Stuck at Zero: Price Rigidity in a Runaway Inflation

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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.

JEL Codes: E31, L16

Key Words: Sticky Prices, Rigid Prices, 0-Ending Price Points, 9-Ending Price points, Runaway Inflation, Hyperinflation, Cost of Price Adjustment, Menu Cost

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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), and Snir and Levy (2021) all study low inflationary environments.

We, in contrast, study a period of a runaway inflation. Using 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, and 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

[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).

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 Fisher 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 $-30\left[\ln\left(1-\overline{f}\right)\right]^{-1}$, where $\overline{f}$ 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.

Figure 1 demonstrates the behavior of prices by depicting, as an example, the price of cocoa

[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 ¼ = 0.25. NIS 10.00 has 3 consecutive right-most zero endings, with a share of ¾ = 0.75.

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 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%.

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[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.

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 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 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%

[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 $-30\left[\ln\left(1-\left(0.411-0.0511\right)\right)\right]^{-1}$, 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.

[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.

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.

[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.

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Table 1

Descriptive summary statistics, January 1978–October 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 price 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 $-30\left[\ln\left(1-\overline{f}\right)\right]^{-1}$, where $\overline{f}$ 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.

Table 2

Regressions of the probability of a price change

	January 1978–June 1979		January 1981–December1982		January 1984–October 1984	
	(1)	(2)	(3)	(4)	(5)	(6)
Share of right-most 0-endings	−0.27*** (0.053)	−0.21** (0.0477)	−0.20** (0.083)	−0.23** (0.087)	−0.21*** (0.038)	−0.15*** (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: $-30\left[\ln\left(1-\left(\overline{f}-d\right)\right)\right]^{-1}$, where $\overline{f}$ 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–December1982		January 1984–October 1984	
	(1)	(2)	(3)	(4)	(5)	(6)
Share of right-most 0-endings	1.15 (1.054)	1.62 (1.833)	2.28** (0.958)	2.47** (0.981)	4.08** (1.691)	5.69** (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. * $p < 10\%$. ** $p < 5\%$

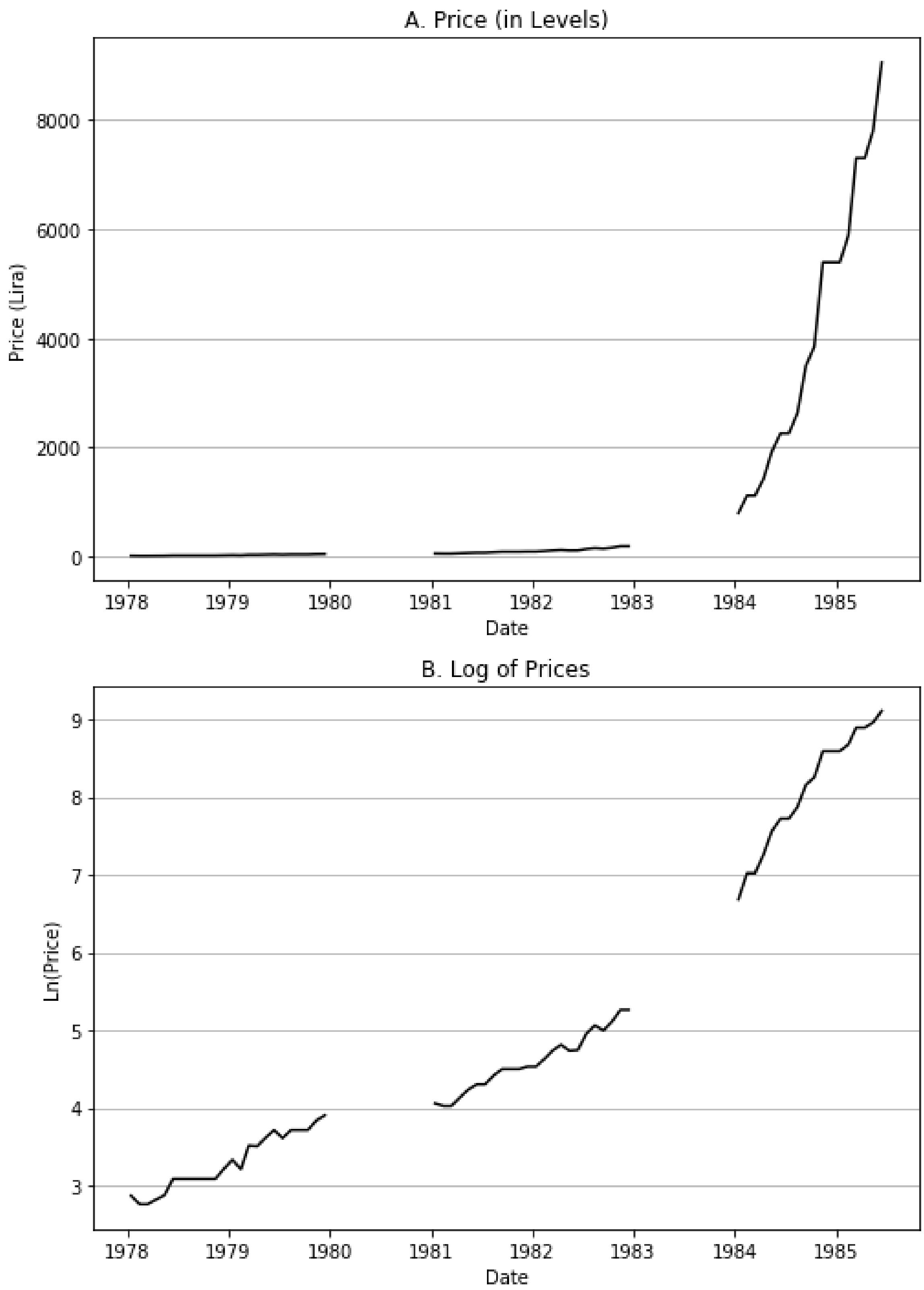

Fig. 1. The price of cocoa-powder, in Israeli Lira, at store 4527, January 1978–September 1984

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.

Online Supplementary Appendix

Stuck at Zero: Price Rigidity in a Runaway Inflation*

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A.1. Israeli inflation 1978–1985

After 1973, the expenditures of the Israeli public sector rose to about 75% of the GDP, resulting in a deficit of about 15%. A large part of this deficit was monetized, leading to inflation. During January 1973 to June 1979, the annual inflation rate was about 40% on average. After June 1979, the annual inflation rate jumped to about 100%, on average. Sussman (1992) suggests that this was the outcome of the liberalization of the foreign currency market enacted in 1979. The reduced controls and the freer access to foreign currency resulted in lower demand for the local currency, resulting in accelerated inflation.

In October 1983, the inflation rate increased once again, this time reaching an annual rate of about 400%. Sargent and Zeira (2011) note these three stages in the Israeli inflationary process and interpret it in the context of the "unpleasant monetary arithmetic" (Sargent and Wallace 1981). The public anticipated that the government debt was likely to increase and predicted that the increase would be financed via an increase in the money supply. In July 1985, the government enacted a comprehensive stabilization program, and inflation came down to around 20% (Fischer, 1987).

The three stages of the Israeli inflation can be seen in Figure A1, which depicts the monthly inflation rate for the period of January 1978 – December 1986. In the first sub-period, up to mid-1979, the average monthly inflation rate was 3.9%. In the second sub-period, from mid-1979 until September 1983, the average monthly inflation rate was 7.1%. In the third sub-period, from October 1983 until August 1985, the average monthly inflation rate was 15.0%. In the final months of 1985, the average monthly inflation rate came down to about 1.5%.

A.2. Summary statistics for the 26 entry-level-items in the sample

The dataset used by Lach and Tsiddon (1992, 1996, and 2007) includes observations on 26 CPI-ELIs (CPI Entry-Level-Items). These are: Arak (anise), beef for soup, challah bread, champagne, chicken breast, chicken liver, cocoa powder, cocoa powder, codfish, drumsticks (chicken legs), fish fillet, fresh beef, fresh beef liver, frozen beef liver, frozen goulash, hock wine, liquor, grey mullet (known as "buri" fish in Israel), red wine, rice, rose wine, steak, sweet red wine, tea, turkey breast, vodka, and white vermouth.

Table A1 presents the summary statistics for the 26 ELIs. We report these statistics separately for each of the three sub-periods: January 1978–June 1979, January 198–December 1982, and January 1984–October 1984. The first column in each panel gives the average price. The second panel gives the average percentage of the consecutive right-most zeros in the prices. The third column gives the average proportion of prices that changed in a given month. The fourth column gives the number of observations.

A.3. Robustness checks

A.3.1. Non-consecutive price changes

In this section, we report the results of several robustness checks that we conducted. In the paper, we define a price change only if we have observations for both month t and $t + 1$. Here we relax this restriction and define a price change as any deviation in the price between two consecutive observations (even if they are separated by a missing data point) that exceed 0.5%.

We estimate separate linear probability model regressions for January 1978–June 1979, January 1981–December 1982, and for January 1984–October 1984. These three sub-periods correspond to the three stages of inflation.

The dependent variable in all regressions is a dummy for a price change. It equals 1 if the price has changed between two consecutive observations, even if they are separated by more than one month, and 0 otherwise. The independent variable is the share of consecutive right-most 0-endings, which we define as the share of consecutive right-most zeros in the price.[1] The estimation results are reported in Table A2. Columns (1)–(2) are for January 1978–June 1979, columns (3)–(4) for January 1981–December 1982, and columns (5)–(6) for the January 1984–October 1984 sub-period. The regression equations in columns (1), (3), and (5) include fixed effects for products in addition to the share of 0-endings.

We find that in all three periods, an increase in the share of 0-ending prices is associated with a decrease in the likelihood of a price change. The coefficients for the first, second, and third sub-periods are -0.27, -0.18, and -0.22, respectively. All three

[1] A price such as NIS 10.50 has 1 consecutive right-most zeros and a total of 4 digits. The share of consecutive right-most zeros, therefore, is ¼ = 0.25. The 4-digit price of NIS 10.00 has 3 consecutive right-most zeros, with a share of consecutive right-most zeros that equals ¾ = 0.75.

coefficients are statistically significant, the first and third coefficients at the 1% level, and the second at the 5% level.

In the regressions in columns (2), (4), and (6), we replace the fixed effects for products with fixed effects for products×stores, and for the observation month. The estimation results remain qualitatively unchanged. The coefficients of the share of 0-ending prices for the first, second, and third periods are $-0.21, -0.19,$ and -0.19, respectively. All three of them are statistically significant, the first and the third coefficients at the 1% level, and the second at the 5% level.

Thus, changing the definition of a price change does not alter our main result: In all three inflationary sub-periods, prices with a high share of right-most consecutive zeros change less often than other prices.

A.3.2. Expanding the final inflationary sub-period to January 1984–June 1985

In the paper, we define the third sub-period as January 1984–October 1984, although we have data until June 1985. The reason is that during the November 1984–June 1985 period, the Israeli government tried two stabilization programs, which included general price controls and might have affected the pattern of price changes. Ultimately, however, the inflation did not slow down until after the stabilization program of July 1985.

In this section, we re-estimate the regressions for the third sub-period, but this time we are using the data for the full sample period, January 1984–June 1985. The estimation results are summarized in Table A3.

We find that the coefficients of the share of 0-ending prices are negative and significant. The coefficient is −0.21 in the regression in column (1), which includes fixed effects for products, and −0.19 in the regression in column (2), which includes fixed effects for products×stores and for months.

A.3.3. Using the number of consecutive right-most zeros rather than their share

As a robustness test, we change the definition of the main independent variable. Instead of defining it as the *share* of the right-most consecutive zeros, we define it as the *number* of the right-most consecutive zeros. The estimation results are summarized in Table A4.

Columns (1)–(2) are for January 1978–June 1979, columns (3)–(4) are for January 1981–December 1982, and columns (5)–(6) are for the January 1984–October 1984 sub-period. The regressions in columns (1), (3), and (5) include fixed effects for products in addition to the number of the consecutive right-most 0-endings.

As the figures in columns (1), (3), and (5) show, we find that in all three sub-periods, an increase in the number of the consecutive right-most 0-endings is associated with a decrease in the likelihood of a price change. The coefficients for the first, second, and third periods are -0.08, -0.04, and -0.03, respectively. All three coefficients are statistically significant, the first and third at the 1% level, and the second at the 10% level.

In the regressions in columns (2), (4), and (6), we include fixed effects for products×stores and for months. We find that the coefficients are still negative, -0.07, -0.04, and -0.02, for the first, second and third sub-periods, respectively. All three of them are statistically significant, the first and the third at the 1% level, and the second at the 5% level.

A.3.4. Estimations using prices in Lira

In February 1980, the Israeli Lira was replaced by the Shekel as a legal tender, at the exchange rate of 10 Lira = 1 Shekel. In the paper, we perform all the calculations and estimations involving the shares of consecutive right-most zeros for the period after this transition, in Shekel denominated prices because the posted prices during that period were in Shekels. However, we do not know how shoppers perceived the prices. For example, it could be that some of them kept on calculating and/or assessing the prices in Liras.[2]

To explore this possibility, we add another right-most zero to every price and calculate the share of consecutive right-most zeros after this addition. We employ the resulting figures as an independent variable in the regressions similar to the ones we estimate in the paper. However, we estimate the regressions only for the post-1980 period, because the Shekel replaced the Lira as a legal tender in 1980. The estimation results are summarized in Table A5.

[2] Marques and Dehaene (2004) study how numerical intuition for prices develops after a switch from one currency to another, like during the adoption of the Euro by the EU member countries.

In columns (1)–(2), we report the estimation results for the January 1981–December 1982 sub-period, and in columns (3)–(4), for the January 1984–September 1984 sub-period. The regressions in columns (1) and (3) include fixed effects for products in addition to the share of consecutive right-most 0-endings.

We find that in both sub-periods, an increase in the share of zero-endings is associated with a decrease in the likelihood of a price change. The coefficients for the two sub-periods are -0.20 ($p < 0.05$), and -0.20 ($p < 0.01$), respectively.

In the regressions in columns (2) and (4), we include fixed effects for products×stores and for months. We find that the coefficients are still negative: -0.23, and -0.15, for the two sub-periods, respectively. Both coefficients are statistically significant. Thus, estimating the regressions in terms of Lira does not change the main results: 0-endings are associated with a lower probability of a price change.

A.3.5. Zero-endings and the size of price changes with the outliers included

In the paper, we estimate the correlation between 0-endings and the size of price changes after we remove outliers. Here we repeat the estimation, but we use all observations, including the outliers. The estimation results are summarized in Table A6.

In columns (1)–(2), we report the estimation results for the January 1979 – July 1979 sub-period, in columns (3)–(4), for the January 1981–December 1982 sub-period, and in columns (5)–(6), for the January 1984–September 1984 sub-period. The regressions in columns (1), (3), and (5) include fixed effects for products in addition to the share of consecutive right-most 0-endings. We find that the coefficients in all three periods are positive: 0.86, 3.48, and 9.06, respectively. They are, however, not statistically significant.

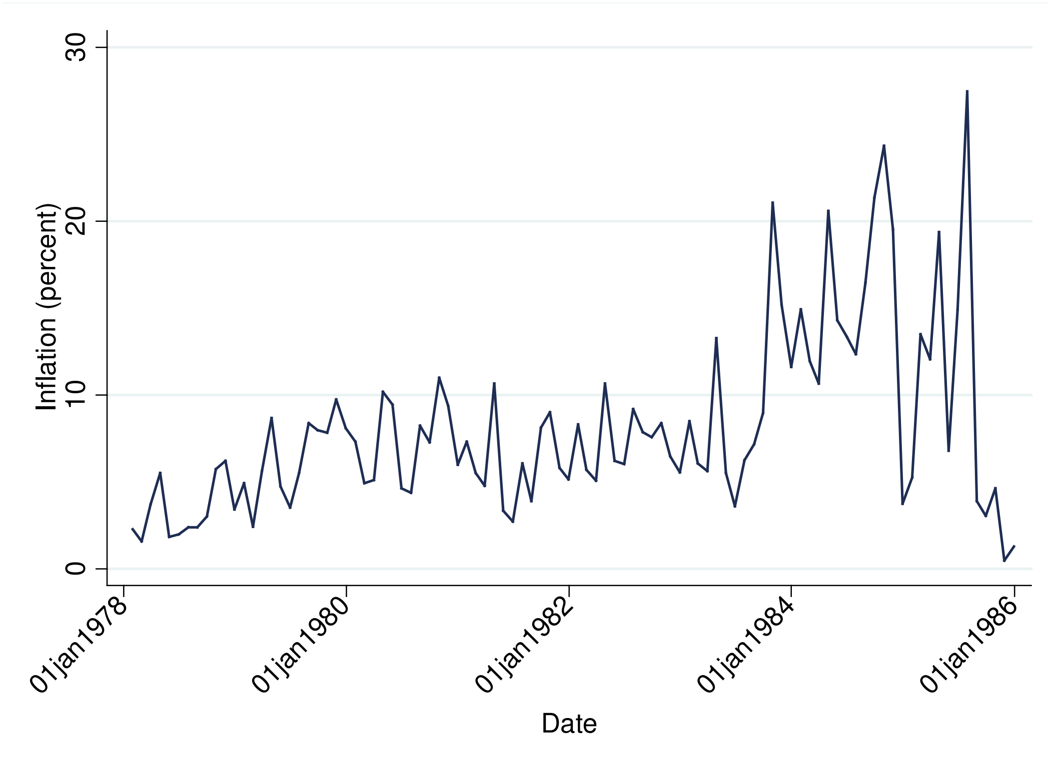
In the regressions in columns (2), (4) and (6), we include fixed effects for products×stores and for months. The coefficients remain positive: 1.24, 4.49 and 19.77 in the first, second and third periods, respectively. The second coefficient is significant at the 10% level. Thus, adding outliers does not change the direction of the effects – they remain positive. However, adding the outliers adds a lot of noise to the estimation, weakening the statistical significance of the coefficients.

A.4. Unit root tests

Our estimation is valid only if the time series data we are using is stationary. In this section, we show that for each period separately, Fischer type panel data unit-root test rejects the null hypothesis of a unit-root for our dependent and independent variables.

Table A7 reports the values of the test statistics for each sub-period. It can be seen from the table that for all sub-periods and for both variables, the null hypothesis of a unit root in all panels is strongly rejected.

Figure A1. Monthly inflation rate in Israel, January 1978–December 1985



Source: The Bank of Israel

Table A1. Summary statistics of the ELIs in the high inflation period data

	January 1978–June 1979				January 1981–December 1982				January 1984–October 1984			
ELI	**Average price**	**% 0-endings**	**% price changes**	***N***	**Average price**	**% 0-endings**	**% price changes**	***N***	**Average price**	**% 0-endings**	**% price changes**	***N***
Arak	31.157	28.176%	26.727%	333	35.047	39.264%	52.211%	475	368.462	50.131%	76.159%	151
	(7.579)	(17.119%)	(44.320%)		(18.038)	(17.763%)	(50.004%)		(194.504)	(16.377%)	(42.753%)	
Beef for soup	101.273	60.242%	47.059%	170	101.795	60.780%	64.567%	656	1292.395	67.420%	87.097%	217
	(18.929)	(15.562%)	(50.061%)		(48.046)	(13.029%)	(48.161%)		(67.421%)	(11.839%)	(33.601%)	
Challah bread	4.129	32.721	15.385%	247	8.285	35.398%	48.684%	304	118.379	45.533%	91.423%	105
	(0.908)	(21.894%)	(36.153%)		(4.367)	(22.312%)	(50.065%)		(55.379)	(18.706%)	(28.128%)	
Champagne	65.167	40.578%	23.500%	200	72.494	39.412%	48.035%	229	888.170	41.921%	75.510%	49
	(21.060)	(14.264%)	(42.506%)		(32.327)	(16.465%)	(50.071%)		(436.391)	(11.214%)	(43.448%)	
Chicken breast	74.023	52.855%	61.613%	620	87.908	53.134%	65.820%	787	1338.134	61.475%	94.444%	324
	(27.612)	(17.936%)	(48.672%)		(63.643)	(14.805%)	(47.462%)		(560.765)	(11.790%)	(22.942%)	
Chicken liver	92.703	59.466%	43.678%	522	108.816	55.258%	59.146%	820	1364.855	59.732%	85.231%	325
	(17.031)	(14.698%)	(49.646%)		(55.258)	(14.941%)	(49.186%)		(658.936)	(14.424%)	(35.534%)	
Cocoa powder	24.481	35.491%	44.552%	413	9.294	39.323%	48.908%	595	190.672	50.848%	79.167%	240
	(6.589)	(19.107%)	(49.763%)		(4.439)	(19.102%)	(50.030%)		(103.162)	(15.391%)	(40.697%)	
Codfish	37.462	49.561%	48.322%	298	47.406	55.328%	65.166%	422	674.598	63.685%	83.660%	153
	(10.443)	(17.119%)	(50.056%)		(23.714)	(14.080%)	(47.701%)		(307.470)	(17.155%)	(37.094%)	
Drumsticks	34.036	47.643%	59.637%	441	43.997	48.361%	67.868%	666	728.301	59.837%	95.038%	262
	(13.254)	(14.043%)	(49.182%)		(26.599)	(14.660%)	(46.733%)		(333.778)	(12.545%)	(21.757%)	
Fish fillet	31.535	49.482%	50.662%	302	35.877	53.217%	61.663%	433	512.158	64.507%	88.268%	179
	(8.0445)	(14.846%)	(50.079%)		(16.042)	(16.303%)	(48.677%)		(288.291)	(15.357%)	(32.270%)	
Fresh beef	92.724	52.348%	56.676%	704	120.358	58.065	64.685%	841	1580.099	65.769%	91.391%	302
	(24.299)	(18.709%)	(59.488%)		(59.634)	(15.148)	(47.823%)		(739.340)	(12.552%)	(28.097%)	
Fresh beef liver	83.779	60.900%	46.847%	444	103.873	63.752%	58.855%	559	1308.887	68.974%	81.951	205
	(21.613)	(17.480%)	(49.956%)		(47.607)	(12.994%)	(49.254%)		(663.853)	(13.774%)	(38.553%)	
Frozen beef liver	57.038	53.006%	56.561%	442	59.293	57.250%	60.137%	730	764.841	63.183%	88.525%	244
	(14.270)	(17.061%)	(49.624%)		(31.118)	(13.225%)	(48.995%)		(460.631)	(14.308%)	(31.938%)	
Frozen goulash	53.543	48.908%	39.148%	751	66.076	43.584%	56.277%	940	939.078	52.006%	90.959%	365
	(23.797)	(14.450%)	(48.841%)		(35.011)	(15.261%)	(49.631%)		(354.430)	(15.270%)	(28.716%)	
Hock wine	18.107	35.061%	23.649%	296	21.878	39.624%	46.640%	506	306.630	47.576%	75.373%	134
	(4.785)	(12.737%)	(42.564%)		(11.104)	(15.885%)	(49.936%)		(172.506)	(11.837%)	(43.245%)	
Liquor	34.968	40.038%	18.777%	229	53.310	37.893%	52.198%	182	804.859	46.099%	76.829%	82
	(13.760)	(13.189%)	(39.139%)		(34.216)	(16.683%)	(50.089%)		(492.770)	(14.432%)	(42.452%)	
Grey mullet	64.710	54.450%	58.159%	239	78.046	58.615%	73.723%	411	1189.726	67.048%	84.459%	148
	(15.876)	(18.323%)	(49.433%)		(40.713)	(14.976%)	(44.068%)		(731.540)	(16.319%)	(36.352%)	
Red wine	18.517	38.123%	23.453%	307	23.120	36.349%	48.471%	425	301.539	48.672%	69.811%	106
	(5.512)	(13.896%)	(42.440%)		(12.674)	(14.726%)	(50.036%)		(160.791)	(12.943%)	(46.126%)	
Rice	12.784	39.345%	30.295%	373	13.558	42.511%	55.984%	493	160.879	54.681%	80.676%	207
	(1.446)	(14.064%)	(46.015%)		(4.691)	(14.364%)	(49.691%)		(98.528)	(12.628%)	(39.579%)	
Rose wine	24.888	39.735%	21.933%	269	32.531	42.794%	51.456%	412	497.100	46.889%	78.495%	93
	(7.320)	(14.640%)	(41.456%)		(18.016)	(14.363%)	(50.040%)		(284.349)	(12.274%)	(41.309)	
Steak	102.459	56.149%	52.137%	468	136.518	60.497%	62.519%	659	1792.29	66.381%	86.381%	257
	(28.431)	(14.101%)	(50.001%)		(65.983)	(11.415%)	(48.444%)		(842.881)	(10.998%)	(34.366%)	
Sweet red wine	20.086	36.277%	21.294%	371	27.238	37.698%	47.790%	362	329.594	48.425%	66.667%	129
	(6.098)	(13.712%)	(40.994%)		(15.255)	(14.895%)	(50.020%)		(169.920)	(11.726%)	(47.324%)	
Tea	8.745	36.486%	23.505%	485	11.705	35.534%	49.157%	415	225.900	50.789%	75.309%	162
	(0.795)	(23.065%)	(42.447%)		(4.980)	(19.941%)	(50.053%)		(104.737)	(12.189%)	(43.255%)	
Turkey breast	89.700	53.276%	60.412%	437	103.884	55.460%	69.231%	520	1324.909	60.107%	90.110%	182
	(25.775)	(16.345%)	(48.960%)		(59.480)	(13.290%)	(46.198%)		(752.998)	(14.809%)	(29.935%)	
Vodka	34.654	35.317%	22.569%	288	38.354	38.118%	49.550%	333	430.561	50.456%	69.492%	118
	(9.965)	(15.477%)	(41.877%)		(21.742)	(15.683%)	(50.073%)		(247.200)	(15.397%)	(46.241%)	
White vermouth	30.363	39.831%	22.472	267	32.530	35.178%	46.957%	230	543.966	42.069%	78.082	73
	(7.342)	(14.811%)	(41.818%)		(15.018)	(15.355%)	(50.016%)		(294.294)	(6.900%)	(41.655	

Notes: The table reports the summary statistics for the 26 ELIs in the sample. The first panel covers the data for the period January 1978–June 1979. The second panel covers the data for the period January 1981–December 1982. The third panel covers the data for the period January 1984–October 1984. The first column in each panel reports the average price. The second column reports the average percentage of consecutive right-most zeros in the prices. The third column reports the average percentage of prices that changed in a given month. The fourth column gives the number of observations. In parentheses are the standard deviations. Prices in the first panel are in Lira. Prices in the second and third panels are in Shekel (10 Lira = 1 Shekel).

Table A2. Price rigidity in case of non-consecutive price changes

	January 1978–June 1979		January 1981–December 1982		January 1984–October 1984	
	(1)	(2)	(3)	(4)	(5)	(6)
Share of consecutive right-most 0-endings	−0.27*** (0.053)	−0.21** (0.048)	−0.18** (0.083)	−0.19** (0.088)	−0.22*** (0.036)	−0.19*** (0.031)
Fixed effect for products	Yes	No	Yes	No	Yes	No
Fixed effect for product-store	No	Yes	No	Yes	No	Yes
Fixed effect for month	No	Yes	No	Yes	No	Yes
R^2	0.0010	0.0010	0.0002	0.0002	0.0007	0.0007
N	9,916	9,916	13,904	13,904	5,224	5,224

Notes: The table presents the results of estimating regressions of the probability of a price change. The dependent variable in all regressions is a dummy that equals 1 if a price has changed between consecutive observations. Columns (1), (3), and (5) report the results of OLS regressions. Columns (2), (4), and (6) report the results of fixed effect regressions. The main independent variable is the share of right-most consecutive zeros in the price. The regressions in columns (1), (3), and (5) include fixed effects for products. The regressions in columns (2), (4), and (6) include fixed effects for products×stores and for months. The R^2's are the overall R^2. Robust standard errors, clustered at the product level, are reported in parentheses. ** $p < 5\%$, *** $p < 1\%$

Table A3. Expanding the final inflationary sub-period to January 1984–June 1985

	(1)	**(2)**
Share of consecutive right-most 0-endings	−0.21*** (0.037)	−0.19*** (0.048)
Fixed effects for products	Yes	No
Fixed effects for product-store	No	Yes
Fixed effects for month	No	Yes
R^2	0.0000	0.0000
N	9,916	9,916

Note: The table presents the results of estimating regressions of the probability of a price change. The dependent variable in both regressions is a dummy that equals 1 if a price has changed between month $t-1$ and month t. The main independent variable is the share of right-most consecutive zeros in the price. The regression in column (1) includes fixed effects for products. The regression in column (2) includes fixed effects for products×stores and for months. The R^2's are the overall R^2. Robust standard errors, clustered at the product level, are reported in parentheses. *** $p < 1\%$

Table A4. Using the number of consecutive right-most zeros as the independent variable

	January 1978–June 1979		January 1981–December 1982		January 1984–October 1984	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Number of consecutive right-most 0-endings	−0.08*** (0.013)	−0.07*** (0.012)	−0.04* (0.021)	−0.05** (0.021)	−0.03*** (0.007)	−0.02*** (0.006)
Fixed effects for products	Yes	No	Yes	No	Yes	No
Fixed effects for product-store	No	Yes	No	Yes	No	Yes
Fixed effects for month	No	Yes	No	Yes	No	Yes
R^2	0.0020	0.0020	0.0009	0.0009	0.0002	0.0002
N	9,916	9,916	13,405	13,405	4,812	4,812

Notes: The table reports the results of estimating regressions of the probability of a price change. The dependent variable in all regressions is a dummy that equals 1 if a price has changed between month $t-1$ and month t. Columns (1), (3), and (5) report the results of OLS regressions. Columns (2), (4), and (6) report the results of fixed effect regressions. The main independent variable is the number of right-most consecutive zeros in the price. The regressions in columns (1), (3), and (5) include fixed effects for products. The regressions in columns (2), (4), and (6) include fixed effects for products×stores and for months. The R^2's are the overall R^2. Robust standard errors, clustered at the product level, are reported in parentheses. * $p < 10\%$, ** $p < 5\%$, *** $p < 1\%$

Table A5. Probability of a price change when prices are denoted in Israeli Liras instead of Shekels

	January 1981–December 1982		January 1984–October 1984	
	(1)	**(2)**	**(3)**	**(4)**
Share of consecutive right-most 0-endings	−0.20** (0.083)	−0.23** (0.087)	−0.20*** (0.038)	−0.15*** (0.037)
Fixed effect for products	Yes	No	Yes	No
Fixed effect for product-store	No	Yes	No	Yes
Fixed effect for month	No	Yes	No	Yes
R^2	0.0000	0.0001	0.0003	0.0003
N	13,405	13,405	4,812	4,812

Notes: The table reports the results of estimating regression equations for the probability of a price change. The dependent variable in all regressions is a dummy that equals 1 if a price has changed between month $t-1$ and month t. Columns (1), and (3) report the results of OLS regressions. Columns (2) and (4) report the results of fixed effect regressions. The main independent variable is the share of right-most consecutive zeros in the price. The regressions in columns (1) and (3) include fixed effects for products. The regressions in columns (2) and (4) include fixed effects for products×stores and for months. The R^2's are the overall R^2. Robust standard errors, clustered at the product level, are reported in parentheses. ** $p < 5\%$, *** $p < 1\%$

Table A6. Absolute size of price changes, with the outliers included

	January 1978–June 1979		January 1981–December1982		January 1984–October 1984	
	(1)	(2)	(3)	(4)	(5)	(6)
Share of right-most zero endings	0.86 (1.035)	1.24 (1.784)	3.48 (2.129)	4.49* (2.323)	9.06 (6.43)	19.77 (16.656)
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	0.0006	0.0006	0.0000	0.0000	0.0001	0.0001
N	7,755	7,755	7802	7802	4,073	4,073

Notes: The table reports the results of OLS regressions of the absolute size of price changes. The dependent variable in all regressions is the absolute size of price changes between month $t-1$ and month t, in the case where the price has changed. The main independent variable is the share of consecutive right-most zero endings in the price. The regressions in columns (1), (3) and (5) include fixed effects for products. The regressions in columns (2), (4) and (6) include fixed effects for products×stores and for months. The R^{2}'s are the overall R^2. Robust standard errors, clustered at the product level, are reported in parentheses. * $p < 10\%$. ** $p < 5\%$

Table A7. Fischer type panel data unit root test

	January 1978–June 1979	**January 1981–December 1982**	**January 1984–October 1984**
Price-change	7,432.9	11,500.0	2,273.0
Share of consecutive right-most 0-endings	3,536.3	6,135.6	4,194.1

Notes: The table presents the results of Fischer type panel data unit-root tests for each of the three sub-periods. The test statistic follows the χ^2 distribution.

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