8. Staggered Price Setting: More Micro Foundations and Empirical Evidence

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Outline

- Derivation from profit maximization
  - “Reverse engineering”
- Briefly contrast with state dependent models
  - Policy implications
- Empirical evidence

Reverse Engineering the Staggered Pricing Equations

Basic idea : Derive price equation from profit maximizing monopolistically competive firms that sell their products to competitive firms.

Competititve firms' production (take N = 2 for simplicity) is assumed to be :

$Y = [Y(1)^q + Y(2)^q]^{1/q} \quad where \;\; 0 < q < 1$

Input demand functions can be derived from a cost minimization :

min $P(1)Y(1) + P(2)Y(2)$ wrt $Y(1), Y(2)$ subject to production function (taking input prices as given)

Form the Langrangian :

$L \;=\; P(1)Y(1) + P(2)Y(2) - \lambda(Y^q - Y(1)^q - Y(2)^q)$

and differentiate :

$$\frac{\partial L}{\partial Y(1)} = P(1) - \lambda q Y(1)^{q-1} = 0$$

$$\frac{\partial L}{\partial Y(2)} = P(2) - \lambda q Y(2)^{q-1} = 0$$

Solve for $Y(1),\ Y(2)$:

$$\left.\begin{aligned} Y(1) &= \left(\frac{P(1)}{\lambda q}\right)^{1/(q-1)} \\ Y(2) &= \left(\frac{P(2)}{\lambda q}\right)^{1/(q-1)} \end{aligned}\right\rangle \Rightarrow Y(i) = (\lambda q)^{-1/(q-1)} P(i)^{1/(q-1)} \Rightarrow (\lambda q)^{-q(q-1)} = \frac{Y(i)^q}{P(i)^{q/(q-1)}} \text{ for } i = 1 \text{ and } 2$$

from the constraint:

$$Y^q = \left(\frac{P(1)}{\lambda q}\right)^{q/(q-1)} + \left(\frac{P(2)}{\lambda q}\right)^{q/(q-1)}$$

$$Y^q = (\lambda q)^{-q(q-1)}[P(1)^{q/(q-1)} + P(2)^{q/(q-1)}]$$

$$Y^q = P(i)^{-q/(q-1)}[P(1)^{q/(q-1)} + P(2)^{q/(q-1)}]Y(i)^q \Rightarrow Y(i) = P(i)^{1/(q-1)}[P(1)^{q/(q-1)} + P(2)^{q/(q-1)}]^{-1/q} Y$$

$$Y(i) = \left(\frac{P(i)}{[P(1)^{q/(q-1)} + P(2)^{q/(q-1)}]^{(q-1)/q}}\right)^{1/(q-1)} Y$$

$$Y(i) = \left(\frac{P(i)}{P}\right)^{1/(q-1)} Y$$

$$\textit{where} \quad P = [P(1)^x + P(2)^x]^{1/x}$$

Now firm i producing intermediate good i sets its price $P_t(i)$ for more than one period (say 2) to maximize profits

$$\pi_t(i) + \beta\pi_{t+1}(i) = [P_t(i) - P_tV_t]\left(\frac{P_t(i)}{P_t}\right)^{1/(q-1)} Y_t + \beta[P_t(i) - P_{t+1}V_{t+1}]\left(\frac{P_t(i)}{P_{t+1}}\right)^{1/(q-1)} Y_{t+1}$$

where PV is marginal cost.

The answer will be a markup of the weighted average of marginal cost in the two periods:

$$P_t(i) = \frac{P_tV_tz_t + P_{t+1}V_{t+1}\beta z_{t+1}}{q(z_t + \beta z_{t+1})} = \frac{P_tV_t\theta_t + P_{t+1}V_{t+1}(1-\theta_t)}{q}$$

where $z_t = \left(\frac{1}{P_t}\right)^{1/(q-1)} Y_t$ and $\theta_t = z_t/(z_t + \beta z_{t+1})$

or approximately:

$$p_t(i) = \frac{1}{2}(p_t + v_t) + \frac{1}{2}(p_{t+1} + v_{t+1})$$

with

$$p_t = \frac{1}{2}(p_t(i) + p_{t-1}(i-1))$$

Much like basic staggered price setting model.

State Dependent in Contrast to Time Dependent Models

- Price changes when the desired price differs by more than a specified amount from the current price
- Motivated by a fixed cost of changing the price
  - "menu" costs in the broadest sense of the word
- A big change in the money supply causes a big increase in number prices changing
  - In extreme money might have little effect on output

Empirical Work on Price Setting

- Early empirical work
  - Large variety of practices depending on the market
  - Wages (once per year very typical), not only union contracts
  - Price adjustment more frequent, but not always (magazines)
  - Close to one-year duration became a common assumption
- A key feature of staggered wage and price setting models is a prevailing wage or price which affects decisions
  - Surveys of prevailing wages are very common in setting wages
  - Cause of persistence
  - This does not happen with perfectly flexible price models.
  - Nor does it happen with “state dependent models,” which behave much like flexible price models in that there is little persistence.

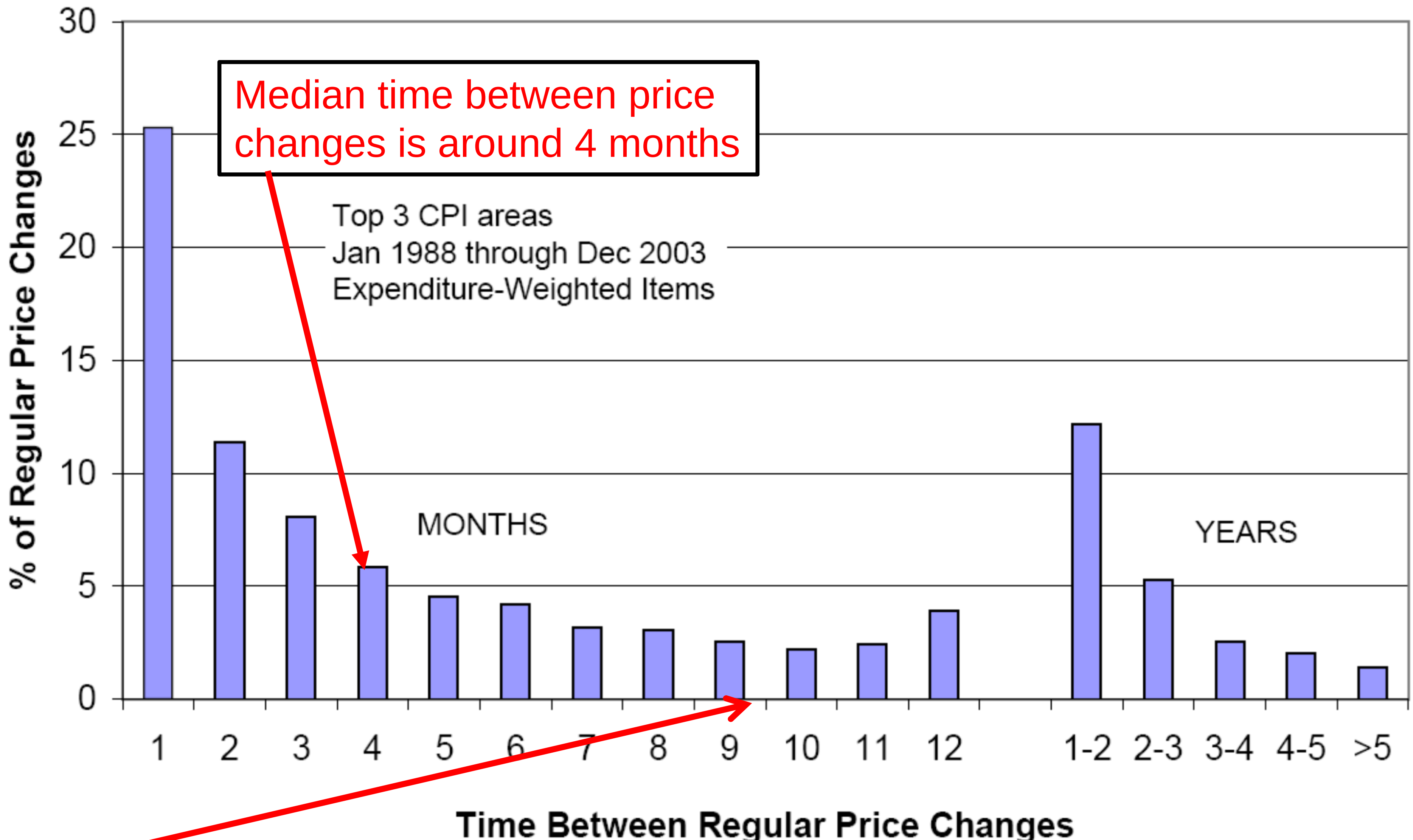
More Recent Empirical Research Using the CPI (Pete Klenow)

- Consumer price index (CPI) is based on a monthly survey of prices throughout the U.S.
  - About 400 BLS employees visit about 20,000 retail establishments and sample consumer prices.
  - Individual prices are then weighted according to a "market basket" (based on consumer expenditure survey) to get the CPI.
- These individual prices provide information about price setting behavior
  - Can be used to test, calibrate, modify
  - Had been untouched until work started by Klenow.
  - Goes beyond earlier work such as magazine prices

BLS-Research Data Base – Important Details

- January 1988-December 2003
  - 13 years of monthly data less one gives 191 months
- 85,000 price quotes per month
- After taking account of outliers, stock outs, seasonally unavailable items, and replacements, Klenow gets to about 55,000 quotes.
- Dealing with “sale” prices
  - 11 percent
  - V shaped pattern
  - Create a “regular” price series

Distribution of Times Between Regular Price Changes



However, Nakamura and Steinsson *QJE* (2008) later found that the median duration was between 8 and 11 months, after correcting for sales.

A Decomposition of Aggregate Inflation

Let ω_{it} be the weight of good i in the CPI

Decompose inflation each period into

- fraction of prices adjusting each period fr_{t}

- average size of the price adjustment each period dp_t

$$\pi_{\mathrm{t}} = \sum_i \omega_{it}(p_{it} - p_{it-1}) = \sum_i \omega_{it} I_{it} \frac{\sum_i \omega_{it}(p_{it} - p_{it-1})}{\sum_i \omega_{it} I_{it}} = (fr_t)(dp_t)$$

where $I_{it} = 0$ if $p_{it} = p_{it\text{-}1}$ and $I_{it} = 1$ *if* $p_{it} \neq p_{it\text{-}1}$. In a simple staggered contract model with prices lasting three months and 1/3 changing every month $fr_t = 1/3$ in monthly data

The purpose of the decomposition is to test
"time dependent pricing" (fr_t is constant, or exogenous)
versus
"state dependent pricing (fr_t is variable, and endogenous)

Figure 5

Fraction of prices changing

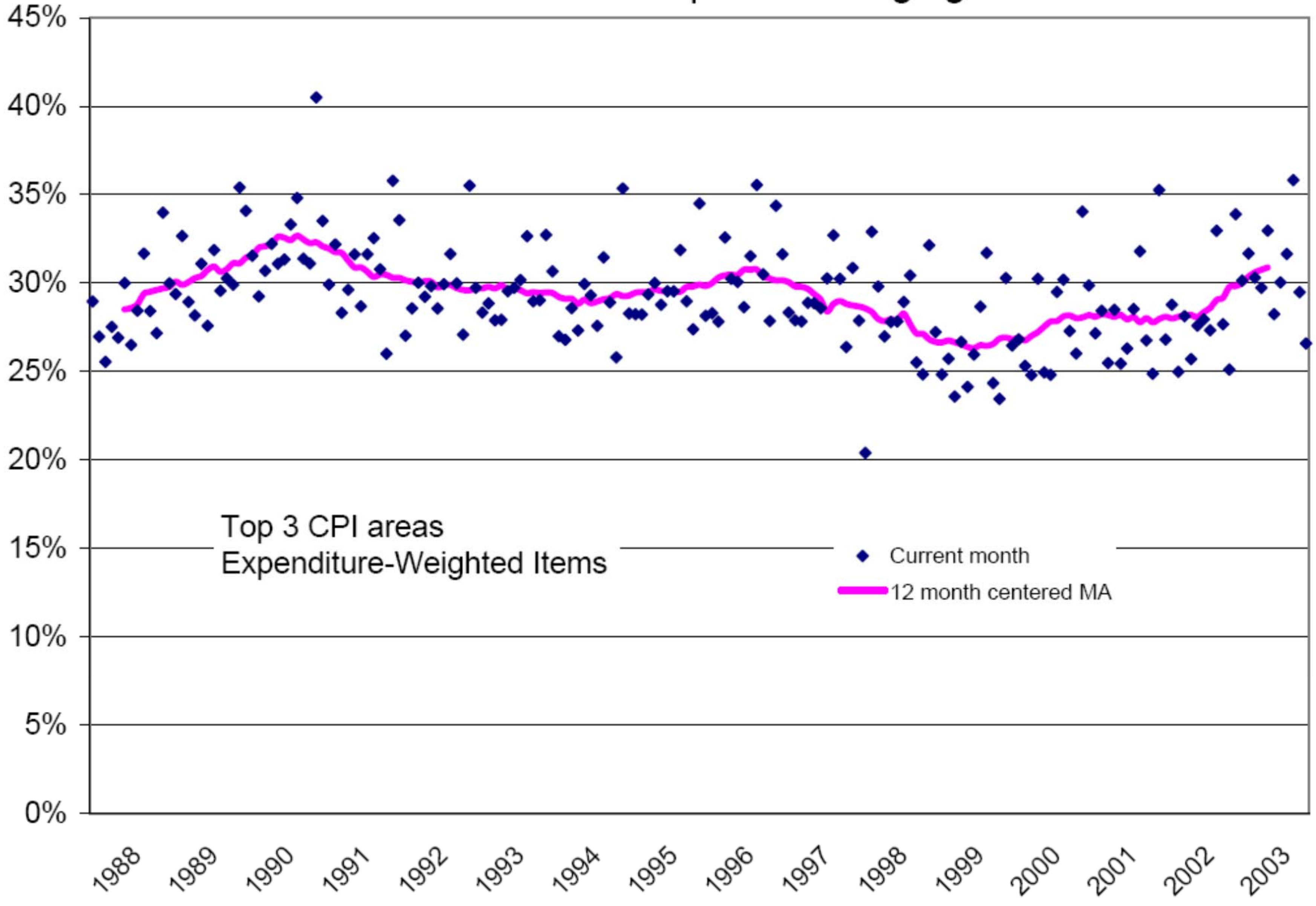


Figure 6

Average size of price changes

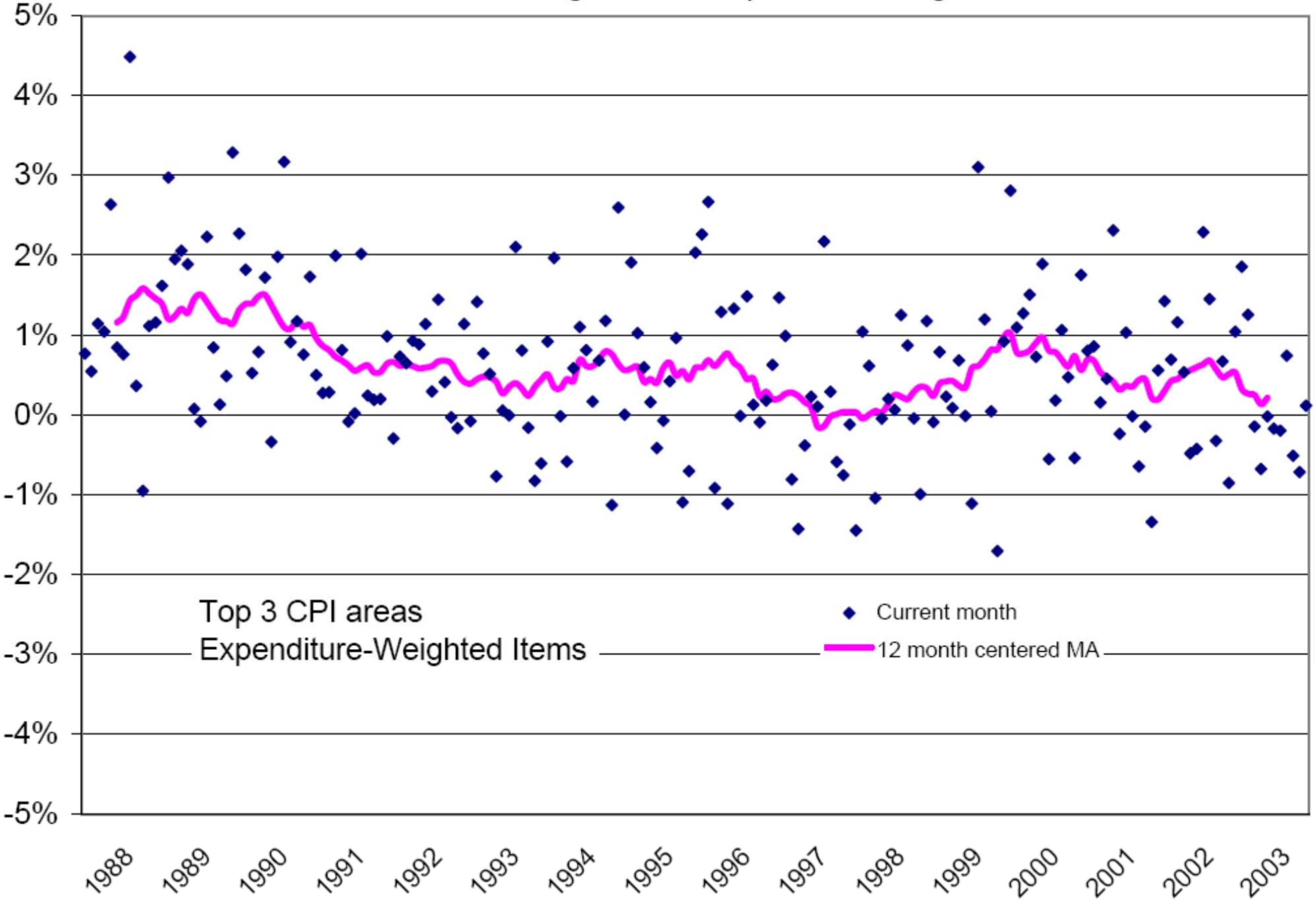


Figure 7

Annual Moving Averages