# Discussion of Price-Setting Behaviour in Euro Area: Evidence from PPI Micro Dada

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# 1 Introduction

- Contributors to this session ought to be congratulated for their most interesting and insightful papers. I learned a great deal and would like to thank ECB and the member country Central Banks for making this possible.
- The rich data sets analyzed and the stylized "facts" obtained will provide researchers with many challenging empirical and theoretical issues for years to come.
- The main findings of these studies are also likely to have important implications for the theory and practice of monetary policy.

# 2 Summary of the Main Findings of the PPI Studies

- Frequency of price changes differ markedly across different commodity groups.

- For given commodity groups the frequency of price changes is quite similar across countries.
- Energy products show the highest degree of price changes - capital goods show the lowest degree of price changes.
- Commodities that exhibit a high degree of price change are often quite close to the raw material input.
- Frequency of price changes tend to be cyclical with important seasonal effects.
- Prices tend to change more often in the upward as compared to the downward direction (60/40 ratio).
- Sizes of price changes in the upward and the downward directions are very similar, around 5%, so inflation seems to be associated with the higher frequency of positive price changes as compared to negative price changes.
- There is some evidence of duration depen-

dence although the evidence is mixed.

- Comparison of the stylized facts obtained from the PPI and CPI data sets can be problematic.

# 3 Some General Comments

- The four studies all exploit very similar methodologies in arriving at their stylized facts.[2] They also tend to focus on the same set of characteristics of the distribution of price changes **over time**, **across firms** and with respect to the **commodity groups**.
- The degree of price stickiness is measured in terms of frequency of price changes or duration (mean price spells) across firms over a given period. The two measures are closely related, but could yield different

[2] My discussion concerns four (Germany, Italy, Spain and Portugal) of the five empirical studies of price formation by producers covered in the presentation slides. French study was not available at the time these comments were prepared..

answers due to possible nonstationarities and left and right censoring. These issues are not treated in the same way across the different studies and could be a problem in country comparisons.

- Despite the pervasive non-homogeneities (both across firms/products and time) the studies often tend to focus on averages or medians of the particular characteristic being considered. It seems a good idea to consider the whole distribution of price changes (with the distribution of positive and negative changes considered separately).
- Frequencies of price changes are clearly an important factor in the measurement of price stickiness. But they need to be augmented with associated measures of input costs. The important question is to see if price changes are commensurate with cost changes. This issue was only addressed explicitly in the case of the

German study, although only in relation to the incident of wage settlements. *Further analysis of the price-cost relationships are needed.*

- Other aspects of the distribution of price changes are also worth considering, such as skewness and Kurtosis (at least in the case of the surveys with quantitative observations).

# 4 Cross Section Price Dispersion and Synchronization

The issue of synchronization of price changes could have been discussed more fully. The measure of synchronization used in the German study is the Fisher-Konieczny ratio defined

$$FK_i = \sqrt{\frac{\sum_{t=1}^{T}(F_{it} - F_i)^2}{(T-1)F_i(1-F_i)}}.$$

This measure is defined over a given period and does not capture the extent to which synchronization might have been varying over time. Cross section dispersion of price changes could provide an important additional measure of synchronization. It is easy to compute and allows one to see if price synchronization is related to cost and/or demand changes.

In the case of the studies based on quantitative data sets (Italy, France and Portugal) measures of cross section dispersion of price changes $[i.e. \pi_{it} = \ln(P_{it}/P_{i,t-1})]$ can be easily computed - for example

$$\hat{\sigma}_t = \sqrt{\frac{\sum_{i=1}^{N_t} (\pi_{it} - \pi_t)^2}{N_t}},$$

where $N_t$ is the number of products (in a given product group) in period $t$. It would be interesting to see how $\hat{\sigma}_t$ has been evolving over time across different commodity groupings.

For qualitative surveys (Germany and France) this cross section dispersion measure can be computed noting that (using the regression approach of Pesaran (1984)) that

$$\pi_t \approx \alpha U_t - \beta D_t,$$

where $U_t$ and $D_t$ are the proportion of firms in period $t$ reporting a price rise and a price fall, respectively, and $\alpha$ and $\beta$ are the average (across firms/products) sizes of price rises and price falls. $D_t$ and $U_t$ are obtainable from surveys, and $\pi_t$ can be measured by the official inflation measure (for the price category under consideration). The parameters $\alpha$ and $\beta$ can be then estimated by a regression of $\pi_t$ on $U_t$ and $D_t$.[3]

Similarly, the cross section dispersion can be derived by noting that

$$\begin{aligned} \hat{\sigma}_t^2 &= \frac{\sum_{i \in U} \left(\pi_{it}^{+}\right)^2 + \sum_{i \in D} \left(\pi_{it}^{-}\right)^2}{N_t} - \pi_t^2 \\ &= \alpha^2 U_t + \beta^2 D_t - \left(\alpha U_t - \beta D_t\right)^2 . \end{aligned}$$

Hence

$$\hat{\sigma}_t^2 = \alpha^2 U_t (1 - U_t) + \beta^2 D_t (1 - D_t) + 2\alpha\beta U_t D_t.$$

[3] When $\alpha = \beta$ (supported by the surveys for Italy, Spain and Portugal), $\pi_t$ will be proportional to the balance statistic, $U_t - D_t$.

Cross section dispersion of prices across particular product lines could provide an important measure of synchronization of price changes. Also since it is measured with respect to the cross section mean, $\pi_t$, it would be robust to the possible effects of cost changes over time.

## 4.1 A Statistical Test for Synchronization of Price Changes

Another important measure of price dispersion is given by the average of pair-wise correlation of price changes (positive, negative or both). Consider the $T$ dimensional vector $\mathbf{x}_i$ which contains $1$ (price change) $0$ (no price change). The simple correlation $r_{ij}$ measures the extent of association of price change between product lines $i$ and $j$ in a given product group. It can be shown that $r_{ij}$ is related uniformly to the $\chi_1^2$ measure of association between price changes of $i$ and $j$ product lines in the standard $2 \times 2$ contingency table

| | Item $i$ | |
|---|---|---|
| Item $j$ | Price Rise | Price Fall |
| Price Rise | $N_{rr}$ | $N_{rf}$ |
| Price Fall | $N_{fr}$ | $N_{ff}$ |

.

An overall measure of price change synchronization can be computed by

$$\bar{r} = \frac{2}{N(N-1)} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} r_{ij}.$$

A formal statistical test of synchronization of price changes can now be based on $\bar{r}$. Under quite general conditions it can be shown that the CD (cross section dependence) statistic defined by

$$\begin{aligned} CD &= \sqrt{\frac{2T}{N(N-1)}} \left( \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} r_{ij} \right) \\ &= \sqrt{\frac{TN(N-1)}{2}} \bar{r} \end{aligned}$$

is distributed as $N(0,1)$ under the null hypothesis of no synchronization of price changes. For details and extensions to unbalanced panels see Pesaran (2004a).

# 5 A Canonical Micro Econometric Model of Sticky Prices

Suppose that for a given product line the fundamental (log) price is given by $f_t$ if there were no costs to price changes. In this case prices of individual products will be given by $p_{it} = f_t$.

In the presence of adjustment costs an optimal price strategy would be typically of the $s, S$ variety. See, for example, Sheshinski and Weiss (1977,1983) and Cecchetti (1986). In this case a simple (canonical) econometric specification could be written as

$$\begin{aligned} p_{it} &= p_{i,t-1} + (f_t - p_{i,t-1})I(f_t - p_{i,t-1} - c_i) \\ &\quad +(f_t - p_{i,t-1})I(p_{i,t-1} - f_t - c_i), \end{aligned}$$

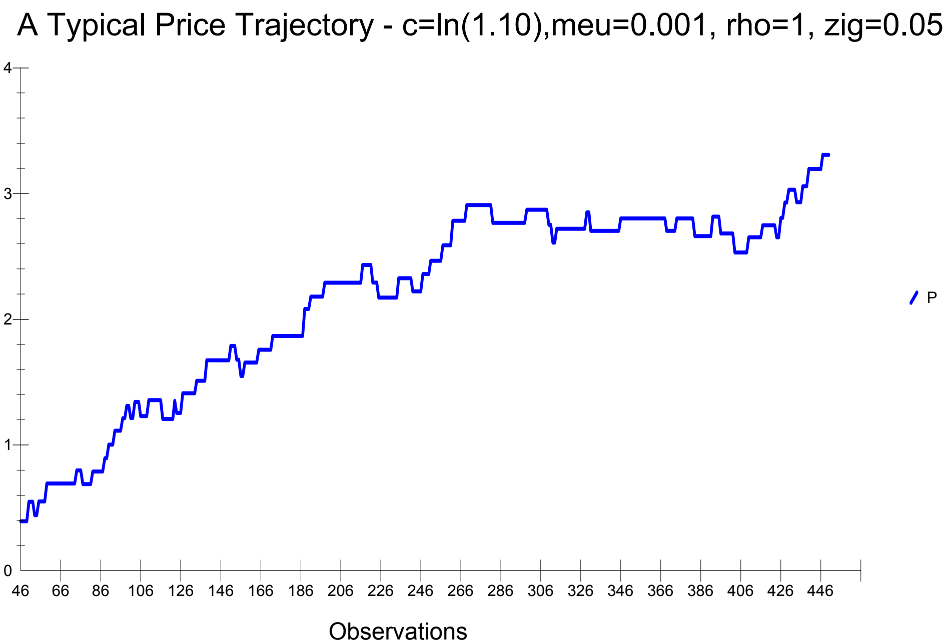
where $I(A)$ is an indicator function that takes the value of unity if $A > 0$ and zero otherwise. $c_i$ measures the extent to which prices changes are costly. Clearly, $p_{it} = f_t$ if $c_i = 0$. But for a sufficiently large $c_i > 0$, $p_{it}$ could remain fixed until a sufficiently large (small) realiztion of $f_t - p_{i,t-1}$ relative to $c_i$ occurs.[4]

The main properties of the above price process can be easily illustrated by simulation. Suppose that

$$
\begin{aligned}
& f_t = \rho f_{t-1} + \mu + \sigma\varepsilon_t, \varepsilon_t \sim N(0,1), \\
\rho &= 1, \mu = 0.001 \text{ random walk with drift,} \\
p_{i0} &\sim iidN(0, \sigma^2) \\
c_i &\sim iidU(\ln(1.10), \ln(1.20)) \\
\sigma &= 0.05,
\end{aligned}
$$

for $i = 1, 2, ..., N$ and $t = 1, 2, ...T$, with $N = 10,000$, $T = 400$.

[4] It is relatively easy to generalize the model to allow for the fundamental price, $p_{it}^*$, to differ across firms by replacing $f_t$ with $\gamma_i f_t$.


A Typical Price Trajectory - c=ln(1.10),meu=0.001, rho=1, zig=0.05
4
3
2
1
0
46 66 86 106 126 146 166 186 206 226 246 266 286 306 326 346 366 386 406 426 446
Observations
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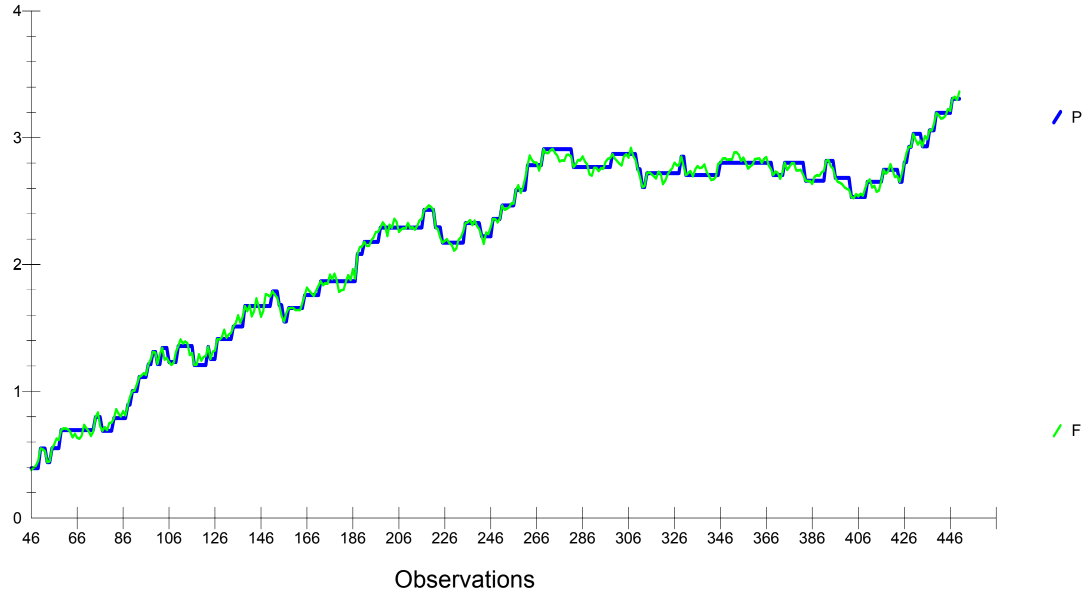
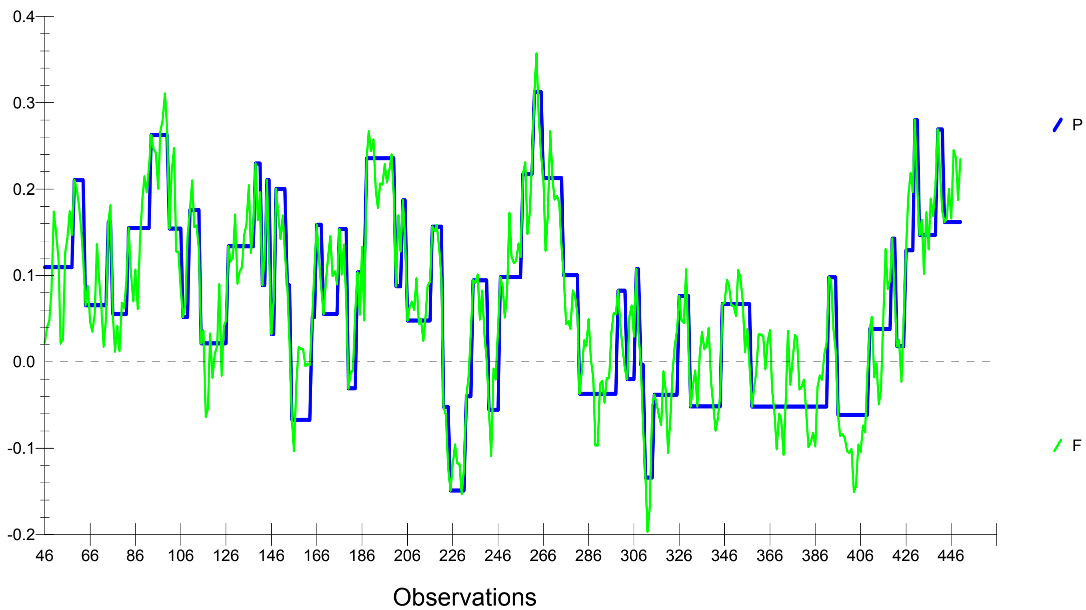
Prices With and Without Adjustment Costs, Rho=1




Prices With and Without Adjustment Costs,  Rho=0.90



## 5.1 Calibration of the Pricing Model

The parameters of the model can be calibrated bearing in mind the stylized facts discovered by the various empirical studies of the price-setting behaviour.

Mean duration spell or frequencies of price changes can be calibrated through changes in the threshold parameter, $c_i, \sigma$ and to a much lesser extent by $\mu$. The trend and unit root properties of prices can be controlled by $\rho$ and $\mu$.

Some examples are provided in Tables below:

Low Inflation Case

$\mu = 0.001, \rho = 1, N = 10,000, T = 400$

| | $\bar{c} = 1.14$ | $\bar{c} = 1.10$ | $\bar{c} = 1.05$ |
|---|---|---|---|
| **Duration** | | | |
| Mean Spell | 11.54 | 7.56 | 2.71 |
| Max Spell | 37.34 | 27.55 | 10.02 |
| Min Spell | 2.13 | 1.47 | 1 |
| **Frequency (%)** | | | |
| Positive Changes | 5.7 | 9.0 | 20.8 |
| Negative Changes | 3.3 | 6.1 | 16.1 |
| Total | 9.0 | 15.1 | 36.9 |
| **Synchronization($\bar{r}$)** | | | |
| Positive Changes | 0.388 | 0.489 | 0.817 |
| Negative Changes | 0.368 | 0.414 | 0.849 |
| Total | 0.350 | 0.413 | 0.783 |

High Inflation Case

$\mu = 0.01, \rho = 1, N = 10,000, T = 400$

| | $\bar{c} = 1.14$ | $\bar{c} = 1.10$ | $\bar{c} = 1.05$ |
|---|---|---|---|
| **Duration** | | | |
| Mean Spell | 10.18 | 7.12 | 2.66 |
| Max Spell | 37.51 | 29.25 | 11.16 |
| Min Spell | 1.31 | 1.19 | 1 |
| **Frequency(%)** | | | |
| Positive Changes | 8.8 | 12.7 | 26.6 |
| Negative Changes | 1.2 | 3.1 | 11.2 |
| Total | 9.0 | 15.8 | 37.8 |
| **Synchronization($\bar{r}$)** | | | |
| Positive Changes | 0.395 | 0.446 | 0.827 |
| Negative Changes | 0.374 | 0.371 | 0.843 |
| Total | 0.376 | 0.400 | 0.792 |

## 5.2 Estimation of Fundamental Unobserved Prices ($f_t$) from Cross Section Averages

In practice $f_t$ is unobserved and need to be estimated. In cases where $N_t$ is reasonably large $f_t$ can be approximated by the cross section mean of (log) prices, namely $\bar{p}_t$, (or a suitably weighted average of the prices) and its lagged values. To see this note that the pricing model can also be written as

$$p_{it} = f_t + d_{it}\left[I(d_{it} - c_i) - I(d_{it} + c_i)\right],$$

where $d_{it} = f_t - p_{i,t-1}$. The expression in [] takes the values of $0$ or $-1$, and assuming that

$\Pr\left(d_{it} > c_i\right) = \theta$ (homogeneous across $i$)

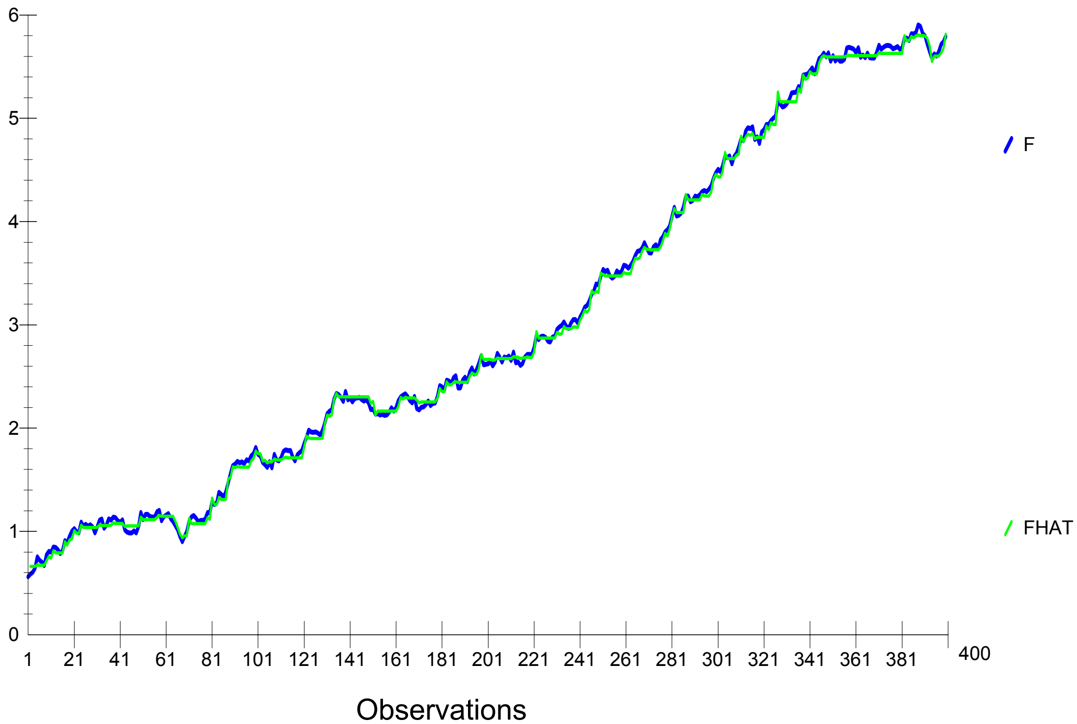
and for $N_t$ sufficiently large we have

$$\bar{p}_t \approx f_t - (1-\theta)\left(f_t - \bar{p}_{t-1}\right),$$

and hence

$$\hat{f}_t = \frac{\bar{p}_t - (1-\theta)\bar{p}_{t-1}}{\theta}.$$

In practice, $\theta$ could be estimated along with other parameters.




$\mu = .001, \bar{c} = 10\%.$

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