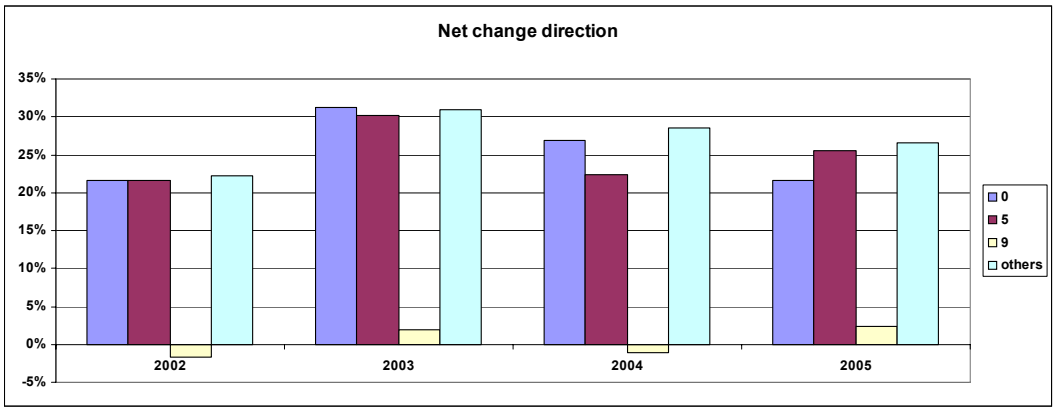


Figure 4 shows the net change direction[6] of prices based on the ending to which the price is changing. The value of the net change direction of 0-, 5-, and other-endings varies between 20 and 30%. In other words, there are 20% to 30% more increased than decreased price-change observations when the price is changing to these endings. Once more, there does not seem to be any consistent pattern over time in the net change direction. What is remarkable, however is that the value of the net change direction of 9-ending prices is around zero. In other words, there are about as many increased as decreased price-change observations when the price is changing to a 9-ending price. Thus, we can say that the difference between net change directions to 9-ending prices and to non-9-ending prices is large.

Earlier in the paper, we introduced three possible price paths for the evolution of the over-representation of 9-ending prices: the *sticky-price path,* the *just-below-price path,* and the *attractive-price path*. Next we consider how well the data fit these possibilities.

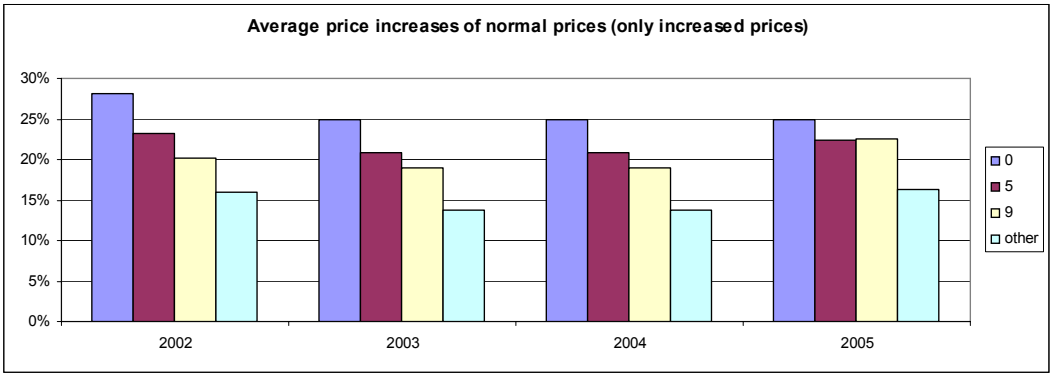
Sticky-price path

We study the idea of sticky prices by examining average price increases (average change size of increased prices) and the frequency of price changes. Figure 6 presents average price increases (only increased prices are considered). According to the sticky-price path, price increases to 9 endings should be smaller than other price increases (because 9 endings restrict price increases). Price increases to 9 endings are smaller than price increases to 0- or 5-endings. On the other hand, price increases to 'other' endings are the smallest. However, the importance of

[6] If there are, for example, 7 increased and 3 decreased price observations, the value of *net change direction* is 100 x (7 – 3)/10 = 40.

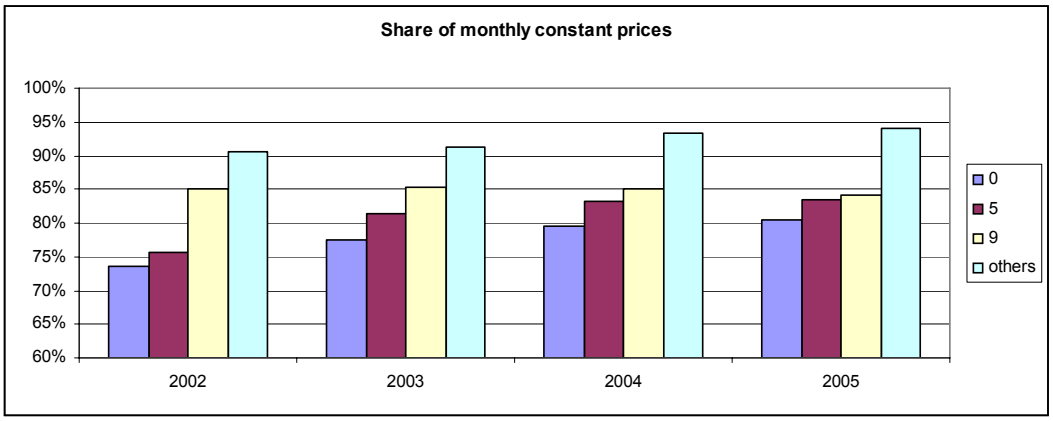
other endings is quite small because their share of all observations is small (see Figure 2).

Figure 6. **Average price increase of prices based on last digit**



Next we consider the sticky-price path by examining the frequency of price changes. If the sticky-price path is the main explanation for the over-representation of 9 endings, 9-ending prices should be stickier than other prices. Figure 7 presents the share of monthly constant prices. It shows that 9-ending prices are stickier than 0- or 5-ending prices. However, again, 'other' endings create a problem for the sticky-price-path viewpoint: these prices are clearly the stickiest.

Figure 7. **Share of monthly constant prices by digits**



In order to study this further, we calculate average duration of prices based on frequency of price changes (see Dhyne et al, 2005, for the methodology). Table 1 shows the average durations of prices based on the last digit. The table shows (more clearly than Figure 7) that the average duration of 9-ending prices have

been about the same during the whole euro period. In fact, average duration of 9-ending prices have been very close to the average duration of all prices found in Vilmunen (2005) between 2000–2003. Instead, average duration of all other grocery prices has increased. The interpretation is that part of the prices of 0-, 5-, and other endings has adjusted to 9-endings and thus duration of these prices has been at the beginning of the euro era shorter than normally.

Table 1. **Average price duration in months based of last digit of the price**

	2002	2003	2004	2005
0	3.3	3.9	4.4	4.6
5	3.6	4.9	5.5	5.5
9	6.2	6.3	6.2	5.8
Others	10.1	11.0	14.5	16.0
Average	7.3	6.6	7.0	6.8

Lastly we test the importance of the sticky-price path by examining price-change frequencies of the most commonly used prices. The idea is that if prices get 'stuck' at numbers like $9.99 or $29.95, then these most commonly used prices should be stickier than prices in general.

The most commonly used prices in grocery data are 0.99 and 1.99 euros. The share of 0.99 was 4.6% and the share of 1.99 was 3.4% of all grocery observations under 4 euros in December 2005. Table 2 shows that around 80% of prices are monthly unchanged. At the beginning of the euro period, 0.99 and 1.99 are stickier than prices on average. However, in 2004 and 2005 the situation is opposite. Evidently the situation in years 2004 and 2005 is more common than the situation at the very beginning of the euro period. Probably in 2002 and 2003, 0.99 and 1.99 were used as anchor prices when pricing was changing from markka to euro pricing.

Table 2. **Share of unchanged prices**

	2002	2003	2004	2005
All grocery prices under 4 euros	79.7	81.1	81.9	82.4
Prices 0.99 and 1.99	85.4	82.8	80.9	79.6

To sum up, there are features supporting the sticky-price path: the 9-ending prices are stickier and they also have smaller price increases than 0- and 5-ending prices. However, prices with 'other endings' are even stickier than 9-ending prices, and they also have the smallest price increases. Further, the most commonly used

prices 0.99 and 1.99 are not stickier than the average grocery price in years 2004 and 2005. Thus, the data is not consistent with the sticky-price path, rather the contrary.

Just-below-price path

A second possible explanation for the over-representation of 9 endings is that these prices are dropped from a higher price, perhaps even the immediately higher 0-ending price, in order to make the price more appealing to the customer. We test this suggestion by examining the amount and form of one-penny price decreases in the data.

The number of one-penny price decreases is relatively small. Table 2 shows that the share of one-penny decreases varies around 3–4% of all price decreases in the data in 2003–2005. Price decreases of one penny are typically changes to 9-ending prices. In 2005, 72.6% of all one-penny price decreases were changes to 9-ending prices. At the same time, 'only' 45.6% of all price decreases were changes to 9-ending prices.

To sum up, the data show that the just-below price path may be one reason for 9 endings. However, it cannot be the main reason, because the share of one-penny price decreases among all price decreases is only about 3–4% (and the share of one-penny price decreases among all price changes only about 1%).

Table 3. **Share of one penny price decreases**

	2002	2003	2004	2005
Total number of price decreases	12,649	11,198	11,217	10,448
Share of one-penny drops	5.27%	4.09%	3.56%	3.13%
9 endings' share of all one-penny drops	35.8%	45.3%	61.5%	72.6%
9 endings' share of all price decreases	21.1%	29.8%	39.6%	45.0%

Attractive-price path

The third possible explanation for the over-representation of 9 endings is the attractive-price path. In the attractive-price path, 9 endings attract prices from both upward and downward directions. Figure 4 has described the net change direction of prices. As can be seen in that figure, there are about the same number of price increases and decreases to 9 endings. Price changes to all other endings are typically increases. This result is strong evidence supporting the attractive-price path suggestion. The result could also be considered evidence against both sticky-price and just-below-price path suggestions.

We also test the attractive-price path to 9-ending prices by examining the particular price endings that were most likely to change to 9 endings. The idea behind this test is that, if there is an attractive pull to 9 endings, this attraction might get greater as a price gets closer to a 9 ending. For price increases, this would predict that prices ending in the digits 5 through 8 would be more likely to change to higher 9-ending price than would prices ending in the digits 0 through 4. For price decreases, this idea would predict that prices ending in the digits 0 though 4 would be more likely to change to the lower 9-ending price than would prices ending in the digits 5 through 8.

Table 3a shows the share of 9 endings among all price increases of ten cents or less as a function of which ending the price is coming from. The first row of Table 3a indicates that on average 18.9% of price increases changed to 9-ending prices in 2002, 23.9% in 2003, 34.1% in 2004, and 41.9% in 2005. The other rows of the table indicate from which endings these prices came as compared to average. For example, the second row of the table indicates that price increases from 0 endings ended up as 9 endings 9.3 percentage points more rarely than average (in other words, 18.9% – 9.6% = 9.3% of all price increases from 0 endings ended up as 9-ending prices). Altogether, the results shown in Table 3a provide evidence that the prices whose endings make them closer to 9-ending prices are more likely than other prices to be raised to a 9-ending price. This seems particularly so for prices ending in the digits 6, 7, and 8.[7]

[7] Table 3a illustrates the problem of statistical testing with the data. In the table, differences between cells larger than 3% are statistically significant ($P = 0.01$) according to binomial distribution. Between some cells, even smaller differences are significant, depending on the number of observations involved. However, it is not mean-ingful to consider what causes the difference between, say, years 2004 and 2005 in the relation to the 8 ending. Instead, it is more important to make interpretations from economically significant differences: changes from 8 endings more often than average result in 9-ending prices.

Table 3a. **Share of 9-ending changes for each possible 'from' ending (increases ≤ 10 cents)**[8]

	2002 (N=9377)	2003 (N=7973)	2004 (N=6007)	2005 (N=5473)
Share of 9 endings among all price changes	18.9	23.9	34.1	41.0
Share of 9 endings for each 'from' ending (difference from yearly average):				
0	-9.6	-11.1	-18.3	-15.0
1	1.2	-3.8	-28.3	-21.0
2	4.2	-8.9	-11.2	-29.7
3	-1.4	3.6	-6.0	-21.8
4	0.0	-2.5	-0.9	-10.4
5	0.4	1.3	1.7	-4.1
6	8.0	21.0	11.6	18.4
7	7.4	15.6	25.2	22.9
8	9.0	5.7	18.4	2.7
9	4.4	8.3	11.3	12.6

Table 3b shows the share of 9 endings among all price decreases of ten cents or less as a function of which ending the price is coming from. The first row of Table 3b indicates that on average 19.9% of price decreases changed to 9-ending prices in 2002, 24.6% in 2003, 31.9% in 2004, and 36.6% in 2005. The other rows of the table indicate from which endings these prices came as compared to average, as in Table 3a. The results shown in Table 3b do not indicate that prices whose endings make them closer to 9-ending prices are more likely than other prices to be lowered to a 9-ending price. The largest proportion of the price decreases to 9 endings in this analysis come from other 9-ending prices, which are the prices that are *most* distant – 10 cents away. Once more, there is a clear time pattern as regards the 9-ending prices: the share price changes of 9 ending prices from 9-endings have increased since euro change over.

The idea of strong pull to 9 endings from nearby numbers appears to be true for price increases, but not for price decreases. Although this result is consistent with the sticky-price path to 9 endings, it is not consistent with the attractive-price path to 9-ending prices. Thus, the data do not provide consistent support for the attractive price path.

[8] Significances of Tables 3a and 3b vary between cells. 95% confidence intervals (according to binomial distribution and assuming that years are independent from each other) are from ±1.2 to ±2.9 percentage units for endings 0, 5 and 9 in Table 3a. In Table 3b confidence intervals for endings 0, 5 and 9 are from ±2.2 to ±3.5. Confidence intervals for other endings are larger because of smaller number of observations.

Table 3b. **Share of 9-ending changes for each possible 'from' ending (decreases ≤ 10 cents)**

	2002 (N=4010)	2003 (N=3900)	2004 (N=3539)	2005 (N=3491)
Share of 9 endings among all price changes	19.9	24.6	31.9	36.6
Share of 9 endings for each 'from' ending (difference from yearly average):				
0	-3.9	-6.7	-14.8	-13.2
1	-4.9	-1.5	-14.5	-3.2
2	13.7	7.2	-1.9	-8.9
3	-1.9	-4.5	4.8	-9.8
4	-1.1	9.7	4.9	-6.0
5	-2.1	-3.0	-0.8	-3.1
6	-1.7	-5.4	-4.3	-26.1
7	-4.1	-3.9	2.9	-22.9
8	-10.3	10.5	5.8	-3.9
9	13.1	9.9	12.0	11.7

6 Discussion

Nominal rigidities play crucial role in most macroeconomic models used for the analysis of monetary policy. Still, the reasons for nominal inertia are far from clear. Attractive prices have risen as one potential explanation of nominal rigidities. One of the important reasons for increased interest about attractive prices as an explanation for price rigidities results from online pricing: it has been shown that prices are rigid also in internet (Chakrabarti and Scholnik, 2005). This would suggest that price rigidity is hardly a result of adjustment costs, as suggested for instance Mankiw (1985) and many others.

In this study we have examined the role of attractive prices, in particular 9-endings, in pricing dynamics. The over-representation of 9-ending prices has been well known and often studied in cross-sectional studies but this is the first study to examine the relationship between nominal values and pricing dynamics. We have utilized grocery observations of Finnish Consumer Price Index data from the years 2002–2005. The period is ideal for examining the effect of different price endings on pricing dynamics because it includes the adjustment process after the euro changeover. Normally grocery prices are very heavily concentrated on 9 endings, and thus there is not enough variability to study the effects of different endings over time.

The results suggest that nominal values have a distinct impact on pricing dynamics. Thus, we are able for the first time to show the importance of price endings to pricing dynamics. We examine the suggested reasons for over-representation of 9 endings: *sticky-price, just-below-price*, and *attractive-price paths.* The price data do not strongly support any of the suggested reasons for 9

endings. We find, however, some evidence for the attractive-price path: 9 endings attract prices from both an upward and downward direction – not mainly from upward (like the just-below-price path suggests) or downward (like the sticky-price path suggests).

An unambiguous result of the study is that the changes to prices with 9 endings are more often decreases than are changes to other endings. Price changes to 9 endings are also of smaller size than are changes to other endings. One should be cautious about generalizing these large differences directly because our data comprise an adjustment period of prices after a currency change. However, it is very probable that price-ending effects observed in this situation reflect some of the processes and managerial practices regarding the more general use of 9 endings in retail prices.

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