Fuhrer and Moore (1995) *AER*
Monetary Policy Trade-offs and the Correlation between Nominal Interest Rates and Output

Overview

• The paper is a pioneer in the introduction of a simple new-Keynesian model for policy analysis. The basic elements are:
  o an IS curve
  o a reaction function equation
  o a contracting equation based on their “Inflation Dynamics” paper

• This simple structural model is able to replicate the dynamic correlations in the data, specifically:
  o negative correlation between real output and short-term rates.
  o the “overshooting” disinflation in response to an increase in the short-term rate.
• This structural model is then used to evaluate the reaction and the monetary policy trade-off of closely vs. loosely targeted inflation and output gap.

**Empirical Evidence**

• Short-term interest rates and output are negatively correlated (?) but it is the long-rate that has real effects on output…

• Therefore, there must be a strong link between short-term and long-term rates and the formation of inflation expectations.
Data

• Quarterly from 1965:I to 1992:IV
• \( \pi_t \): inflation in the implicit deflator for nonfarm business output.
• \( r_t \): 3-month T-Bill rate
• \( y_t \): log of per capita nonfarm business output.
• \( \bar{y}_t \): deviation of \( y_t \) from trend.

[Insert Figure 1 here]

Reduced Form Evidence

• The dynamic autocorrelations are properties that the model will need to match and they do not depend on identification issues.
• There is a strong, short-term rate, real-output gap correlation.
Computing the Expected Log-Term Real Rate

\[ \rho_t = \frac{1}{1 + D} \sum_{i=0}^{\infty} \left( \frac{D}{1 + D} \right)^i E_t \left( r_{t+i} - \pi_{t+i+1} \right) \]

- \( \rho_t \): real yield to maturity.

- \( D_t \): duration \( \equiv \frac{1 - e^{R,M}}{R_t} \) with \( R_t \) the yield to maturity, and \( M \) the maturity.

This expression is similar to the usual term-structure relations:

- it incorporates expectations on future short-term rates.
- it incorporates future inflation.
- it then takes a weighted average of these two.
VAR Evidence

Using a VAR with the original variables, one can construct the implied long real rate using the previous expression.

Figure 2. Comparison of Long Real Rate and Bill Rate
The Structural Model

Non-arbitrage in the bond market

\[ \rho_t - D[E_t(\rho_{t+1}) - \rho_t] = r_t - E_t(\pi_{t+1}) \]

IS – curve

\[ \bar{y}_t = a_0 + a_1 \bar{y}_{t-1} + a_2 \bar{y}_{t-2} - a_\rho \rho_{t-1} + \epsilon_{yt} \]

In s-s, \( \bar{y}_t = 0 \Rightarrow \rho = a_0 / a_\rho \)

Note: \( \rho_t \) is not computed from the reduced-form VAR. Rather, the dynamic, non-arbitrage condition is imposed on the model when solved and the implied \( \rho_t \) are the outcome of the solution.
Reaction Function

\[ \Delta r_t = \alpha_0 + \sum_{i=1}^{2} \alpha_{r_i} \Delta r_{t-i} + \sum_{j=1}^{3} \alpha_{\pi_j} \pi_{t-j} + \alpha_y \bar{y}_t + \epsilon_{rt} \]

Assumption: \[ \sum \alpha_{\pi_j} > 0; \alpha_y 0 \]

In s-s, \( \bar{y} = 0; \rho = a_0 / a_\rho \), therefore by the non-arbitrage condition \( r_t - \pi_{t+1} = a_0 / a_\rho \) so that the rates of change of \( r_t \) and \( \pi_{t+1} \) are equal.

Contracting Equations

- Agents negotiate nominal contracts that remain in effect for 4 quarters.
- Assume monopolistic competition and a fixed mark-up from wages to prices.
- This assumption allows one to express the contracting equation using prices directly.
\[(x_t - p_t) = \sum_{i=1}^{3} \beta_i (x_{t-i} - p_{t-i}) + \sum_{i=1}^{3} \beta_i E_t (x_{t+i} - p_{t+i}) + \sum_{i=1}^{3} \gamma_i E_t (\bar{y}_{t+i}) + \varepsilon_{xt}\]

Remarks:

- agents care about relative contract prices – i.e., ex-ante “real” contracts.
- agents weigh equally past and future contracts.
- a positive output gap in the current period or expected future output gaps have a positive effect on contract prices.
- the number of quarters in the contracting equation is ad-hoc.
- Inflation is independently persistent to shocks in demand captured in the output gap.
Estimating the Model – FIML

\[
\begin{align*}
\bar{y}_t &= a_0 + a_1\bar{y}_{t-1} + a_2\bar{y}_{t-2} - a_\rho \rho_{t-1} + \varepsilon_{yt} \\
\Delta r_t &= \alpha_0 + \sum_{i=1}^{2} \alpha_i \Delta r_{t-i} + \sum_{j=1}^{3} \alpha_{\pi_j} \pi_{t-j} + \alpha_y \bar{y}_t + \varepsilon_{rt} \\
(x_t - p_t) &= \sum_{i=1}^{3} \beta_i (x_{t-i} - p_{t-i}) + \sum_{i=1}^{3} \beta_i E_t (x_{t+i} - p_{t+i}) + \sum_{i=0}^{3} \gamma_i E_t (\bar{y}_{t+i}) + \varepsilon_{xt}
\end{align*}
\]

\[
\begin{align*}
\rho_t - 40 [E_t (\rho_{t+1}) - \rho_t] &= r_t - E_t (\pi_{t+1}) \\
p_t &= \sum_{i=0}^{3} f_i x_{t-i} \\
f_i &= 0.25 + (1.5 - i)s
\end{align*}
\]

The parameters to be determined are:

\[a_0, a_1, a_2, a_\rho, \alpha_0, \alpha_{\pi_j}, \alpha_y, s\]

Remarks: the \( \beta_i \) and \( \gamma_i \) are deterministic functions of the \( f_i \), which in turn only depend on \( s \).
### Estimation Results:

<table>
<thead>
<tr>
<th>Equation</th>
<th>Parameter</th>
<th>Estimate</th>
<th>Standard error</th>
<th>t statistic</th>
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<td>0.005</td>
<td>1.4</td>
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<td>(10),(12)</td>
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<td>(13)</td>
<td>$\gamma$</td>
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</tbody>
</table>


$Q(12)$ statistic ($p$ value):
- IS curve: 28.6 (0.005)
- Reaction function: 19.3 (0.082)
- Contracting equation: 26.1 (0.010)
Remarks:

- High real-rate elasticity in the IS curve – $a_\rho = 0.36$
- The implied equilibrium inflation rate is 4.5%
- The model’s parameters seem robust to pre- and post-1979 samples
- The dynamic correlations implied by the structural model conform with those obtained from the reduced-form VAR.

[Insert Figure 3 here]

Policy Experiments
Simplify the reaction function to:

$$\Delta r_t = \alpha_\pi (\pi_t - \bar{\pi}) + \alpha_y \bar{y}_t$$

with $\alpha_\pi = \alpha_y = 0.1$
Sensitivity of the nominal rate/output correlation

As both $\alpha_\pi$ and $\alpha_y$ increase – i.e., the monetary authority reacts more strongly to deviations from target, then:

- there is no evidence that output would be correlated with the short-real rate.

Monetary Policy Trade-offs

Measures:

- **The sacrifice ratio**: cumulative % point deviation of output from potential, discounted at 3% per annum, for each reduction of inflation by 1%
- **The variance measures**: of inflation, output gap and interest rate variability.
Results

<table>
<thead>
<tr>
<th>Policy</th>
<th>$\alpha_x$</th>
<th>$\alpha_y$</th>
<th>Sacrifice ratio</th>
<th>Variance</th>
<th>Inflation</th>
<th>Bill rate</th>
<th>Output</th>
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<td>0.0006</td>
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</table>

Figure 7. Sacrifice Ratio

Figure 8. Inflation Variance

Figure 9. Bill-Rate Variance

Figure 10. Output-Gap Variance
Conclusions

• More vigorous monetary policy affects:
  - the correlation between the current short-rate and future inflation in that it changes sign.
  - the correlation between current inflation and future values of the short-term rate in that it is strengthened
  - the correlation between the long-rate and the short-rate becomes weaker.

• Inflation overshooting under the baseline policy is because of less vigorous targeting, i.e., interest rates do not respond as quickly when inflation misses the target. This justifies the negative correlation between the current bill rate and future inflation.

• Under vigorous targeting, over-shooting disappears because of higher response of short-term rates to overshooting in the future. This changes the correlation between present rates and inflation from positive to negative.