Title:

Analysis of Price Setting Behavior in Iran: Micro Evidence

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Submission of Conference Paper for the International Conference on Iran’s Economy, 24-25 June 2013, Bilgi University, Istanbul, Turkey
Motivation

One of the starting points of many macroeconomic models for monetary policy analysis is that due to the existence of sticky prices, monetary policy has short-term real effects on goods and services produced.

Both theoretical modeling and empirical work have been developed to show the real effects of monetary policy when sticky prices are present. However, recent researches on the frequency of price adjustment using micro data have cast some doubt on the validity of some of the popular models of infrequent price adjustment.
Goals of Our Paper:

1. The first goal of this paper is to present some stylized facts about price setting behavior, in Iran such as: frequency of price changes, size of price changes, etc.

2. The second goal of this paper is to evaluate credibility of models of infrequent price adjustment for monetary policy analysis for Iran.
Contents

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- Summary
a pioneer work by Bils and Klenow (2004) released the first study for the US.

Studies for Europe:

Studies for American countries:

Such Studies for Asian countries are very few. For instance, Baharad and Eden (2004) and Saita et al (2006) studied price setting behavior for Israel and Japan.
Data Description

Although most of studies examining the price setting at micro level have used CPI Price quotes data, but Due to the unavailability and lack of access to price quotes, we inevitably use the monthly sectoral price indices. The sectoral price indexes are available at different levels of disaggregation: from least disaggregate (12 major groups) to most disaggregate (359 items of goods and services). Focusing on the most disaggregated retail prices in this paper, we use the monthly price indices of 359 items of goods and services (272 goods and 87 items of services). The sample used for analysis, begins in 1383:1 (2004:3/4) and ends in 1390:7 (2011:9/10).
Methodology

Frequency of price Changes

\[ I_{it} = \begin{cases} 
1 & \text{if } p_{it} \neq p_{it-1} \\
0 & \text{if } p_{it} = p_{it-1} 
\end{cases} \]

\[ K_i = \{0 \leq t \leq T, I_{it} \in \{0,1\}\} \]

\[ f_i = \frac{\sum I_{it}}{T - 1} \]

Let \( N_g \) be the number of items in group \( g, g = 1, \ldots, G \)

the frequency of price changes for group \( g \) is the weighted average

frequency across items in that group. we have 12 major groups so \( G=12 \).

\[ f_g = \sum_{i=1}^{N_g} \frac{W_i}{W_g} f_i \]
\[ f = \sum_{g=1}^{G} w_g f_g \]

Assume \( I_{it}^+ = 1 \) if \( p_{it} > p_{it-1} \)

\[ f^+ = \sum_{g=1}^{G} w_g \sum_{i=1}^{N_g} \frac{w_i}{w_g} \left( \frac{\sum_{t \in K_i} I_{it}^+}{T - 1} \right) = \sum_{g=1}^{G} \sum_{i=1}^{N_g} w_i \left( \frac{\sum_{t \in K_i} I_{it}^+}{T - 1} \right) \]

Similarly, \( I_{it}^- = 1 \) if \( p_{it} < p_{it-1} \)

\[ f^- = \sum_{g=1}^{G} w_g \sum_{i=1}^{N_g} \frac{w_i}{w_g} \left( \frac{\sum_{t \in K_i} I_{it}^-}{T - 1} \right) = \sum_{g=1}^{G} \sum_{i=1}^{N_g} w_i \left( \frac{\sum_{t \in K_i} I_{it}^-}{T - 1} \right) \]

\[ f_{it}^+ = \sum_{i=1}^{P_t} w_i I_{it}^+ \]

\[ f_{it}^- = \sum_{i=1}^{n_t} w_i I_{it}^- \]
Duration of Price Changes

\[ D_g = \frac{-1}{\ln (1 - f_g)} \]

\[ D_g = \frac{1}{f_g} \]

\[ D = \frac{-1}{\ln(1 - \sum_{g=1}^{G} w_g f_g)} \]

Hazard Function

A price hazard function, defined as a conditional probability of price changes in terms of time, is a key concept in understanding price setting behavior. Empirical hazard functions are calculated by the Kaplan-Meier product limit estimator.
\[ p_t = \frac{d_t}{r_t} \]

Where \( d_t \) is the number of data whose prices were revised in period \( t \) and \( r_t \) is the risk set in period \( t \). The risk set \( r_t \) is the number of spells at risk in period \( t \). The term *spell* means the duration of prices, that is, the length of time in which the price is fixed.

**Size of price changes**

\[
\Delta p_i = \frac{\sum_{t \in K_i} |\Delta p_{it}|}{f_i}
\]

\[
\Delta p_{it} = \log(p_{it}) - \log(p_{it-1})
\]

\[
\Delta p = \sum_{i=1}^{N} w_i \Delta p_i
\]
\[ \Delta p_t^+ = \frac{\sum_{i=1}^{p_t} w_i \Delta p_{it}^+}{\sum_{i=1}^{p_t} w_i} \]

\[ \Delta p_t^- = \frac{\sum_{i=1}^{n_t} w_i \Delta p_{it}^-}{\sum_{i=1}^{n_t} w_i} \]
Results

Frequency of price changes

Figure (1). Distribution of average monthly frequency of price change
Table (1). Weighted mean frequency of price change and duration (all items)

<table>
<thead>
<tr>
<th>study</th>
<th>weighted mean frequency</th>
<th>weighted mean positive frequency</th>
<th>weighted mean negative frequency</th>
<th>percentage of positive frequency</th>
<th>Pseudo duration</th>
<th>implied duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Klenow and Kryvtso (2008)</td>
<td>29.9</td>
<td>United States</td>
<td>0.17</td>
<td>0.19</td>
<td>51.5</td>
<td>46.1</td>
</tr>
<tr>
<td>Aucremanne and Dhyne (2004)</td>
<td>0.22</td>
<td>Belgium</td>
<td>0.17</td>
<td>0.19</td>
<td>29.9</td>
<td>24.1</td>
</tr>
<tr>
<td>Baudry et al. (2007)</td>
<td>0.19</td>
<td>France</td>
<td>0.17</td>
<td>0.19</td>
<td>29.9</td>
<td>24.1</td>
</tr>
<tr>
<td>Dias et al. (2004)</td>
<td>0.22</td>
<td>Portugal</td>
<td>0.17</td>
<td>0.19</td>
<td>29.9</td>
<td>24.1</td>
</tr>
<tr>
<td>Kovanen (2006)</td>
<td>51.5</td>
<td>Sierra Leone</td>
<td>0.17</td>
<td>0.19</td>
<td>29.9</td>
<td>24.1</td>
</tr>
<tr>
<td>Medina et al. (2007)</td>
<td>46.1</td>
<td>Chile</td>
<td>0.17</td>
<td>0.19</td>
<td>29.9</td>
<td>24.1</td>
</tr>
</tbody>
</table>
Assessing the heterogeneity in price stickiness across main consumption categories

Figure (2). Average monthly frequency of price changes (increases & decreases) for main groups (%)
Figure (3). Frequency of subgroups of “Food & Beverages”
Size of price changes

Figure (4). Distribution of monthly average absolute size of price changes (all items)
Figure (5). Average monthly change by main categories of CPI (in percent per month)
Is there a clear relationship between the size and frequency of price changes?

- Similar to the frequency of price changes of main groups, there is substantial heterogeneity in average size of price adjustment across the consumption groups.

- The monthly average rate of price increases is very high for “education” (6.94%). The frequency of price increases for this group is rather low relative to other groups (29.4%).

- The monthly average rate of price increases is very low for “transportation” and “communication” groups (0.56 and 0.83 percent). The frequency of price increases for “communication” is very low (3.4%), whereas the frequency of price increases for “transportation” is rather high (45%).

- As a result, a high (low) frequency of price changes does not necessarily indicate high (low) size of price changes.
Factors affecting the frequency and size of consumer price changes
Figure (6). The time series of the frequency of price increases and decreases (for all items)
Figure (7). The time series of the size of price increases and decreases (for all items)
These explanatory factors can be classified in three broad types:

1) **Time dependent factors** (seasonal patterns, hazard function)
2) **state dependent factors** (macroeconomic variables)
3) **other factors** (like price regulations)

In this paper we examine the effects of the seasonality and hazard function (as the time-dependant factors) and the level of inflation (as a state-dependant factor) on frequency and size.

Due to the fact that **price regulations** are common in Iranian economy and there are some institutions for monitoring the pricing procedure (like “Governmental Discretionary Punishments Organization” and “consumers and producers protection organization”), further researches should be done to assess their effects on the frequency and size of price changes.
The frequency of price decreases range from 8% to 13%.
The existence of seasonal pattern in the frequency of price changes has not been proved by Iranian consumer price data.
there is evidence of seasonality in the average size of price decreases.
4th and 2th months reveal the highest size of price decreases (8.1 % and 7.6%) whereas in M11 the lowest size of price decreases is observed (3.4%).
However, the rather small difference in size of price increases by month doesn’t indicate the existence of seasonal pattern.

Time dependency is not supported.
Hazard Function

The shape of the hazard function of price changes is a key feature in analyzing the pricing behavior.

Calvo (1983) model assumes a flat hazard function

Taylor (1980) model predicts a zero hazard except at a single age, where the hazard is one.

Menu-cost models can generate a variety of shapes, depending on, among other things, the relative importance of transitory and permanent shocks to marginal costs. Permanent shocks, which accumulate over time, tend to yield an upward sloping hazard function, while transitory shocks tend to flatten or even produce a downward-sloping hazard function (e.g., sellers may be more attentive to getting prices right when revenue is temporarily high for a product due to idiosyncratic supply or demand considerations).
Our finding shows that hazard function is downward-sloping.

The hazard function does not support Calvo and Taylor time-dependent models.
State-dependant factors
The correlation of the level of inflation with the frequency and size of price changes

- According to the state dependant pricing models, the state of the economy is likely to influence price setting behavior of firms.
- One of the important variables describing the macroeconomic condition is inflation rate.
- We expect that the higher level of inflation increases the fraction of firms increasing their prices and also the magnitude of this adjustment increase in these periods and vice versa.

<table>
<thead>
<tr>
<th>variable</th>
<th>Mean</th>
<th>Std dev</th>
<th>Regression on inflation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>coefficient</td>
</tr>
<tr>
<td>$f_{t}^+$</td>
<td>0.65</td>
<td>0.103</td>
<td>4.65</td>
</tr>
<tr>
<td>$f_{t}^-$</td>
<td>0.11</td>
<td>0.048</td>
<td>-2.53</td>
</tr>
<tr>
<td>$\Delta p_{t}^+$</td>
<td>0.03</td>
<td>0.008</td>
<td>0.75</td>
</tr>
<tr>
<td>$\Delta p_{t}^-$</td>
<td>0.05</td>
<td>0.027</td>
<td>-0.980</td>
</tr>
</tbody>
</table>
The relation between the frequency and inflation in main groups

<table>
<thead>
<tr>
<th>Main categories</th>
<th>F⁺</th>
<th>F⁻</th>
<th>Price increase inflation</th>
<th>Price decreases inflation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Food &amp; Beverages</td>
<td>61.09</td>
<td>24.76</td>
<td>9.476 (0.0000)</td>
<td>-7.169 (0.0000)</td>
</tr>
<tr>
<td>2 Tobacco</td>
<td>58.5</td>
<td>19.8</td>
<td>-2.7903 (0.5403)</td>
<td>-1.522 (0.6385)</td>
</tr>
<tr>
<td>3 Clothing and Footwear</td>
<td>71.37</td>
<td>7.21</td>
<td>4.687 (0.0272)</td>
<td>-2.319 (0.0188)</td>
</tr>
<tr>
<td>4 Housing, water, electricity, gas &amp;...</td>
<td>84.92</td>
<td>0.72</td>
<td>1.685 (0.6271)</td>
<td>-0.175 (0.1347)</td>
</tr>
<tr>
<td>5 Furnishings, household equipment…</td>
<td>63.88</td>
<td>5.58</td>
<td>5.258 (0.0118)</td>
<td>-2.136 (0.054)</td>
</tr>
<tr>
<td>6 Medical care</td>
<td>65.14</td>
<td>1.71</td>
<td>0.8247 (0.5807)</td>
<td>0.3135 (0.3264)</td>
</tr>
<tr>
<td>7 Transportation</td>
<td>45.01</td>
<td>12.84</td>
<td>4.18 (0.0529)</td>
<td>-3.268 (0.0828)</td>
</tr>
<tr>
<td>8 Communication</td>
<td>3.45</td>
<td>6.6</td>
<td>-0.2225 (0.6873)</td>
<td>-2.026 (0.0088)</td>
</tr>
<tr>
<td>9 Recreation &amp; culture</td>
<td>31.57</td>
<td>15.07</td>
<td>2.845 (0.0506)</td>
<td>-1.194 (0.359)</td>
</tr>
<tr>
<td>10 Education</td>
<td>29.44</td>
<td>1.08</td>
<td>0.613 (0.8524)</td>
<td>0.0393 (0.9511)</td>
</tr>
<tr>
<td>11 Restaurants &amp; hotels</td>
<td>89.58</td>
<td>0.64</td>
<td>4.134 (0.0207)</td>
<td>-0.304 (0.3567)</td>
</tr>
<tr>
<td>12 Miscellaneous goods and services</td>
<td>65.12</td>
<td>2.35</td>
<td>3.366 (0.0145)</td>
<td>-0.275 (0.5497)</td>
</tr>
</tbody>
</table>
### The relation between the size and inflation in main groups

<table>
<thead>
<tr>
<th>Main categories</th>
<th>( S^+ )</th>
<th>( S^- )</th>
<th>Price increase</th>
<th>( R^2 )</th>
<th>Price decrease</th>
<th>( R^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Food &amp; Beverages</td>
<td>0.0425</td>
<td>0.06</td>
<td>1.27</td>
<td>(0.0000)</td>
<td></td>
<td>-1.28</td>
</tr>
<tr>
<td>2 Tobacco</td>
<td>0.014</td>
<td>0.003</td>
<td>0.034</td>
<td>(0.8408)</td>
<td></td>
<td>0.047</td>
</tr>
<tr>
<td>3 Clothing and Footwear</td>
<td>0.0126</td>
<td>0.006</td>
<td>0.26</td>
<td>(0.0003)</td>
<td></td>
<td>0.044</td>
</tr>
<tr>
<td>4 Housing, water, electricity, gas &amp;...</td>
<td>0.0126</td>
<td>0.009</td>
<td>0.75</td>
<td>(0.0000)</td>
<td></td>
<td>-0.05</td>
</tr>
<tr>
<td>5 Furnishings, household equipment…</td>
<td>0.0132</td>
<td>0.004</td>
<td>0.32</td>
<td>(0.0026)</td>
<td></td>
<td>-0.054</td>
</tr>
<tr>
<td>6 Medical care</td>
<td>0.0176</td>
<td>0.019</td>
<td>0.025</td>
<td>(0.8125)</td>
<td></td>
<td>-0.131</td>
</tr>
<tr>
<td>7 Transportation</td>
<td>0.015</td>
<td>0.0078</td>
<td>0.21</td>
<td>(0.2622)</td>
<td></td>
<td>0.014</td>
</tr>
<tr>
<td>8 Communication</td>
<td>0.011</td>
<td>0.0168</td>
<td>0.12</td>
<td>(0.5452)</td>
<td></td>
<td>-0.137</td>
</tr>
<tr>
<td>9 Recreation &amp; culture</td>
<td>0.0210</td>
<td>0.0154</td>
<td>0.54</td>
<td>(0.0049)</td>
<td></td>
<td>-0.165</td>
</tr>
<tr>
<td>10 Education</td>
<td>0.0199</td>
<td>0.0006</td>
<td>0.175</td>
<td>(0.6369)</td>
<td></td>
<td>-0.02</td>
</tr>
<tr>
<td>11 Restaurants &amp; hotels</td>
<td>0.0132</td>
<td>0.0005</td>
<td>0.178</td>
<td>(0.0223)</td>
<td></td>
<td>-0.006</td>
</tr>
<tr>
<td>12 Miscellaneous goods and services</td>
<td>0.0144</td>
<td>0.0043</td>
<td>0.133</td>
<td>(0.2211)</td>
<td></td>
<td>0.1765</td>
</tr>
</tbody>
</table>
Identifying the pattern of pricing

In addition to regressing the frequency and size of price changes on the rate of inflation, there are two methods proposed in literature for recognizing the pattern of pricing (Klenow and Kryvtsov (2008)).

1. variance decomposition of the inflation rate
2. simulating the sticky price models
Variance decomposition

- One way to show the state or time dependency of price setting is to decompose the variance of the inflation rate into the variance of the average size of price change, the variance of the fraction changing price, and their covariance.

- As proposed by Klenow and Kryvtsov (2008), if the variance of the average size of price change (named the intensive margin) has a considerable share in explaining the variance of inflation, then we can deduce that the pricing pattern may be time dependant.

- In a general manner, Different models of price-setting have clear implications for this decomposition.

- In the perfectly staggered price setting models like Taylor and Calvo model, the intensive margin will account for all of inflation’s variance, whereas the fraction of items changing price plays an important role in some SDP models, such as Dotsey, King and Wolman (1999).
Variance decomposition

\[ \pi_t = f_t \ast \Delta p_t \]

\[ f_t = \sum_{i \in n} w_i I_{it} \quad \Delta p_t = \frac{\sum_{i \in n} w_i \Delta p_{it}}{\sum_{i \in n} w_i I_{it}} \]

First - Order Taylor-series expansion

\[ \pi_t \sim \bar{fr} \bar{dp} + \bar{fr}(dp_t - \bar{dp}) + \bar{dp}(fr_t - \bar{fr}) \]

\[ \pi_t \sim \bar{frdp}_t + \bar{dpfr}_t - \bar{fr} \bar{dp} \]

\[ \text{var}(\pi_t) = \bar{fr}^2 \text{var}(dp_t) + \bar{dp}^2 \text{var}(fr_t) + 2\bar{fr} \bar{dp} \text{cov}(fr_t, dp_t) + 0_t \]

\[ \text{TD term (IM)} \quad \text{SD term (EM)} \]
Results of decomposition

- **TD term** accounts for about **92%** of variance of inflation.

- Fluctuations in the average size of price changes played an important role in the dynamics of inflation over the sample period while the movements in the frequency of price changes has a minor role.

- This finding indicates that the pattern of pricing at micro level in Iran might follow a time dependant model.
Now this question arises whether a possible reason for **minor role of SD term** is that the movements in the frequency of price increases and decreases offset each other and results in little variation in the overall frequency of price changes.

**Gagnon (2009)** first emphasized the usefulness of further decomposing inflation in terms of price increases and decreases.
We can decompose the variance of inflation into 4 components (in addition to covariance terms) including: variance of positive fraction, negative fraction, positive size and negative size.

\[
\pi_t = f_t^+ \cdot \Delta p_t^+ - f_t^- \cdot \Delta p_t^-
\]

\[
\pi_t = \left( \sum_{i \in \eta_t^+} w_i I_{it}^+ \right) \left( \frac{\sum_{i \in \eta_t^+} w_i \Delta p_{it}^+}{\sum_{i \in \eta_t^+} w_i I_{it}^+} \right) + \left( \sum_{i \in \eta_t^-} w_i I_{it}^- \right) \left( \frac{\sum_{i \in \eta_t^-} w_i \Delta p_{it}^-}{\sum_{i \in \eta_t^-} w_i I_{it}^-} \right)
\]

**First-order Taylor-series expansion**

\[
\pi_t = \overline{\Delta p}^+ f_t^+ + \overline{f}^+ \Delta p_t^+ - \overline{f}^- \Delta p_t^- - \overline{\Delta p}^- f_t^- + \overline{\Delta p}^+ \overline{\Delta p}^- + O_t
\]

\[
\text{var}(\pi_t) = \overline{\Delta p}^{+2} \text{var}(f_t^+) + \overline{f}^{+2} \text{var}(\Delta p_t^+) + \overline{f}^{-2} \text{var}(\Delta p_t^-) + \overline{\Delta p}^{-2} \text{var}(f_t^-) + 2 \overline{\Delta p}^+ \overline{f}^+ \text{cov}(f_t^+, \Delta p_t^+) - 2 \overline{\Delta p}^- \overline{f}^- \text{cov}(f_t^+, \Delta p_t^-) - 2 \overline{\Delta p}^+ \overline{\Delta p}^- \text{cov}(f_t^+, f_t^-) - 2 f_t^+ f_t^- \text{cov}(\Delta p_t^+, \Delta p_t^-) - 2 \overline{\Delta p}^- \overline{f}^+ \text{cov}(f_t^-, \Delta p_t^+) + 2 \overline{\Delta p}^- \overline{f}^- \text{cov}(f_t^-, \Delta p_t^-) + O_t
\]

\[
\text{var}(\pi_t) = IM^+ + IM^- + EM^+ + EM^-
\]
Results

- Ignoring the covariance terms and high order terms (because of their small share), the positive (negative) average size of price changes ($IM^+ (IM^-)$) account for about 42% and 13% while the positive (negative) fraction ($EM^+ (EM^-)$) account for 10.56% and 10.40%.

- We find that average size of price increases are the most important factors driving inflation movements.

- If there is high degree of heterogeneity in pattern of pricing between main categories of CPI, performing the variance decomposition at aggregate level might be misleading. For future research, performing Variance decomposition of 12 main categories of CPI might be useful for recognizing the pattern of pricing in major sectors.
Summary of main stylized facts about pricing behavior

- Consumer prices are **highly flexible**. The average monthly frequency of price changes is 75.5%, so that prices change on average once every 1.3 months (if we assume that prices are changed at most once per month). Alternatively, if we assume that prices can be changed at any moment, according to the amount of estimated duration (0.7 month), consumer prices are changed once every 20 days.

- Price decreases are less frequent than price increases (86% of price changes are price increases). So, there is a high degree of **downward rigidity**. This finding is consistent with high and chronic inflation in Iran economy.

- There is a considerable amount of heterogeneity in the **frequency of price changes** among main categories of CPI. The frequency of price changes is highest for “Restaurants and Hotels” and “food & beverages”, while the frequency is lowest for “communication” and “education”.
Summary of main stylized facts about pricing behavior

- Heterogeneity is also noticeable for the size of price changes across main consumption categories. A high (low) frequency of price changes does not necessarily indicate high (low) size of price changes.

- Both the frequency and size of price changes depend on the inflation rate. This stylized fact is consistent with state-dependent pricing model. Whenever, the inflation is high, price increases are more frequent and the size of price increases is larger (vice versa). However, note that the effect of inflation rate on average size of price changes is stronger than the corresponding effect on the frequency of price changes.

- According to the results of variance decomposition of inflation, fluctuations in the average size of price changes played an important role in the dynamics of inflation over the sample period while the movements in the frequency of price changes has a minor role. This finding indicates that the pattern of pricing at micro level in Iran might follow a time dependant model.
Future research

In this paper, we have analyzed the price setting behavior at consumer level. Examining the price setting behavior at the **producer level** and compare it with the stylized facts at consumer is the subject of our future research.
Thanks