Inflation Persistence in the Euro Area:

I: Evidence from Aggregate and Sectoral Data

Discussion

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The 12 papers in this session address two topics:

1. How persistent is the univariate inflation process?

1. What is the half-life of a univariate shock? wide range of estimates

2. Is inflation less persistent if you first eliminate shifts in its mean? yes

3. Has persistence changed (fallen) recently? yes
2. Is the aggregate inflation (HICP) more persistent than disaggregated (sectoral, country) inflation?

1. Do disaggregate inflation series show less, more, or the same persistence as aggregate inflation?

2. Are the disaggregate and aggregate persistence estimates mutually consistent? yes
Matteo presented an excellent summary of the substantive findings of the 12 papers.

**My presentation:**

A. Motivation for these studies

B. Discuss statistical/econometric issues

C. Provide alternate estimates of inflation persistence, and relate these to those in the papers

D. Return to larger implications of these estimates (their strengths and limitations) + misc comments
A. Why should we study inflation persistence?

1. To improve forecasts

2. To better understand dynamic effect of exogenous price shocks

3. To inform and to refine the conduct of (dynamic) monetary policy

4. To assess whether different monetary policy regimes produce different persistence (did persistence decrease with the creation of ECB and inflation range targets?)
B. Econometric Issues with for Measuring Persistence: the Univariate Case

- How persistent is the inflation process?
- What is the dynamic effect of a univariate shock to inflation?
- The answer seems to depend on your view about whether there have been regime shifts.
- Look at Euro-area inflation: three striking features:
  - large reduction in average inflation post-85
  - lower volatility of inflation post-85
  - Because inflation has been more stable post-85, it seems logical that persistence has decreased
Figure 1

Euro-Area Price Inflation (Quarter-over-Quarter, Annual Rate)
Inference about persistence is linked to inference about mean breaks

- If there really is a mean shift but this is ignored, this can be mistaken for persistence (Perron)
- If there isn’t a mean shift but one is permitted, this can result in persistence measures that are biased towards zero (evidence on this shortly)

The framework in most of these papers is the single-break mean shift model

Some papers have multiple breaks; but the econometric issues are the same so I focus on the single break model
Single-break mean shift-model:

\[ \pi_t = \mu_1 + \mu_2 D_{k,t} + \rho \pi_{t-1} + \phi(L)\Delta \pi_{t-1} + \varepsilon_t \]

\( D_{k,t} = 1 \) if \( t \geq k \), 0 otherwise.

\( \rho \) = persistence parameter

*Note: this trend model allows for gradual adjustment (at rate \( \rho \)) to the new mean level of inflation – precisely what you see in the early 1980s*

Two tasks:

- How to determine if there has been a break?
- How to estimate \( \rho \)?
Methods for break determination used

- Ignore the possibility of a break
- Chow test for a single break, known date
- QLR test for a single break, unknown date
  - what critical value to use?
- Bai-Perron test for multiple breaks, unknown dates
  - what critical value to use?
- Altissimo-Corradi estimator for the number of breaks
  - what long-run variance estimator to use?

Methods for inference on $\rho$ used

- OLS
- Median-unbiased (Hansen grid bootstrap)
- 90% confidence intervals (Hansen grid bootstrap)
A Digression on Nuisance Parameters

Let

\[ S = \text{test statistic} \]
\[ \theta = \text{parameter of interest} \]
\[ \phi = \text{nuisance parameter} \]

What if the distribution of \( S \) under \( \theta_0 \) depends on \( \gamma \)?

- If the (asymptotic) distribution of \( S \) under \( \theta_0 \) depends on \( \theta_0 \) or \( \gamma \) (in a neighborhood of \( \theta_0 \) or \( \gamma \)), the statistic \( S \) is not (asymptotically) pivotal
- Critical values depend on \( \gamma \)
- Somehow, inference using \( S \) about \( \theta \) must involve \( \gamma \) and/or \( \theta_0 \).
Ideally, nuisance parameters are handled by constructing a pivotal statistic

**Example**: conventional regression

- The error variance is a nuisance parameter
- The distribution of $\hat{\beta}$ depends on $\sigma$
- The (null) distribution of the $t$-statistic doesn’t depend on $\sigma$

In time series with persistence, statistics typically are not pivotal

**Example**: Dickey-Fuller $t$-statistic does not have a pivotal distribution, even asymptotically (its distribution changes in a neighborhood of 1).

- Bootstrap is invalid if $\rho$ is estimated (more later)
Return to the mean-shift autoregression:

Break in mean:

$$\pi_t = \mu_1 + \mu_2 D_{k,t} + \rho \pi_{t-1} + \phi(L) \Delta \pi_{t-1} + \varepsilon_t$$  \hspace{1cm} (1)

Let

QLR = QLR (sup-Chow)) test of $\mu_2 = 0$ in (1)

$\hat{\rho} = \text{OLS estimator of } \rho \text{ in (1), with QLR pretest}$

QLR, $\hat{\rho}$, and $F_{\rho}$ are not pivotal. In particular:

- Distribution of QLR depends on $\rho$
- Distribution of $\hat{\rho}$ depends on $\mu_2$
- These issues are most important when $\rho$ is large – an important possibility in this application
Break in mean and persistence:

\[ \pi_t = \mu_1 + \mu_2 D_{k,t} + \rho_1 \pi_{t-1} + \rho_2 D_{k,t} \pi_{t-1} + \phi(L) \Delta \pi_{t-1} + \varepsilon_t \]  \hspace{1cm} (2)

Let:

QLR = QLR (sup-Chow)) test of \( \mu_2 = 0 \) in (2)

\( \hat{\rho}_1 \) = OLS estimator of \( \rho_1 \) in (2), with QLR pretest

\( F_\rho \) = Chow F-test of \( \rho_2 = 0 \), given break date, in (2)

QLR, \( \hat{\rho}_1 \), and \( F_\rho \) are not pivotal.

How important is this quantitatively?
QLR mean-break critical values: Stationary/asymptotic (pink) and n=80 finite sample (local-to-unity)
Rho constancy Chow test critical values:
Stationary/asymptotic (pink) and n=80 finite sample
(local-to-unity)
What about estimation of $\rho$?

Digress: median-unbiased estimation.

- A median-unbiased estimator of $\rho$ is:
  - is less than the true $\rho$ in 50% of realizations
  - is a 0% coverage, equal-tailed confidence interval
  - is constructed by inverting a test of $\rho = \rho_0$ (the set of $\rho_0$ that can be rejected at the 100% significance level, equal-tailed)
  - If the critical values of a test statistic depend on nuisance parameters, then the median-unbiased estimator must handle this, else it won’t be median-unbiased.
Median Bias of “median-unbiased” estimators of $\rho$

$$\pi_t = \mu_1 + \mu_2 D_{k,t} + \rho \pi_{t-1} + \phi(L) \Delta \pi_{t-1} + \epsilon_t$$

Monte Carlo results: $\rho = .95$, $\epsilon_t$ i.i.d. N(0,1)

<table>
<thead>
<tr>
<th>$\mu_2/\sigma$</th>
<th>Break if:</th>
<th>$\hat{\rho}^{mu}$ method</th>
<th>$% \hat{\rho}^{mu} &lt; \rho$</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>ignore break</td>
<td>ignore break</td>
<td>.51</td>
</tr>
<tr>
<td>0</td>
<td>QLR &gt; 8.68</td>
<td>fix break</td>
<td>.72</td>
</tr>
<tr>
<td>0</td>
<td>QLR &gt; 10.22</td>
<td>fix break</td>
<td>.69</td>
</tr>
<tr>
<td>0</td>
<td>QLR &gt; 17.61</td>
<td>fix break</td>
<td>.57</td>
</tr>
<tr>
<td>0</td>
<td>QLR &gt; 17.61</td>
<td>fix break</td>
<td>.50</td>
</tr>
<tr>
<td>2</td>
<td>ignore break</td>
<td>ignore break</td>
<td>&lt;.5 (Perron)</td>
</tr>
</tbody>
</table>
What about split sample methods?

\[ \pi_t = \mu_1 + \mu_2 D_{k,t} + \rho_1 \pi_{t-1} + \rho_2 D_{k,t} \pi_{t-1} + \phi(L) \Delta \pi_{t-1} + \varepsilon_t \]  

(2)

Monte Carlo results: \( \rho = .95, \varepsilon_t \text{ i.i.d. } N(0,1) \)

<table>
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<tr>
<th>( \mu_2/\sigma )</th>
<th>Break if:</th>
<th>( \hat{\rho}_{1}^{mu} ) method</th>
<th>% ( \hat{\rho}_{1}^{mu} &lt; \rho )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>ignore break</td>
<td>ignore break</td>
<td>.50</td>
</tr>
<tr>
<td>0</td>
<td>QLR &gt; 8.68</td>
<td>fix break</td>
<td>.64</td>
</tr>
<tr>
<td>0</td>
<td>QLR &gt; 10.22</td>
<td>fix break</td>
<td>.62</td>
</tr>
<tr>
<td>0</td>
<td>QLR &gt; 17.61</td>
<td>fix break</td>
<td>.56</td>
</tr>
</tbody>
</table>

Split sample methods have the same problem
Summary: testing for intercept break

• $QLR$ critical values depend on $\rho$:
• Bootstrap isn’t a solution for getting critical values of $QLR$ – dependence is too strong (formally, invalid in a local neighborhood of 1)
• Plug-in procedure won’t work, for same reason
• Could use Bonferroni bounds (97.5% interval for $\rho$, then 2.5% test for break) but power would be very low
• Arguably, using maximum (fixing $\rho = 1$) has higher power than Bonferroni method
• There is no “best” answer – an interesting research problem!
Summary: estimation of $\rho$

(a) Hansen GB ($\hat{\rho}^{mu}$), ignoring possible break:
- if no break, median unbiased
- if large break, biased up

(b) Hansen GB ($\hat{\rho}^{mu}$), computed after break pretest:
- If true break small, biased down
- If true break large, median unbiased

(c) Hansen GB ($\hat{\rho}_1^{mu}$) on subsample, computed after break pretest:
- If true break small, biased down
- If true break large, median unbiased

With this in mind, let’s revisit the empirical work…
C. Median-unbiased estimates of $\rho$, with and without break (AIC lag lengths)

<table>
<thead>
<tr>
<th>Series</th>
<th>Sample</th>
<th>QLR</th>
<th>$\hat{\rho}^{mu}$, no break</th>
<th>$\hat{\rho}^{mu}$, 1 break</th>
</tr>
</thead>
<tbody>
<tr>
<td>AWM-GDPD</td>
<td>70-02</td>
<td>8.75</td>
<td>.99</td>
<td>.78</td>
</tr>
<tr>
<td>HICP</td>
<td>70-02</td>
<td>14.44</td>
<td>.87</td>
<td>.64</td>
</tr>
<tr>
<td>FR GDPD</td>
<td>83-02</td>
<td>6.72</td>
<td>.83</td>
<td>—</td>
</tr>
<tr>
<td>GE GDPD</td>
<td>83-02</td>
<td>7.65</td>
<td>.73</td>
<td>—</td>
</tr>
<tr>
<td>IT GDPD</td>
<td>83-02</td>
<td>12.92</td>
<td>.78</td>
<td>.43</td>
</tr>
</tbody>
</table>

QLR critical values: 8.68 (asy), 10.22 ($\rho=.5$), 17.61 ($\rho=1$)

Using $\rho = 1$ critical value, breaks in 11 of 48 series of Levin and Piger (they found breaks in 28)
Other econometric methods

(a) Rolling Windows

- Compute $\hat{\rho}^{mu}$ (no-break) on a rolling window
- This sidesteps break pretest problem
- Disadvantage is low precision (large confidence intervals)

Typical figure from O’Reilly and Whelan:
Figure 4
Rolling 12-Year Univariate Grid-Bootstrap Estimates of Rho (GDP Deflator)
Other econometric methods, ctd.:

(b) Altissimo-Corradi estimator of number of breaks

- Clever estimator number of no. of breaks using the cumulative demeaned inflation process
- This is another method for first-stage inference about the number of breaks
- Not valid (in theory) when $\rho$ is large (local-to-unity)
- In any event, this doesn’t solve the nuisance parameter problem
Other econometric methods, ctd.:

(c) Use a different measure of persistence:

- Half life
  - This is a function of $\rho$, so it inherits any problems with the estimator of $\rho$

- $1 - \text{Expected # of crossings (Marques, Dias-Marques)}$
  - $= 1 - \frac{N}{T}$, $N =$ # times inflation crosses mean
  - In AR(1) case, this is a function of $\rho$ - so this inherits same problems as estimation of $\rho$
  - If $E(N/T)$ is small, the normal approximation to the distribution of $N/T$ is poor; better to construct confidence intervals using methods for small proportions (e.g. exact binomial)
D. Misc. Additional Comments

Papers on disaggregate v. aggregate persistence

• Important, detailed, and difficult work
• Main finding across papers: faster adjustment in disaggregate prices than in aggregate prices
• Two possible reasons:
  1. Measurement error at micro level makes it appear that persistence is less
  2. Actual micro persistence is less, but aggregation effects increase persistence
• Second explanation appears important part of the story (Altissimo et. al.)
• Implications for:
  o Monetary policy (presumably, ultimate focus is aggregate)
  o Theoretical work (modeling market-by-market price responses to shocks)
Broader question: disentangling different types of shocks

• What are economic reasons for separating out breaks?
  o Long-term mean reflects monetary regimes
  o Then persistence is interpreted as “within-regime”
• But can we be so sure that all long-term movements in mean are from shifts in monetary regimes?
• Can we be so sure that three will be no more regime shifts? Looming “regime shift” possibilities:
  o Growth and Stability Pact
  o Greenspan’s retirement
  o U.S. budget deficit
  o $