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Stuck at zero: Price rigidity in a runaway inflation

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ABSTRACT

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.

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.[1] 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 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 (2008) 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.

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

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[1] Examples include \$1 newspapers at newspaper stands, \$3 popcorn at movie-theaters, \$4 hot-dogs at baseball games, \$6 beers at football games, etc. See, e.g., Knotek (2008, 2011) and Fisher and Konieczny (2000).

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Table 1
Descriptive summary statistics, January 1978October 1984.

	January 1978–June 1979	January 1981–December 1982	January 1984–October 1984
Price	51.71 (35.376)	63.87 (55.420)	886.29 (707.300)
Share of 0-ending prices	97.6%	99.0%	99.9%
Number of right-most 0-endings	1.91 (0.837)	2.06 (0.833)	3.08 (0.937)
Share of right-most 0-endings	46.43% (18.80%)	49.05% (17.81%)	57.83% (15.73%)
Average frequency of prices changes per month	41.1%	58.2%	84.6%
Average spell between price changes (in days)	56.7	34.4	16.0
Average absolute size of price change (in %)	5.6%	12.4%	18.3%
N	10,966	14,630	5,651

Notes:
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 $-30\left[\ln\left(1-\bar{f}\right)\right]^{-1}$, where $\bar{f}$ 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.

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.[2] 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 $-30\left[\ln\left(1-\bar{f}\right)\right]^{-1}$, where $\bar{f}$ is the average monthly frequency of price changes, equals 56.7, 34.4 and 16.0 days in the first, second and third subperiods, respectively.

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.[3] Visually, 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.[4]

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

2 The share of right-most zero endings is the number of consecutive right-most zero endings divided by the total number of digits in the price. A price such as NIS 10.50 has 1 consecutive right-most zero ending and a total of 4 digits, yielding a share of 1/4 = 0.25. NIS 10.00 has 3 consecutive right-most zero endings, with a share of 3/4 = 0.75.

3 In February 1980, as the inflation rate accelerated, the government cut a zero off all nominal quantities as a means of anchoring the public's inflationary expectations. For that purpose, the Israeli currency at that time, the Lira, was replaced by the Shekel, at the conversion rate of 10 Lira = 1 Shekel. For ease of visual interpretation, the prices in the figure are quoted in Liras. However, in the regressions for the sub-periods after 1980, we use price quotations in Shekels because it was the legal tender at that point.

4 There were 128 price changes, out of a total of 21,494 price changes (0.6%), that were less than 0.5% in size.

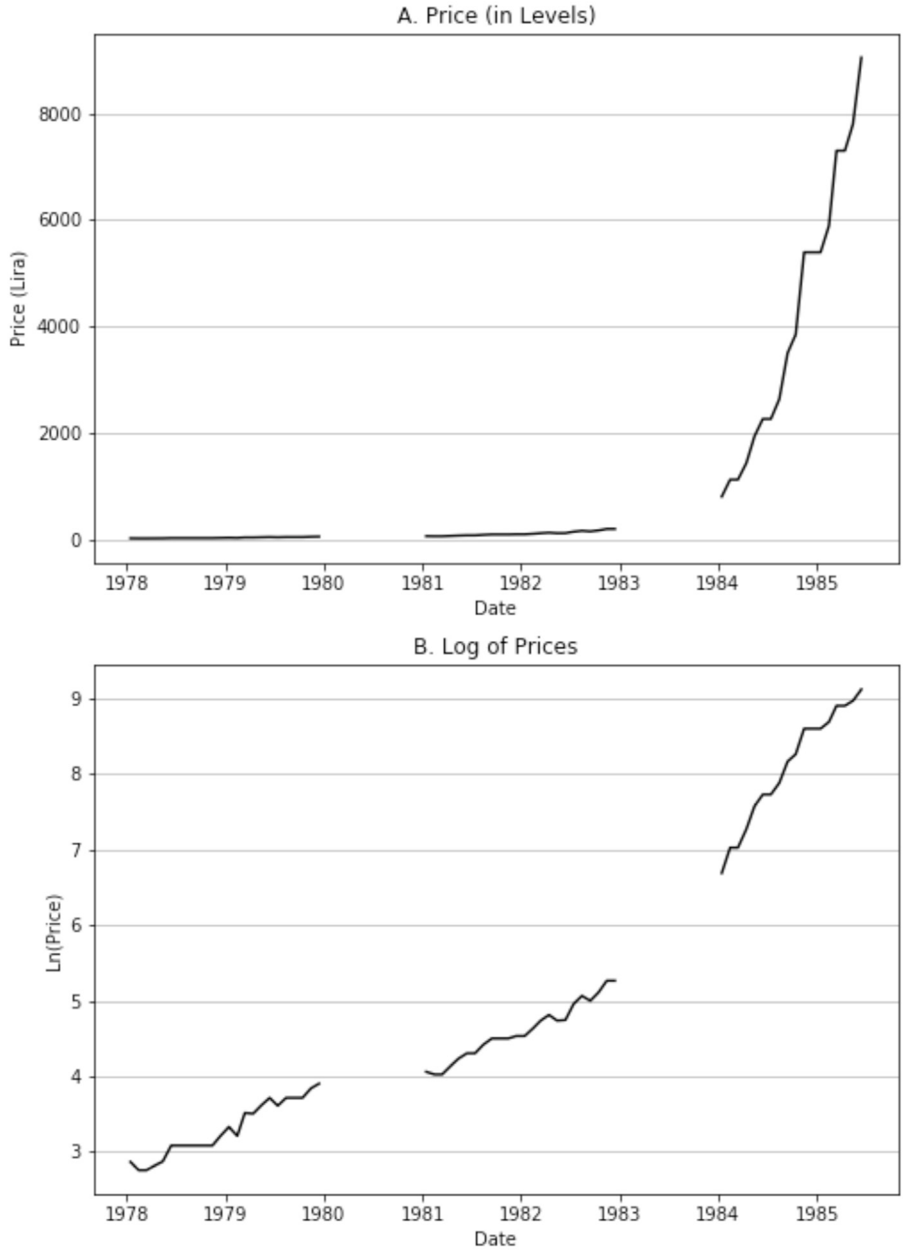

Fig. 1. The price of cocoa-powder, in Israeli Lira, at store 4527, January 1978–September 1984. *Notes*: 1. In February 1980, the Lira was replaced by Shekel as the legal tender. 2. The prices on the diagram are measured in Lira, using the official conversion rate, 10 Lira for 1 Shekel.

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 12.4% relative to the average frequency, 41.1%.

In the second subperiod, increasing the share of consecutive right-most zero endings from the average of 0.491 by one standard-deviation, 0.178, is associated with a decrease of 3.6% in the frequency of monthly prices changes, a drop of 6.2% relative to the average frequency, 58.2%.

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, 84.6%.

In columns (2), (4), and (6), we add fixed effects for products × 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

Table 2
Regressions of the probability of a price change.

	January 1978–June 1979		January 1981–December 1982		January 1984–October 1984	
	(1)	(2)	(3)	(4)	(5)	(6)
Share of right-most 0-endings	−0.27***	−0.21**	−0.20**	−0.23**	−0.21***	−0.15***
	(0.053)	(0.0477)	(0.083)	(0.087)	(0.038)	(0.037)
Effect on the monthly frequency of price changes	−5.1%	−3.9%	−3.6%	−4.1%	−3.3%	−2.4%
Effect on the spell between price changes (in days)	10.5	7.8	3.6	4.1	1.9	1.3
Fixed effect for products	Yes	No	Yes	No	Yes	No
Fixed effect for products × stores	No	Yes	No	Yes	No	Yes
Fixed effect for months	No	Yes	No	Yes	No	Yes
R^2	0.0010	0.0010	0.0001	0.0001	0.0003	0.0003
N	9,916	9,916	13,405	13,405	4,812	4,812

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 $t-1$ and month t.
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: $-30\left[\ln\left(1-\left(\bar{f}-d\right)\right)\right]^{-1}$, 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 × 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%.

Table 3
Regressions of the size of a price change.

	January 1978–June 1979		January 1981–December 1982		January 1984–October 1984	
	(1)	(2)	(3)	(4)	(5)	(6)
Share of right-most 0-endings	1.15	1.62	2.28**	2.47**	4.08**	5.69**
	(1.054)	(1.833)	(0.958)	(0.981)	(1.691)	(2.598)
Effect on the size of a price change	0.21%	0.30%	0.41%	0.44%	0.64%	0.90%
Days of average inflation	1.6	2.3	1.8	1.9	1.4	2.0
Fixed effect for products	Yes	No	Yes	No	Yes	No
Fixed effect for products × stores	No	Yes	No	Yes	No	Yes
Fixed effect for months	No	Yes	No	Yes	No	Yes
R^2	0.0022	0.0025	0.0001	0.0001	0.0010	0.0011
N	7,735	7,735	7,682	7,682	3,822	3,822

Notes:
1. The table reports the results of OLS regressions of the absolute size of price changes.
2. The dependent variable in all regressions is the absolute size of price changes in percent between month $t-1$ and month t, if the price change is different than zero.
3. The main independent variable is the share of consecutive right-most 0-endings in the price.
4. The effect on the size of a price change is calculated by multiplying the regression coefficients by the standard deviation of the share of 0-ending prices.
5. Days of average inflation is the number of days of average inflation equivalent to the change in the size of price changes. It is calculated by dividing the effect on the size of a price change by the average daily inflation rate.
6. Columns (1), (3) and (5) include fixed effects for products.
7. Columns (2), (4) and (6) include fixed effects for products × stores and for months.
8. The R^2 is the overall R^2.
9. Robust standard errors, clustered at the product level, are reported in parentheses.
10. *p < 10%. **p < 5%.

whether 0-ending price points which are associated with greater price rigidity, are also associated with larger price changes.

In Table 3, we report the estimation results of regressions equivalent to the ones we report in Table 2, but this time the dependent variable is the *size* of price changes in percent. To minimize the effect of outliers, we exclude from the analysis price changes that are more than 2.5 standard-deviations away from the mean.[5] We focus on cases in which the price has changed.

The coefficient estimates in columns (1), (3) and (5), are 1.14, 2.28 and 4.08, respectively, with the latter two being statistically significant. Thus, in the second sample period, an increase of one standard-deviation in the share of consecutive right-most zero endings is associated with an increase of $2.28 \times 0.178 = 0.41\%$ in the size of price changes, an increase of 3.3% relative to the average size, 12.4%.

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 prices changes implies an increase of 10.5 days in the average spell between price changes, from 56.7 to 67.2 days.[6] An increase

[5] We exclude from this analysis a total of 391 observations, which comprise 2% of all price changes.

[6] We calculate the implied spell as $-30\left[\ln\left(1-(0.411-0.0511)\right)\right]^{-1}$, where 0.411 is the average frequency of monthly price changes and 0.0511 is the change in the monthly frequency of price changes due to a one standard deviation increase in the share of rightmost 0s.

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 0-ending price points 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.

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[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.