Monetary Policy Drivers of Bond and Equity Risks

John Y. Campbell, Carolin Pflueger, and Luis M. Viceira

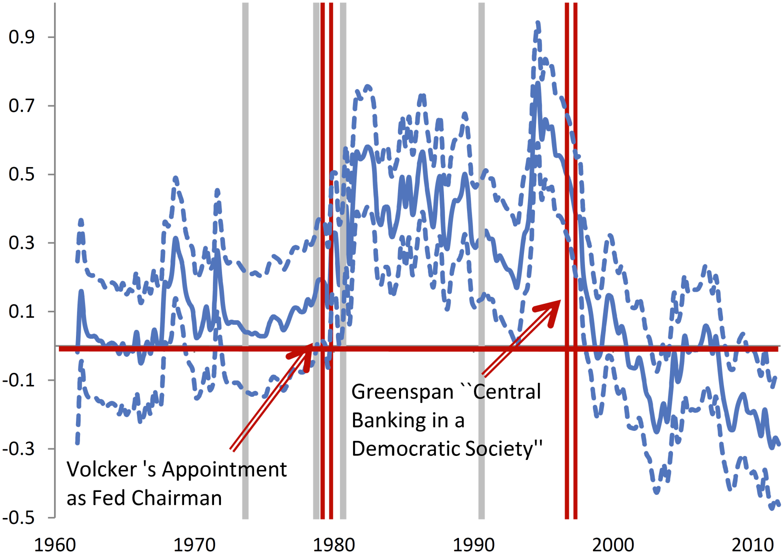
Harvard Economics, UBC Sauder, and HBS

EFMA 2014 Annual Conference, University of Rome Tor Vergata, June 2014

Changing Risks of Treasury Bonds

- US Treasuries are viewed differently today:
  - "Inflation risk premium" in 1980s
  - "Anchor to windward" or "safe haven" in 2000s.
- Treasuries comoved positively with stocks and the economy in the 1980s, negatively in the 2000s.
- Important implications for portfolio construction and asset pricing:
  - Bonds hedge stocks in endowment portfolios
  - Increased default risk for firms with long-term liabilities
- What has caused this change in bond risks? Two hypotheses:
  1. Changes in macroeconomic shocks
  2. Changes in monetary policy.

Changing Beta of US Treasury Bonds (Fig. 1A)



This Paper

- A New Keynesian asset pricing model with time varying risk premia
- Identify and estimate three distinct monetary policy regimes (Pre-Volcker, Volcker-Greenspan, Greenspan-Bernanke)
- Empirical calibration of model to three monetary regimes
- Counterfactual analysis of bond and equity risks

Related Literature

- **Empirical time-variation in bond risks:** Baele, Bekart, and Inghelbrecht (2010), Viceira (2012), David and Veronesi (2013), Campbell, Sunderam, and Viceira (2013), Kang and Pflueger (2013).
- **Affine term structure models with macro factors:** Ang and Piazzesi (2003), Ang, Dong, and Piazzesi (2007), Rudebusch and Wu (2007).
- **Asset-pricing implications of real business cycle models:** Bansal and Shaliastovich (2010), Buraschi and Jiltsov (2005), Burkhardt and Hasseltoft (2012), Gallmeyer et al (2007), Piazzesi and Schneider (2006).
- **Term-structure implications of New Keynesian models:** Andreasen (2012), Bekaert, Cho and Moreno (2010), van Binsbergen et al. (2012), Kung (2013), Palomino (2012), Rudebusch and Wu (2008), Rudebusch and Swanson (2012).
- **Monetary policy regime shifts:** Clarida, Gali and Gertler (1999, 2000), Boivin and Giannoni (2006), Rudebusch and Wu (2007), Smith and Taylor (2009), Chib, Kang, and Ramamurthy (2010), Ang, Boivin, Dong, and Kung (2011), Bikbov and Chernov (2013).

Road Map

- A New Keynesian asset pricing model
- Data
- Estimating monetary policy rules in three regimes
- Model calibration to three monetary regimes
- Counterfactual analysis of bond and equity risks

Model Overview

- "A standard New Keynesian model has emerged" (Blanchard and Gali 2007):
  - Euler equation is New Keynesian equivalent of Investment and Savings (IS) curve
  - Phillips Curve (PC) with both forward-looking and backward-looking components captures nominal rigidities and productivity shocks
  - Monetary Policy (MP) rule follows a Taylor (1993) rule with time-varying inflation target.
- Stochastic discount factor (SDF) with habit formation generates Euler equation and prices stocks and bonds:
  - Risk premia increase during recessions, consistent with the empirical evidence on stock and bond return predictability (Fama and French 1989).

Euler Equation (IS Curve): SDF with Habit Formation

- Habit formation preferences of Campbell and Cochrane (1999):
  - Surplus consumption drives time variation in marginal utility and its volatility.
- Current and lagged output gap affect level of surplus consumption:
  - Empirically plausible: 90% correlation between stochastically detrended log consumption and the log output gap (Figure 2A).
- For preference parameter α and heteroskedasticity parameter $b > 0$, assume analytically tractable form:

$$\begin{aligned} \ln U_t' &= -\alpha(x_t - \theta x_{t-1} - v_t) \\ \mathrm{Var}_t(\ln U_t') &= \alpha^2 \bar{\sigma}^2 (1 - b x_t) \end{aligned} \tag{1}$$

  - Output gap negatively affects volatility of surplus consumption and hence marginal utility:
  - Countercyclical risk premia and asset return volatility

Summary of the Macro Model

$$
\begin{aligned}
x_t &= \rho^{x-} x_{t-1} + \rho^{x+} E_{t-} x_{t+1} - \psi(E_{t-} i_t - E_{t-} \pi_{t+1}) + u_t^{IS} \\
\pi_t &= \rho^{\pi} \pi_{t-1} + (1 - \rho^{\pi}) E_{t-} \pi_{t+1} + \lambda x_t + u_t^{PC} \\
i_t &= \rho^{i} (i_{t-1} - \pi_{t-1}^*) + (1 - \rho^{i}) \left[\gamma^x x_t + \gamma^{\pi} (\pi_t - \pi_t^*) \right] + \pi_t^* + u_t^{MP} \\
\pi_t^* &= \pi_{t-1}^* + u_t^*
\end{aligned}
$$

Stochastic Volatility for All Shocks

- Independently and conditionally normal vector of shocks:

$$u_t = [u_t^{IS}, u_t^{PC}, u_t^{MP}, u_t^*]'$$

- Conditional variance-covariance matrix:

$$\Sigma_u (1 - bx_{t-1}) = \begin{bmatrix} (\sigma^{IS})^2 & 0 & 0 & 0 \\ 0 & (\sigma^{PC})^2 & 0 & 0 \\ 0 & 0 & (\sigma^{MP})^2 & 0 \\ 0 & 0 & 0 & (\sigma^*)^2 \end{bmatrix} (1 - bx_{t-1}) .$$

- Common stochastic volatility for all shocks makes model tractable and generates time-varying risk premia.

Solution Properties

- Non-explosive dynamics for output gap, inflation gap, and interest rate gap.
- New Keynesian model includes both forward-looking and backward-looking terms:
  - Lagged terms rule out "sunspot" solutions (Clarida, Gali, Gertler 2000, McCallum 2003, Cochrane 2011).
  - Finite number of potential non-explosive solutions.
- Impose additional criteria (local E-stability and Cho-Moreno criterion) to rule out unreasonable solutions (McCallum 2004, Evans 1985, 1986, Evans and Honkapohja 1994, Cho and Moreno 2011).
- These criteria give us a unique solution in all three monetary regimes, despite weak MP response to inflation in the first regime.

Modeling Bonds and Stocks

- Model stocks as levered claim on log output gap (Abel 1990, Campbell 1986, 2003): $d_t = \delta x_t$.
- Solve for equity returns using Campbell and Shiller (1988) loglinear approximation.
- Solve for nominal and real bond returns using Campbell and Ammer (1993) exact loglinear return decomposition.
- Solve for the nominal bond CAPM beta, and the volatilities of stock and bond excess returns.

Non-Linear Properties of the Model for Asset Prices

- Contercyclical risk premia generate a non-linear effect of fundamental shocks on bond betas that can amplify their linear effect.
  - Example: simultaneously recessionary and deflationary shock.
- Countercyclical volatility induces a Jensen's Inequality or convexity effect on bond prices that pushes bond prices higher in recessions, lowering bond betas.
  - In practice, modest contribution to bond betas at maturities we consider.

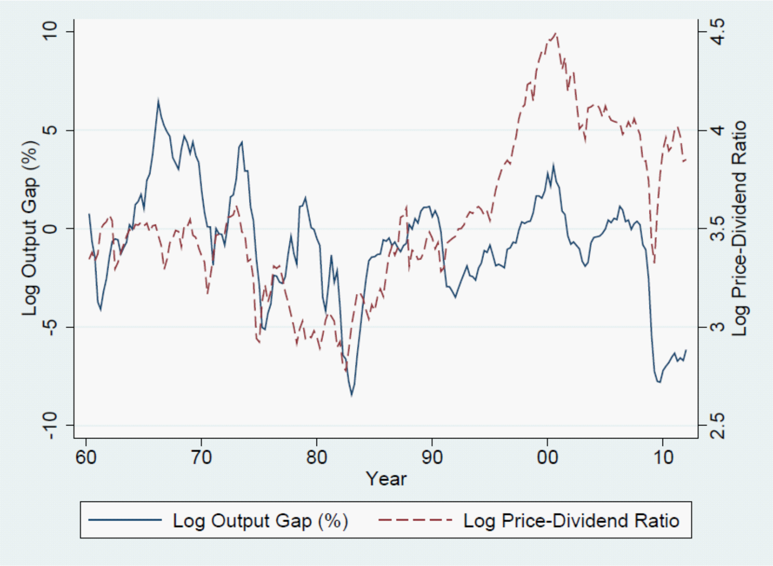
Data

- GDP in 2005 chained dollars and GDP deflator from Bureau of Economic Analysis.
- Potential output from Congressional Budget Office.
- Federal funds rate from Federal Reserve H.15 publication.
- Five-year bond yield from CRSP Fama-Bliss data base.
- Value-weighted NYSE/AMEX/Nasdaq stock return from CRSP.
- S&P 500 dividend-price ratio from Robert Shiller's web site.
- Real consumption expenditures data for nondurables and services from the Bureau of Economic Analysis.

Output Gap Forecasts Stock Returns (Table 2)

Log Exc. Stock Ret. xr^e_{t+1}	60.Q1-11.Q4	60.Q1-79.Q2	79.Q2-96.Q4	97.Q1-11.Q4
Output Gap x_t	-0.49*	-0.61*	-0.32	-0.47
	(0.20)	(0.30)	(0.48)	(0.40)
Constant	0.59	0.81	1.12	0.18
	(0.61)	(0.95)	(1.14)	(1.36)
R^2	0.03	0.04	0.01	0.02

Output Gap and Price-Dividend Ratio (Fig. 2.B)



Monetary Policy Regimes

$$i_t = \rho^i (i_{t-1} - \pi^*_{t-1}) + (1 - \rho^i) \left[\gamma^x x_t + \gamma^\pi \left(\pi_t - \pi^*_t \right) \right] + \pi^*_t + u^{MP}_t$$

- Divide sample in three subperiods and estimate MP rule:
  1. Pre-Volcker period (1960.Q1-1979.Q2): inflation accommodating
  2. Volcker - pre-1997 Greenspan period (1979.Q3-1996.Q4): $\hat{\gamma}^x \downarrow$, $\hat{\gamma}^\pi \uparrow$
  3. Post-1996 Greenspan-Bernanke period (1997.Q1-2011.Q4): $\hat{\gamma}^x \uparrow$, $\hat{\rho}^i \uparrow$
- Subperiod 3 newly identified in this paper.
  - Increased central bank transparency and gradualism.
  - Change lines up with decline in bond risks in the late 1990's

Estimating Monetary Policy Rules (Table 4)

Fed Funds i_t	60.Q1-11.Q4	60.Q1-79.Q2	79.Q3-96.Q4	97.Q1-11.Q4
Output Gap x_t	0.06	0.18**	-0.04	0.05
	(0.04)	(0.06)	(0.13)	(0.04)
Inflation π_t	0.21	0.30**	0.83**	0.21**
	(0.11)	(0.07)	(0.21)	(0.07)
Lagged Fed Funds i_{t-1}	0.81**	0.56**	0.43*	0.89**
	(0.05)	(0.10)	(0.17)	(0.06)
Constant	0.42	0.91*	1.75	-0.12
	(0.26)	(0.38)	(0.92)	(0.29)
R^2	0.79	0.75	0.69	0.91
Implied $\hat{\gamma}^x$	0.32	0.42**	-0.07	0.44
	(0.21)	(0.13)	(0.22)	(0.21)
Implied $\hat{\gamma}^\pi$	1.08**	0.69**	1.44**	1.92*
	(0.43)	(0.16)	(0.19)	(1.26)
Implied $\hat{\rho}^i$	0.81**	0.56**	0.43**	0.89**
	(0.05)	(0.10)	(0.17)	(0.06)

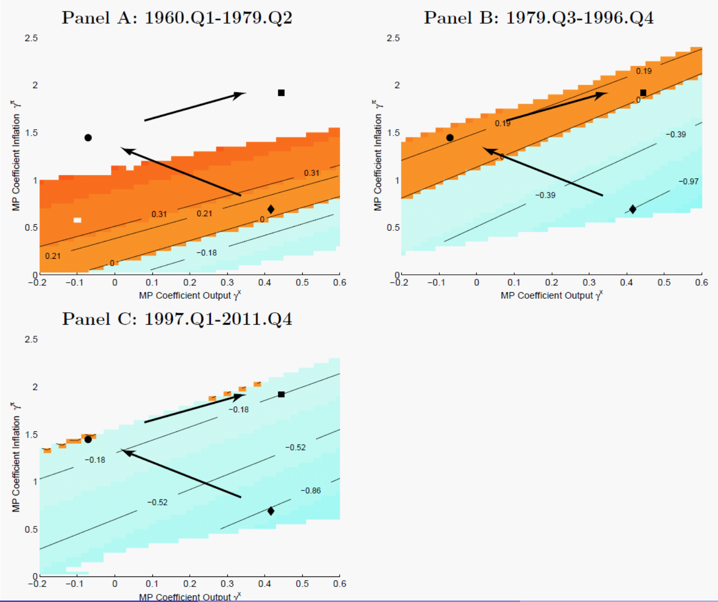
Calibration Procedure

- Specify time-invariant vs. time-varying parameters to isolate effects of changing monetary policy and macroeconomic shocks (Smets and Wouters, 2007)
  - Some parameters (α, b, θ, ρ^{π}, λ) are held invariant across subperiods.
- Parameters minimize distance between model and empirical moments:
  - Slope coefficients and residual volatilities for a VAR(1) in log output gap, inflation, Fed funds rate, and five-year nominal yield; volatilities of bond and stock returns; and beta of bonds with stocks.
- Model produces moments close to empirical counterparts in each subsample, including moments not included in the calibration:
  - In particular, it matches well changes in bond betas.

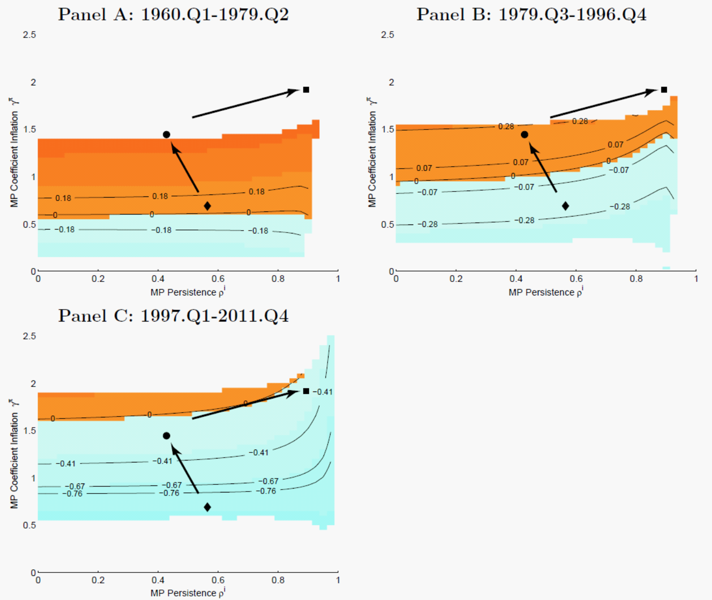
Counterfactual Analysis

- Monetary policy and size of macroeconomic shocks vary across calibrations:
  - Monetary policy coefficients
  - Volatilities of MP and inflation target shocks
  - Volatilities of IS and PC shocks.
- How do changes in each contribute to nominal bond and equity risks?
  - Counterfactual analysis based on monetary policy parameters for each sub-period calibration
  - Impulse response functions

Beta and MP Inflation and Output Responses (Figure 3)



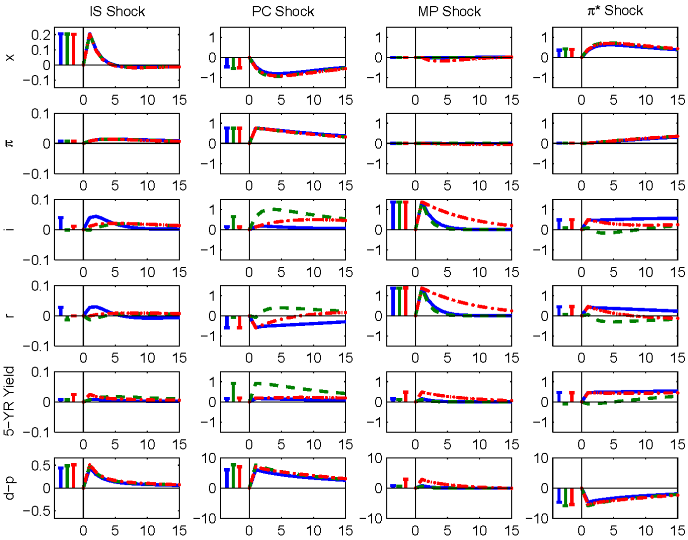
Beta and MP Inflation Response and Persistence



Impulse Response Functions

- Impulse responses are to same size shock across subperiods (sample-size weighted average of shock standard deviations)
- Units for the output gap and dividend-price ratio are in percent deviations from the steady state.
- Units for other variables are annualized percentage points.
- 60.Q1-79.Q2= blue solid, 79.Q3-96.Q4=green dash, 97.Q4-11.Q4=red dash-dot.
- Vertical bars indicate size of initial shock reaction.

Impulse Response Functions (Figure 5)



Impulse Response Functions: IS, PC, and MP Shocks

- Expansionary IS shock raises output and dividends temporarily, but has only a small effect on inflation:
  - Modest impact on bond beta, as stock prices and bond yields remain mostly flat.
- Inflationary PC shock has a persistent inflationary and contractionary effect:
  - Stock prices fall as a result of a persistent decline in dividends and output and an increase in the equity risk premium.
  - Bond prices fall as a result of persistent inflation; an immediate and aggressive anti-inflationary central bank reaction can add to this decline through a rising real interest rate.
  - Therefore, PC shock has a positive impact on nominal bond beta
- MP shocks have only very small effects on bonds and stocks.

Impulse Response Functions: Inflation Target Shocks

- Inflation target shocks have permanent but delayed impact on inflation.
- As inflation rises to new level, sticky price firms' production decisions give rise to temporary boom.
- Stock prices rise in response to increasing dividends and a lower equity risk premium.
- Immediate impact on bond yields and bond beta depends on monetary policy:
  - Period 1: Central bank raises nominal and real short rates in response to output boom, driving down bond prices and bond beta.
  - Period 2: Central bank accommodates output boom and lowers the real interest rate in response to below-target inflation, driving up bond prices and bond beta.
  - Period 3: Inflation target shock feeds immediately into bond prices as monetary policy reacts only gradually to output and below-target inflation, driving down bond beta.

Amplification Through Time-Varying Risk Premia

- In our model, risk premia increase in absolute value during recessions.
- Hence, the negative nominal bond beta in the third regime makes the term premium procyclical (less negative in booms, more negative in recessions).
- This amplifies some of the shock responses in the third regime:
  - Inflationary PC shock creates a recession, lowers the term premium, and thereby increases bond prices, amplifying the negative bond beta
  - Inflation target shock creates a boom, raises the term premium, thereby lowers bond prices, amplifying the negative bond beta.

Conclusion

- Fed anti-inflationary stance after 1979 increased nominal bond beta:
  - Large increase in Fed funds rate in response to inflation shock
  - Increase in Fed Funds rate depresses output, stock prices, and bond prices.
- Persistent monetary policy (gradualism) and shocks to inflation target generate negative nominal bond beta since mid 1990s:
  - Inflation target shock generates inflation and temporary output boom.
  - With slowly moving monetary policy, higher expected inflation leads directly to lower bond prices.
  - Changes in official central bank inflation target or central bank credibility?
- Phillips Curve (supply) shocks increase nominal bond beta.
- Changing risk premia offer important amplification mechanism.