Comments on

No-Arbitrage Taylor Rules by A. Ang, S. Dong, and M. Piazzesi

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Affine Term Structure Models

- **Term Structure:** $P_t^{(n)} = E_t(m_{t+1} P_{t+1}^{(n-1)})$
- **Pricing Kernel:** $m_{t+1} = \exp(-r_t - 0.5\lambda_t'\lambda_t - \lambda_t \varepsilon_{t+1})$
- **Short Rate:** $r_t = \delta_0 + \delta_1 X_t$
- **Price of Risk:** $\lambda_t = \lambda_0 + \lambda_1 X_t$
- **State Variables:** $X_t = \mu + \Phi X_{t-1} + \Sigma \varepsilon_t$

→ **Enforces consistency between cross-section of bond yields and temporal evolution of pricing kernel**
(cf. Diebold, Piazzesi, and Rudebusch AER 2005)

Recent Macro-Finance Literature

- **Ang, Piazzesi & Wei (2004) use 3 observed factors (short rate, term spread, and GDP growth); analyze forecasting performance**

- **Ang & Bekaert (2004) use 1 observed factor (inflation) and 2 latent factors, specifies regime-switching process for X_t**

- **Kim (2004) uses 3 latent factors (one identified as expected inflation); incorporates actual inflation in estimating the model; compares with survey data and TIPS**

- **D'Amico, Kim & Wei (2004) use 3 latent factors; incorporate actual inflation and indexed bond yields in estimating the model**

The Recent Literature (contd.)

- **Rudebusch & Wu (2004) use 2 observed factors (GDP growth and inflation) and 2 latent factors that can be interpreted in terms of equilibrium real rate (r*) and inflation objective (π*)**

- **Hördahl, Tristani & Vestin (2004) use 3 observed factors (short rate, GDP growth, and inflation) and 1 latent factor (π*) in conjunction with structural VAR for X_t**

- **Bekaert, Cho & Moreno (2004) use 3 observed factors (short rate, output gap, and inflation) and 2 unobserved factors in conjunction with New Keynesian model for X_t**

Given the procrustean bed upon which we write, we must apologize to all whose work we cannot cite." (DPR 2005)

Model Specification

- **State vector includes 2 observed factors (inflation & GDP growth) and 1 latent factor (interpreted as policy shock)**

- **Therefore, short rate equation can be interpreted as a policy reaction function (*although <u>not</u> as a Taylor-style rule*):**

$$r_t = \delta_0 + \delta_g g_t + \delta_\pi \pi_t + u_t$$

- **By imposing additional restrictions, short rate equation can be interpreted as a *forward-looking* policy reaction function:**

$$r_t = \delta_0 + \delta_1 \underset{t}{\mathrm{E}}\left(g_{t+k}\right) + \delta_2 \underset{t}{\mathrm{E}}\left(\pi_{t+k}\right) + u_t$$

Estimation Methodology

- **Bayesian estimation using MCMC with Gibbs sampling**

- **Latent factor appears to be close to a random walk process with no relation to macro variables ($\hat{\phi}_3$ = 0.931 with SE 0.032).**

- **"Given that there must be some underlying economic relation between bond prices and macro variables,….Bayesian estimation avoids this stochastic singularity by *a suitable choice of priors*."**

- **Diagnostic checks needed to confirm validity of estimated model (Bayes Factors, out-of-sample forecast performance)**

Is the Taylor Principle Satisfied?

- Benchmark “Taylor Rule”

		δ_0	δ_g	δ_π
1952:2 - 2002:4	**OLS**	**0.01** **(0.001)**	**0.04** **0.07)**	**0.64** **(0.08)**
	Model	**0.01** **(0.002)**	**0.09** **(0.06)**	**0.32** **(0.14)**
1983:1 - 2002:4	**OLS**	**0.01** **(0.002)**	**0.24** **(0.10)**	**0.61** **(0.13)**
	Model	**0.01** **(0.001)**	**0.16** **(0.11)**	**0.25** **(0.11)**

Checking the Taylor Principle (contd.)

- Forward-Looking Rules: Yes if horizon $k \geq 8$ (full sample)
- Combined Forward-Backward Rules (full sample)

	δ_0	r_{t-1}	g_{t+k}	g_{t-1}	π_{t+k}	π_{t-1}
k = 1	**-0.002** **(0.003)**	**0.86** **(0.057)**	**0.15** **(0.22)**	**-0.01** **(0.03)**	**0.51** **0.15)**	**-0.07** **(0.15)**
k = 4	**-0.007** **(0.006)**	**0.69** **(0.16)**	**0.50** **(0.42)**	**-0.01** **(0.02)**	**0.998** **(0.29)**	**-0.05** **(0.07)**

Implications of Real-Time Data

$$r_t = \rho r_{t-1} + (1-\rho)(\alpha + \beta\pi_{t+1|t} + \gamma y_{t|t}) + \varepsilon_t$$

	ρ	α	β	γ
1966:1-79:2	**0.75**	**2.9**	**0.8**	**1.4**
Ex Post(HP)	**(0.07)**	**(1.4)**	**(0.3)**	**(0.5)**
1966:1-79:2	**0.68**	**2.0**	**1.5**	**0.2**
Real Time	**(0.07)**	**(1.3)**	**(0.4)**	**(0.2)**
1979:3 -	**0.77**	**1.2**	**1.9**	**0.2**
1995:4	**(0.10)**	**(2.1)**	**(0.6)**	**(0.2)**

(Orphanides AER 2002; JME 2003; JMCB 2003)

Forecast-Based Rules with Survey Expectations

$$r_t = \rho_1 r_{t-1} + \rho_2 r_{t-2}$$

$$+ (1 - \rho_1 - \rho_2)(\alpha + \beta \pi_{t+4|t} + \gamma y_{t|t}) + \varepsilon_t$$

	ρ_1	ρ_2	α	β	γ
1979:3 - 1995:4	**0.77 (0.08)**	**-0.04 (0.10)**	**0.3 (1.6)**	**2.11 (0.5)**	**0.1 (0.2)**
1966:1 - 1979:2	**1.05 (0.15)**	**-0.31 (0.14)**	**3.2 (1.4)**	**1.13 (0.34)**	**0.41 (0.18)**
1966-73 & 1977-79	**1.2 (0.2)**	**-0.46 (0.17)**	**3.8 (1.3)**	**0.91 (0.34)**	**0.41 (0.25)**

Combining Partial Adjustment & Serially-Correlated Errors

(from English, Nelson & Sack BEP 2003)

b_0	1.02
	(1.04)
b_π	1.83
	(5.64)
b_y	0.85
	(4.59)
λ	0.58
	(7.05)
ρ	0.75
	(5.91)
R^2	0.97

Estimated using quarterly data from 1987Q1 to 2001Q4.

Suggested Refinements

- **Sample period with stable policy regime: 1987-2005**
- **Monthly frequency**
- **Short rate as observed factor**
- **Smoothed or core inflation in policy rule**
- **Policy rule should include level of output gap, unemployment rate, or capacity utilization**
- **Real-time data and survey expectations**

Long-Run Expected Inflation
(Consensus Economics 6-10 years ahead)