Stuck at zero: Price rigidity in a runaway inflation

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A B S T R A C T

We use micro level retail price data from convenience stores to study the link between 0-ending price points and price rigidity during a period of a runaway inflation, when the annual inflation rate was in the range of 60%-430%. Surprisingly, we find that more round prices are less likely to adjust, and when they do adjust, the average adjustments are larger. These findings suggest that price adjustment barriers associated with round prices are strong enough to cause a systematic delay in price adjustments even in a period of a runaway inflation, when 85 percent of the prices change every month.

The existing evidence, however, comes from periods of low or modest inflation. For example, Kashyap (1995) studies a period with annual inflation rate of 1.0%-13.5%, while Knotek (2006) studies a period with annual inflation rate between $-10\%$ and $+18\%$. Similarly, Levy et al. (2011, 2020), Anderson et al. (2015), Ater and Gerlitz (2017), Snir and Levy (2021) all study low inflationary environments.

We, in contrast, study a period of a runaway inflation. Using a unique retail store-level price dataset, we find that as inflation accelerates and the price level increases, almost all prices end in 0. However, the more round a price is, the less likely it is to change. Even when annual inflation is 430%, prices that have one SD more than the average number of right-most zeros are 3.9% less likely to change than an average price. We also find that when round prices do change, they change by more than less round prices.

1. Introduction

Price points are a common phenomenon in many retail settings (Stiving and Winer, 1997). In large supermarkets, drugstores, etc., between 40%-95% of the prices end in 9, far higher than the 10% predicted by a uniform distribution (Levy et al., 2011; Anderson et al., 2015; DellaVigna and Gentzkow, 2019; Snir and Levy, 2021). In convenience stores, in contrast, 0 is the most common price point. For example, Knotek (2011) finds that about 60% of the prices in his sample are 0-ending. Snir et al. (2021) report that in their sample, over 70% of the prices are 0-ending.

There is also evidence that prices that end in price points are less likely to change than other prices, generating substantial price rigidity (Kashyap, 1995; Knotek, 2008; Klenow and Malin, 2011; Levy et al., 2011, 2020). Some of the studies conclude that the correlation between price points and price rigidity is causal (Ater and Gerlitz, 2017; Knotek et al., 2020).

The paper is organized as follows. In Section 2, we describe the data. In Section 3, we present the empirical findings. In Section 4, we discuss robustness checks. In Section 5, we conclude.

2. Data

We use the store level price dataset of Lach and Tsiddon (1992, 1996, 2007). The dataset includes monthly prices of 26
Entry-Level-Items (ELIs) in Israel, in the years 1978–1979, 1981–1982, and 1984–June 1985. The data were collected by the Israel's Central Bureau of Statistics for compiling the consumer price index (CPI). According to Lach and Tsiddon (1992, 1996, 2007), the products in the sample are homogeneous, they did not change substantially either in quality or in their market structure during the sample period, and their prices were not controlled by the government. In addition, as they note, the stores are small grocery stores and specialty stores, i.e., convenience outlets.

The 1978–1985 time period corresponds to three steps in the inflationary process in Israel (Dornbusch and Fischer, 1986; Liviatan and Piterman, 1986; Fischer, 1987; Sargent and Zeira, 2011). During January 1978–June 1979, the average monthly inflation was 3.9%, equivalent to annual inflation of about 58%. During July 1979–September 1983, the average monthly inflation was 7.0%, equivalent to annual inflation of about 126%. During October 1983–July 1985, the average monthly inflation was 14.9%, equivalent to annual inflation of about 429%.

We focus on 0-ending prices, which fits our convenience stores data. To measure a price roundness, we use (1) the average number of consecutive right-most zero endings, and (2) the average share of consecutive right-most zero endings in a price: the greater they are, the rounder the price is (Johnson et al., 2009).

Table 1 presents the summary statistics of average prices, the share of 0-ending prices, the average number of consecutive right-most zero endings, and the average share of consecutive right-most zero endings. According to the Table, in all periods, almost all prices are 0-ending. In addition, as the inflation accelerates and the price level increases, we observe an increase in the average number of consecutive right-most zero endings, and in the average share of consecutive right-most zero endings.

Table 1 also reports the average frequency of price changes per month: 41.1%, 58.2%, and 84.6% in the first, second and third time periods, respectively. To put these numbers in perspective, assume 30-day months. Then, following Nakamura and Steinsson (2008), the implied time spell between price changes, given by $-30 \ln (1 - f)^{-1}$, where $f$ is the average monthly frequency of price changes, assuming 30-day months.

Finally, Table 1 also reports the average sizes of price changes: 5.6%, 12.4% and 18.3% in the first, second and third time periods.

Fig. 1 demonstrates the behavior of prices by depicting, as an example, the price of cocoa powder in Lira, in Store 4527. Visualy, it appears as if before 1980, the price of cocoa powder rose at a moderate rate, but it actually rose at a rate of about 60% a year. During 1981–1982 the price rose, on average, at the rate of over 80% a year. From 1984 to June 1985, at the peak of the inflation, the price of cocoa powder rose at an annual rate of 403%.

### 3. Results of econometric model estimation

Focusing on cases where we have consecutive observations at both $t$ and $t - 1$, we split the data into three sample periods, corresponding to the three steps in the inflationary process: January 1978–June 1979, January 1981–December 1982, and January 1984–October 1984. After October 1984, the government tried two stabilization programs that included general price controls, and, therefore, we exclude that period. To minimize the chance of mistakes, we follow Lach and Tsiddon (1992) and others in defining a "price change" as a price change of 0.5% or more. To test whether 0-endings are correlated with price rigidity, we estimate a separate regression for each sample period. The dependent variable is a dummy for a price change. To control

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1. In February 1980, the Lira was replaced by Shekel as a legal tender. The prices in the table are presented in Lira for the period 1978–1979, and in Shekel for 1981 onwards. The conversion rate between the Lira and the Shekel was 10 Lira for 1 Shekel.
2. The price row gives the average price in each sample period.
3. Share of 0-ending prices gives the share of all prices that are 0-ending.
4. The number of right-most 0-endings is the average number of consecutive right-most 0-endings.
5. Share of right-most 0-endings is the average of the number of consecutive right-most 0-endings divided by the total number of digits in the price.
6. Standard deviations are reported in parentheses.
7. Average frequency of price changes per month is the proportion of price changes out of all prices.
8. The average spell between price changes (in days) is calculated according to $-30 \ln (1 - f)^{-1}$, where $f$ is the average monthly frequency of price changes, assuming 30-day months.
9. The average absolute size of price change is the average absolute size of price changes in percent, calculated after removing 391 outlier observations, defined as observations that are 2.5 standard deviations away from the mean. See footnote 5.
for the effects of 0-ending price points, we do not add a dummy for prices that end in zero because only about 1.1% and 0.2% of the prices in the second and third sample periods, respectively, have a non-zero ending. Instead, to capture the roundness of prices, we use the share of consecutive right-most zero endings as our independent variable. The estimation results are reported in Table 2. In columns (1), (3), and (5), the regressions also include product fixed effects.

The coefficient estimates are $-0.27$, $-0.20$, and $-0.21$ in columns (1), (3) and (5), respectively, all three statistically significant. Thus, 0-ending prices are associated with a lower probability of a price change during periods of 58%, 126%, and over 400% annual inflation, respectively.

The size of the effect is also significant. In the first subperiod, increasing the share of consecutive right-most zero endings from the average of 0.464 by one standard-deviation, 0.188, is associated with a decrease of 5.1% in the frequency of monthly prices changes, a drop of 6.2% relative to the average frequency, 0.188.

In the second subperiod, an increase in the share of consecutive right-most zero endings from the average of 0.578 by one standard-deviation, 0.157, is associated with a decrease of 3.3% in the frequency of monthly prices changes, a drop of 3.9% relative to the average frequency, 0.578.

In the third subperiod, an increase in the share of consecutive right-most zero endings from the average of 0.578 by one standard-deviation, 0.157, is associated with a decrease of 3.3% in the frequency of monthly prices changes, a drop of 3.9% relative to the average frequency, 0.578.

In columns (2), (4), and (6), we add fixed effects for products $\times$ stores and for months, to control for the variability in the inflation. The estimation results do not change substantially.

Next, we focus on the size of price changes. According to Kashyap (1995), Knotek (2008), and Levy et al. (2011), if price points are a barrier to price changes, then when prices do change, they are expected to be larger than average. We therefore test
In the third sample period, an increase of one standard-deviation in the share of consecutive right-most zero endings is associated with an increase of $4.08 \times 0.157 = 0.64\%$ in the size of price changes, an increase of $3.5\%$ relative to the average size, $18.3\%$. Thus, 0-ending prices are associated with both (1) lower probability of price change, and (2) larger price changes, when prices do change.

To assess the importance of these findings, we measure the effect of 0-endings on the price rigidity and on the size of price changes. In the first sample period, with annual inflation of $58\%$ (0.13% daily), a decrease of $5.1\%$ in the frequency of monthly price changes implies an increase of $10.5\%$ in the average spell between price changes, from 56.7 to 67.2 days. In the second sample period, a decline of 0-ending prices by 1.15% is associated with an increase of 3.3% relative to the average size, 12.4%.

Notes:
1. The table reports the results of linear probability model regressions for the probability of a price change.
2. The dependent variable in all regressions is a dummy that equals 1 if a price has changed between month $t$ and month $t-1$.
3. The main independent variable is the share of consecutive right-most 0-endings in the price.
4. The effect on the monthly frequency of price changes is calculated by multiplying the regression coefficients by the standard deviation of the share of 0-ending prices. The effect on the spell between price changes is calculated as: $-30 \ln (1 - (1 - \bar{f} f d))^{-1}$, where $\bar{f}$ is the average monthly frequency of price changes from Table 1, and $d$ is the effect on the monthly frequency of price changes.
5. Columns (1), (3) and (5) include fixed effects for products.
6. Columns (2), (4) and (6) include fixed effects for products $\times$ stores and for months.
7. The $R^2$ is the overall $R^2$.
8. Robust standard errors, clustered at the product level, are reported in parentheses.
9. ** $p < 5\%$, *** $p < 1\%$.
of 0.21% in the size of a price change is equivalent to 1.6 days of average inflation.7

In the second sample period, with annual inflation of 126% (0.23% daily), a decrease of 3.6% in the frequency of monthly prices changes implies an increase of 3.6 days in the average spell between price changes, from 34.4 to 38.0 days. An increase of 0.41% in the size of a price change is equivalent to 1.8 days of average inflation.

In the third sample period, with annual inflation of 429% (0.46% daily), a decrease of 3.3% in the frequency of monthly prices changes implies an increase of 1.9 days in the average spell between price changes, from 16.0 to 17.9 days. An increase of 0.64% in the size of a price change is equivalent to 1.4 days of average inflation.

Thus, when inflation ranges between 58%–126%, round prices are associated with longer spells between price changes. Although this is accompanied by larger price changes, the increase in the size of price changes is not large enough to compensate for the longer spells. When inflation reaches 400%, price points are still associated with longer spells between price changes (albeit to a smaller degree as compared to when the inflation was more moderate, reflecting the higher inflationary pressure on the retailers to increase prices), but the increase in the size of price changes compensates for it almost fully.

4. Robustness

We run the following robustness checks.8 First, we consider non-consecutive price changes. Second, we expand the data to cover the period up to June 1985. Third, we use the number of consecutive right-most zero endings, rather than their share. Fourth, we re-estimate the regressions using the prices expressed in Liras, rather than in Shekels. Fifth, we estimate the regressions of the size of price changes without excluding the outliers. The findings we report in the paper remain unchanged under these alternative specifications and models.

5. Conclusions

Using data from a runaway inflation period, we find that zero-ending prices are associated with price rigidity: more round prices are less likely to change, and when they do change, the average change is bigger. The finding that price points are associated with price rigidity even in a runaway inflation—in our case, when the annual inflation rate exceeds 400%, underscores the power of the barriers to price adjustment, when prices are set at price points.

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Appendix A. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.econlet.2021.109885.

References


7 Average daily inflation was 0.13%. Therefore, a price increase of 0.21% is equivalent to 0.21/0.13×1.6 days of average inflation.

8 In the Appendix we provide further details about the data and discuss the robustness checks. In Appendix A, we provide more information about the inflationary process in Israel. In appendix B, we provide summary statistics on the 26 ELIs. In appendix C, we discuss the robustness checks in detail. In appendix D, we test and reject the hypothesis of a unit-root in the dependent and independent variables for each sample period.