Fiscal Policy and the Term Structure of Interest Rates

Aleš Maršál
Lorant Kaszab
Roman Horvath

Workshop DYME 2016

Outline

Preview

Outline

Outline

Outline

Outline

Preview

Model

Fidings

Finance story

- Theoretical decomposition
- Quantitative decomposition

Factor attribution

Outline

Contents

What do we do?

- macro-finance paper
- we believe that asset prices are driven by macro fundamentals
- statistical approach (Nelson-Siegel, unrestricted VAR)
- structural approach
  - partial equilibrium models or static general equilibrium models
  - DSGE

Our approach

- the goal is not to find great investment opportunity but explain existing prices = asset pricing
- Is there some formula which tells how much is the bond worth? $P_t = E_t[X_{t+1}]$
- We **assume** THERE IS! Implied by what become a paradigm in this literature
- NK model with EZ preferences
- we calculate derivatives of pricing kernel(uncertainty, unexpected shock)
- question if they make sense

How do we differ from the rest of the literature?

1. We look at the whole term structure, the rest of the literature looks only at NTP
   - we look at the level, slope and curvature whereas RS (2008,2012), Andreasen (2011), Ferman (2011), HTV (2007), Paoli (2012) and all the others, look just at the slope
   - Why is all this important? NTP tells you why 10 year bond bears higher yield than short maturity bond. We explain the model implied bond price itself, where the risk comes from and show it over the whole maturity profile
2. We derive the pricing kernel in terms of conditional second moments
3. attribution - quantitatively evaluate the decomposition
4. Fiscal story

Fiscal story

- Large part of NTP (more than half) is usually explained by TFP shocks. No one cares much about government spending shocks as they play minor role (explain about 5 % of NTP)
- show that if you increase the uncertainty about government spending shocks to levels which are historically observed the fiscal story gets important also from quantitative point of view
- We apply the theoretical and quantitative decomposition (point 2 and 3) to show exactly the transmission of government spending shocks to bond prices
- we show
  - the transmission depends on monetary policy
  - fiscal policy is history dependent

Contents

Household problem

Representative, infinitely-lived agent have Epstein and Zin (1989) preferences.

$$V_t = u(C_t, N_t) + \beta[E_t V_{t+1}^{1-\alpha}]^{\frac{1}{1-\alpha}} \tag{1}$$

The period utility is given by:

$$u(C_t, L_t) = e^{\beta_t} \left\{ \frac{C_t^{1-\sigma_1}}{1-\sigma_1} - \omega \frac{N_t^{1+\sigma_2}}{1+\sigma_2} \right\} \tag{2}$$

- Preference for early resolution of uncertainty
- Long run risk
- separability of risk aversion from coefficient of intertemporal elasticity of substitution

Supply side

Firm's problem

Final good firms operate under perfect competition and use following technology to bundle the intermediate good

$$Y_t = \left(\int_0^1 Y_t^{\frac{1}{1+\lambda_t}}(i)di \right)^{1+\lambda_t} \tag{3}$$

We follow Smets and Wouters (2003) and allow some degree of substitutability across differentiated intermediate goods λ_t to vary over time (time varying mark up). Profit maximization gives demand for intermediate good

$$Y_t(i) = \left(\frac{P_t(i)}{P_t} \right)^{-\frac{1+\lambda_t}{\lambda_t}} Y_t \tag{4}$$

The implied aggregate price level is given by
$P_t = \left(\int_0^1 P_t(i)^{-\frac{1}{\lambda_t}} \right)^{-\lambda_t}$

Supply side

Firm's problem

In the intermediate good sector all firms have identical Cobb-Douglas PF:

$$Y_t = A_t \bar{K}^{\theta} N_t^{1-\theta} \tag{5}$$

where A_t is the aggregate level of technology, $\bar{K}$ is fixed, N_t hours worked

Price stickiness

The price stickiness is introduced by Rotemberg adjustment cost. Firms can reset the prices of each differentiated good in every period paying the quadratic adjustment costs

$$\frac{\varphi_p}{2}\left[\frac{P_t(i)}{P_{t-1}(i)}\frac{1}{\bar{\pi}} - 1\right]^2 P_t Y_t \tag{6}$$

Closing the model

Monetary authority follows interest rate rule:

$$i_t = \bar{i} + \Phi_\pi \pi_t + \Phi_y Y_t \tag{7}$$

The market clearing condition in the final good market

$$Y_t = C_t + G_t + \delta \bar{K} \tag{8}$$

Fiscal Policy

Government spending

$$G_t = \rho_G G_{t-1} + \sigma_G \epsilon_t^G \tag{9}$$

where $\epsilon_t^G \in N(0,1)$
Spending reversals (Corsetti 2009)

- G is financed $T_t + Q_{t+1} D_{t+1} = D_t + P_t G_t$
- taxes are endogenous $T_{Rt} = \Psi_t D_{rt}$

$$G_t = (1-\rho_G)\bar{G} + \rho_G G_{t-1} + \Psi_t D_{Rt} + \sigma_G \epsilon_t^G \tag{10}$$

The model is calibrated and driven by productivity, mark-up, preference shocks. macro calib, fiscal calib

Bond prices

$$Q_{t,t+n} = \beta^n \left(\frac{C_{t+n}}{C_t}\right)^{-\gamma} \prod_{j=0}^{n} \frac{\zeta_{t+j}}{\pi_{t+j+1}} \left[\frac{R_{t+j}}{V_{t+j+1}}\right]^{\alpha} \qquad (11)$$

- by chaining the pricing kernel we can price bond of any maturity
- having the term structure of interest rates $\widehat{ytm}_t^n = -\frac{1}{n} q_{t,t+n}$ we can calculate the derivatives:
  1. $\partial \widehat{ytm}_t^n / \partial \epsilon_t^G$ unexpected increase in government spending
  2. we explain where the risk premium $\partial \widehat{ytm}_t^n - r^f$ comes from and calculate $\partial \widehat{ytm}_t^n / \partial \sigma_G$
  3. term premium $NTP_t^n = i_t^n - \sum_t E_t[i_{t+j}]$, $\partial NTP_t^n / \partial \sigma_G$

chart

Contents

Benchmark model

$\phi_y = 0.075$

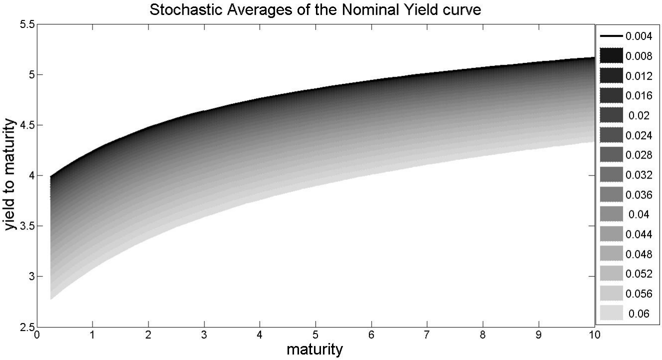

Figure: Term structure and varying volatility of G shocks. In the legend is the volatility of the G innovation.

Benchmark model

$\phi_y = 0$

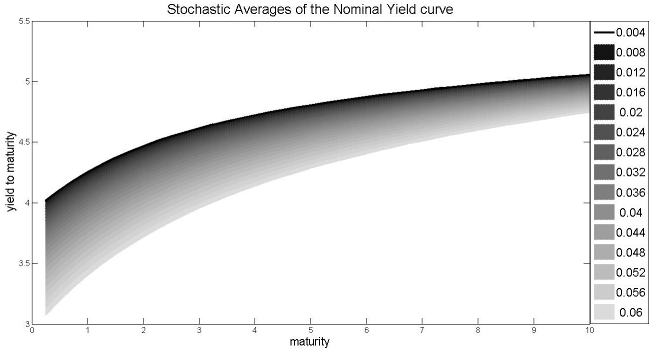

Figure: Term structure and varying volatility of G shocks in the benchmark model when central bank puts zero weight on output gap stabilization. In the legend is the volatility of the government spending innovation.

Results

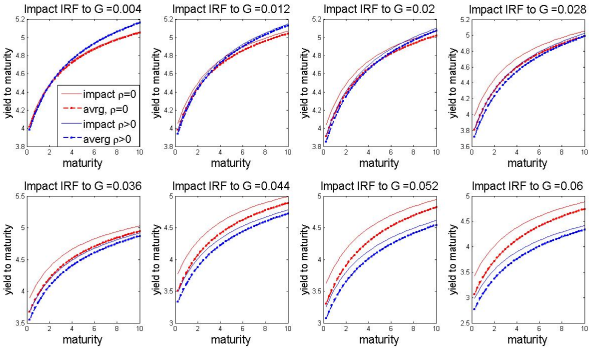

Figure: The Role of Monetary Policy. The stochastic steady state of the term structure and the impact of increase in government spending on the yield curve for two policy regimes.

Model with spending reversals

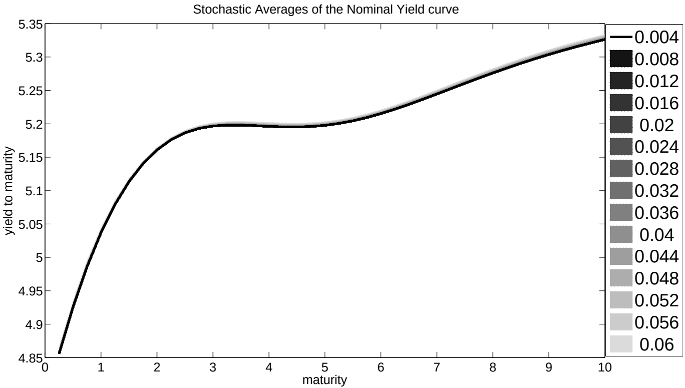

Figure: Term structure and varying volatility of G shocks. In the legend is the volatility of the shock. In the box is the maximal slope over the whole grid of parameters.

Contents

Analytical decomposition

$$\begin{aligned}
\widehat{ytm}_t^n &= -\frac{1}{2n}\left\{\mathrm{Var}_t \sum_{j=1}^{n}\left(\hat{\zeta}_{t,t+j}\right) + \gamma^2 \mathrm{Var}_t\left(\Delta^n \hat{\mathbf{c}}_{t+n}\right) + \mathrm{Var}_t \sum_{j=1}^{n}\left(\hat{\pi}_{t,t+j}\right)\right\} \\
&- \frac{\alpha^2}{2n}\mathrm{Var}_t S_{t+n}(\cdot) + \frac{\gamma}{n}\mathrm{Cov}_t\left(\sum_{j=1}^{n}\hat{\zeta}_{t,t+j}, \Delta^n \hat{\mathbf{c}}_{t+n}\right) \\
&+ \frac{1}{n}\mathrm{Cov}_t\left(\sum_{j=1}^{n}\hat{\zeta}_{t,t+j}, \sum_{j=1}^{n}\hat{\pi}_{t+j}\right) - \frac{\gamma}{n}\mathrm{Cov}_t\left(\Delta^n \hat{\mathbf{c}}_{t+n}, \sum_{j=1}^{n}\hat{\pi}_{t+j}\right) \\
&+ \frac{\alpha}{n}\mathrm{Cov}_t\left(\sum_{j=1}^{n}\hat{\zeta}_{t,t+j}, S_{t+n}(\cdot)\right) - \frac{\gamma\alpha}{n}\mathrm{Cov}_t\left(\Delta^n \hat{\mathbf{c}}_{t+n}, S_{t+n}\right) \qquad (12) \\
&- \frac{\alpha}{n}\mathrm{Cov}_t\left(\sum_{j=1}^{n}\hat{\pi}_{t+n}, S_{t+n}\right)
\end{aligned}$$

Contents

Precautionary savings

Stand alone factors	B	$\phi_y = 0.075$	$\phi_y = 0$	TFP	Mark up	Pref
$-\frac{\gamma^2}{2n} Var_t(\Delta C_{t+n})$	1.3	0.9	1.3	1.4	0.2	1.2
$-\frac{1}{2n} Var_t(\sum_{j=1}^{n} \pi_{t+n})$	85.4	59.7	78.5	63.3	100	126.4
$-\frac{\alpha^2}{2n} Var_t(S_{t+n})$	-8.1	-5.1	-8.8	-8.8	0	-8.9
$-\frac{1}{2n} \mathrm{Var}_t \sum_{j=1}^{n} (\zeta_{t,t+j})$	2.1	0	0	0	0	6.4
Factor interactions						
$-\frac{\gamma}{n} Cov_t(\Delta C_{t+n}, \sum_{j=1}^{n} \pi_{t+n})$	-0.2	0.1	-0.1	-0.1	-0.2	1.5
$-\frac{\gamma\alpha}{n} Cov_t(\Delta C_{t+n}, S_{t+n})$	29.4	41.8	64.6	73.18	0	-5.7
$-\frac{\alpha}{n} Cov_t(S_{t+n}, \sum_{j=1}^{n} \pi_{t+n})$	-43.5	2.6	-34.7	-28.2	-0.1	-87.9
$+\frac{\alpha}{n} Cov_t(S_{t+n}, \sum_{j=1}^{n} (\zeta_{t,t+j}))$	36.4	0	0	0	0	120
$+\frac{\gamma}{n} Cov_t(\Delta C_{t+n}, \sum_{j=1}^{n} (\zeta_{t,t+j}))$	-1.7	0	0	0	0	-5.76
$+\frac{1}{n} Cov_t(\sum_{j=1}^{n} (\zeta_{t,t+j}), \sum_{j=1}^{n} \pi_{t+n})$	-1	0	0	0	0	-3.44
Total						
$E_t[ytm_t^n] - \overline{ytm_t}$	-0.96	-0.02	-0.01	-0.58	-0.08	-0.29

Table: attribution

chart 1, chart 2, chart 3 Attribution

Market price of risk

is independent of the specific characteristics of the asset being priced

$$\begin{aligned}
\widehat{ytm}_t^n &= -\frac{1}{2n}\left\{\mathrm{Var}_t \sum_{j=1}^{n}\left(\hat{\zeta}_{t,t+j}\right) + \gamma^2 \mathrm{Var}_t\left(\Delta^n \hat{\mathbf{c}}_{t+n}\right) + \mathrm{Var}_t \sum_{j=1}^{n}\left(\hat{\pi}_{t,t+j}\right)\right\} \\
&- \frac{\alpha^2}{2n}\mathrm{Var}_t S_{t+n}(\cdot) + \frac{\gamma}{n}\sigma_{\hat{\zeta}}\sigma_{\Delta\hat{\mathbf{c}}}\mathrm{Corr}_t\left(\sum_{j=1}^{n}\hat{\zeta}_{t+j}, \Delta^n\hat{\mathbf{c}}_{t+n}\right) \\
&+ \frac{1}{n}\sigma_{\hat{\zeta}}\sigma_{\hat{\pi}}\mathrm{Corr}_t\left(\sum_{j=1}^{n}\hat{\zeta}_{t+j}, \sum_{j=1}^{n}\hat{\pi}_{t+j}\right) - \frac{\gamma}{n}\sigma_{\Delta\hat{\mathbf{c}}}\sigma_{\hat{\pi}}\mathrm{Corr}_t\left(\Delta^n\hat{\mathbf{c}}_{t+n}, \sum_{j=1}^{n}\hat{\pi}_{t+j}\right) \\
&+ \frac{\alpha}{n}\sigma_{\hat{\zeta}}\sigma_S\mathrm{Corr}_t\left(\sum_{j=1}^{n}\hat{\zeta}_{t+j}, S_{t+n}(\cdot)\right) - \frac{\gamma\alpha}{n}\sigma_{\Delta\hat{\mathbf{c}}}\sigma_S\mathrm{Corr}_t\left(\Delta^n\hat{\mathbf{c}}_{t+n}, S_{t+n}\right) \\
&- \frac{\alpha}{n}\sigma_{\hat{\pi}}\sigma_S\mathrm{Corr}_t\left(\sum_{j=1}^{n}\hat{\pi}_{t+n}, S_{t+n}\right) \qquad (13)
\end{aligned}$$

Nominal Term Premium

Stand alone factors	B	$\phi_y = 0.075$	$\phi_y = 0$	$\sigma_g = 0.06$	TFP	Pref
$-\frac{\gamma^2}{2n} Var_t(\Delta C_{t+n})$	1.7	4.1	2	2	1.3	1.7
$-\frac{1}{2n} Var_t(\sum_{j=1}^{n} \pi_{t+n})$	-1.2	0	0	0	-1.1	-1.3
$-\frac{\alpha^2}{2n} Var_t(S_{t+n})$	0	0	0	0	0	0
$-\frac{1}{2n} \mathrm{Var}_t \sum_{j=1}^{n} (\zeta_{t,t+j})$	6.2	0	0	0	0	9.8
Factor interactions						
$-\frac{\gamma}{n} Cov_t(\Delta C_{t+n}, \sum_{j=1}^{n} \pi_{t+n})$	0.7	0.1	0	0	-0.1	0.3
$-\frac{\gamma\alpha}{n} Cov_t(\Delta C_{t+n}, S_{t+n})$	-14.6	105.2	56	56	36	-44.8
$-\frac{\alpha}{n} Cov_t(S_{t+n}, \sum_{j=1}^{n} \pi_{t+n})$	44.5	-9.2	42	42	62	35
$+\frac{\alpha}{n} Cov_t(S_{t+n}, \sum_{j=1}^{n} (\zeta_{t,t+j}))$	68.3	0	0	0	0	108
$+\frac{\gamma}{n} Cov_t(\Delta C_{t+n}, \sum_{j=1}^{n} (\zeta_{t,t+j}))$	-5.1	0	0	0	0	-8.1
$+\frac{1}{n} \Delta Cov_t(\sum_{j=1}^{n} (\zeta_{t,t+j}), \sum_{j=1}^{n} \pi_{t+n})$	-0.5	0	0	0	0	0
Total						
$E_t[ytm_t^n] - \overline{ytm_t}$	1.19	0.007	0.01	0.6	0.43	0.74

Table: NTP

Results

Factor attribution over the maturity profile $\phi_y = 0.075$

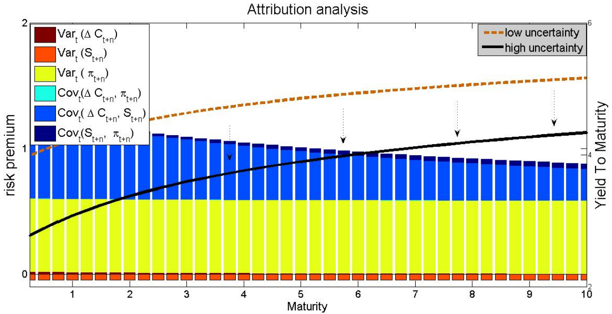

Figure: Factor attribution over the maturity profile $\phi_y = 0.075$

Results

Factor attribution over the maturity profile $\phi_y = 0$

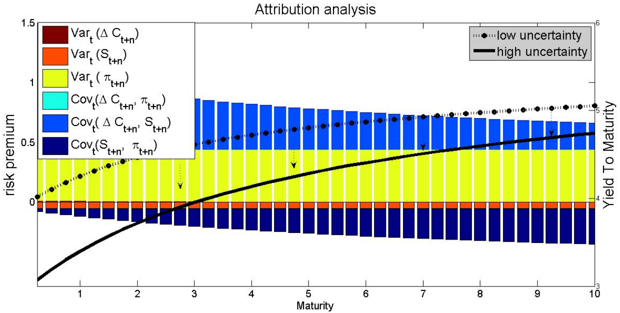

Figure: Factor attribution over the maturity profile $\phi_y = 0$

Contents

Summing it up . . .

- rise in uncertainty about government spending amplifies the hedging property of bonds against long run risks to consumption and leisure
- Depending on the monetary policy conduct the inflation risk acts as leverage to the long run consumption and leisure and thus increases the risk premium
- nominal risk increases over the maturity profile whereas the real risk declines
- spending reversals break the link between quantity of fiscal risk and risk premium

Thank you for your attention

Benchmark model

- to explain the transmission of exogenous government spending on term structure it is necessary to understand how the model economy works
- imagine that the economy is in the steady state (long run equilibrium)
- next, the economy is hit by exogenous G shock ($\varepsilon_G > 0$ at $t = 1$ and $\varepsilon_G = 0$ at $t > 1$)
- economy response is driven by wealth effect

Results

Benchmark model

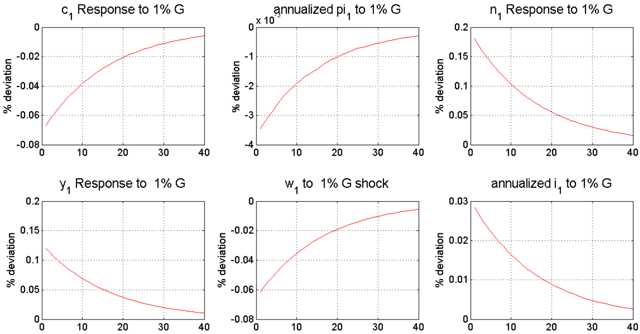

Figure: IR functions to 0.8% shock in G in basic NK model with regime shifts. In Taylor rule $\rho_y > 0$

Benchmark model

- $\Delta\ G > 0$ decreases disposable income implies $\frac{\partial C}{\partial G}$, $\frac{\partial L}{\partial G} < 0$ assuming they are normal goods
- less leisure causes $\Delta N > 0$
- aggregate demand goes up because $\frac{\partial C}{\partial G} < \Delta G \uparrow$
- $\frac{\partial N}{\partial G} > 0$ implies higher $Y_t = A_t \bar{K}^{\theta} N_t^{1-\theta}$ than in real terms $Y_t = C_t + G_t + \delta \bar{K}$ thus prices must go down
  - firms cannot cut prices fully because of nominal rigidities
  - they respond by reducing output and labor demand, this decreases wages
  - MP rices nominal interest rate - accommodating the rise in Y, real rate falls

Important: consumption and prices fall

Benchmark model

- rise is driven by the expected higher nominal interest rates
- response of NTP is very small
- CB rises i_t to accommodate output

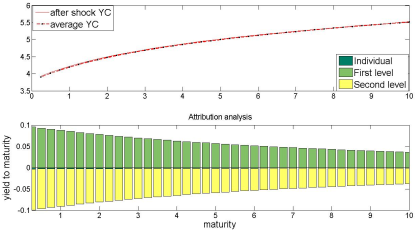

Figure: Attribution analysis of the period impact

Results

Baseline model with output stabilization

- imagine that the economy is in the steady state (long run equilibrium)
- next, the economy is hit by exogenous G shock ($\varepsilon_G > 0$ at $t = 1$ and $\varepsilon_G = 0$ at $t > 1$)
- MP is not responding to rise in Y_t and accommodates the additional money demand
- firms can respond to additional demand by rising their prices

Important: consumption fall, prices rise

Results

Baseline model with output stabilization

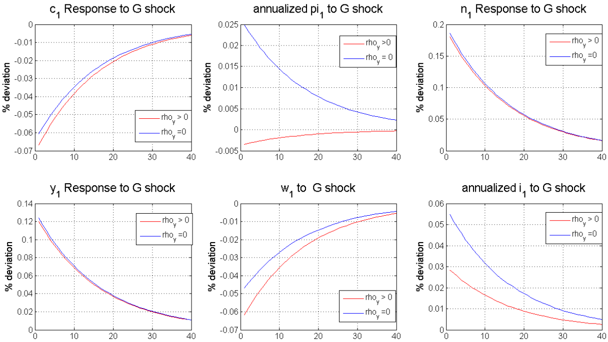

Figure: IR functions to 0.8% shock in G

Taylor rule

As highlighted above, the conduct of monetary policy is important determinant of the slope and level of the term structure in response to government spending shock. For this reason, we test the robustness of our findings over the whole grid of Taylor rule estimates found in the data.

Study	Period	ϕ_π	ϕ_y
Taylor (1996)	1987 - 1997	1.53	0.77
Judd and Rudebush (1998)	1987 - 1997	1.54	0.99
Clarida, Gali and Gertler (1998)	1979 - 1994	2.2	0.07
Clarida, Gali and Gertler (2000)	1979 - 1996	2.15	0.93
Orphanides (2003)	1979 - 1995	1.89	0.18

Table: Taylor rule estimates for US

Taylor rule - robustness check

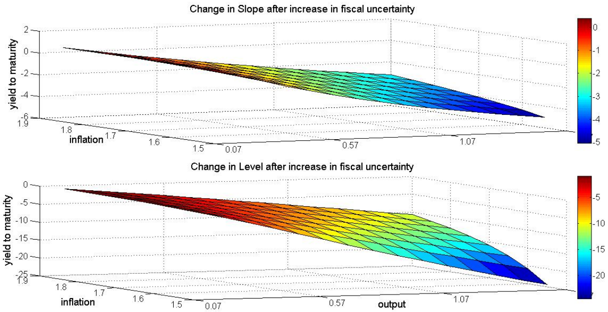

Figure: Changes in the level and slope of the term structure of interest rate over the grid of Taylor rule regimes after the change in volatility of government spending shock ranging from $\sigma_G = 0.004$ to $\sigma_G = 0.06$

Taylor rule - robustness check

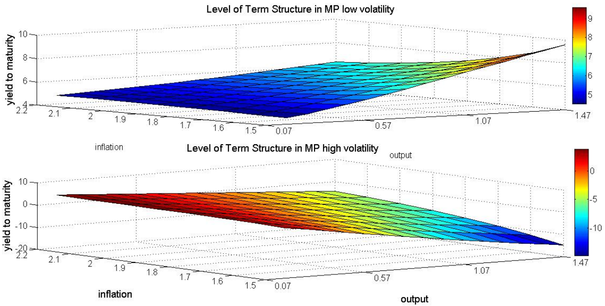

Figure: Level and slope of the term structure of interest rate over the grid of Taylor rule regimes for volatility (upper one) $\sigma_G = 0.004$ and volatility $\sigma_G = 0.06$ (bottom)

Taylor rule - robustness check

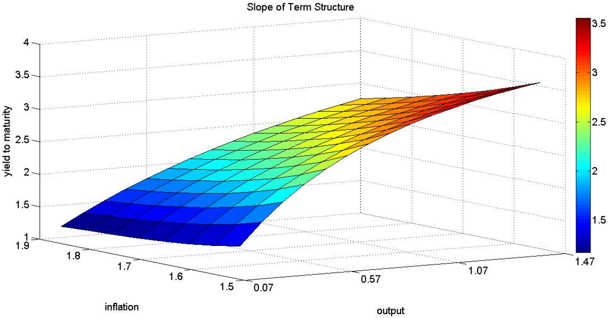

Figure: Slope of the term structure of interest rate over the grid of Taylor rule regimes for volatility $\sigma_G = 0.004$

Empirical evidence

Where do we stand?

- we did not find study relating government spending as we define it with dynamics of the yield curve
- something we currently intensively work on - first estimates suggest our conclusions are qualitatively in line with data (we insert into Ramey codes yields)
- our arguments are model based
- model fits stylized macro and yield curve facts

Empirical evidence

Literature review

The literature studying the effects of fiscal policy on interest rates documents relationship. For instance:

- Barth (1991) surveys 43 studies; 18 positive effect, 6 mixed effects, 19 not significant or negative
- Gale and Orsag (2003) redo Barth (1991); from 19 studies with projected deficits 13 positive, 5 mixed effects, 1 no effect
- similar conclusion Mankiw (1999)
- often cited papers as Evans (1987) or Plosser (1982) no effect
- Afonso Martins (2010) using macro - finance model find government debt and the budget deficit rise sovereign yield curve in US

Empirical evidence

Afonso Martins (2010)

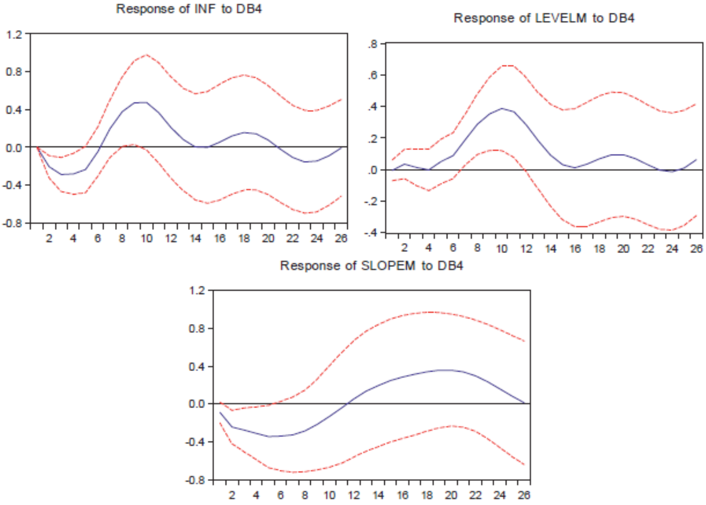

Figure: Response to Debt to GDP ratio

Empirical evidence

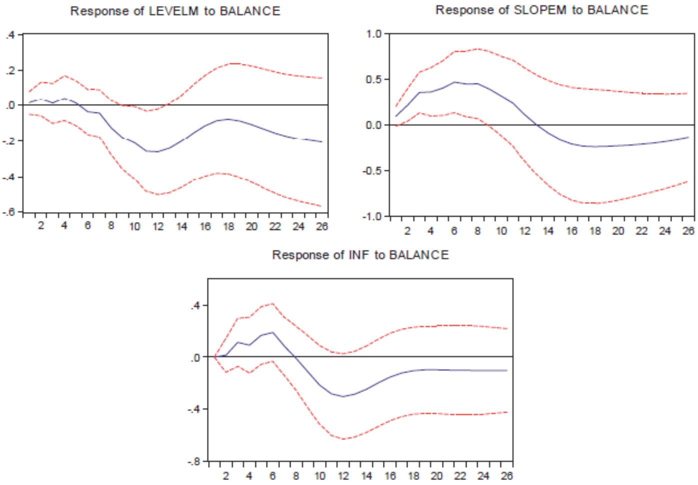

Figure: Response to Budget Balance

Supplemental content.

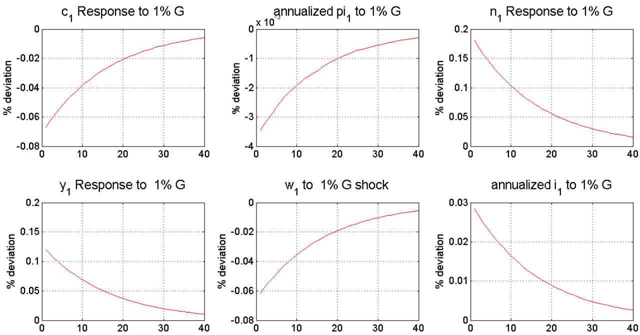

Figure: IR functions to 0.8% shock in G. In Taylor rule $\rho_y > 0$

Back to main.

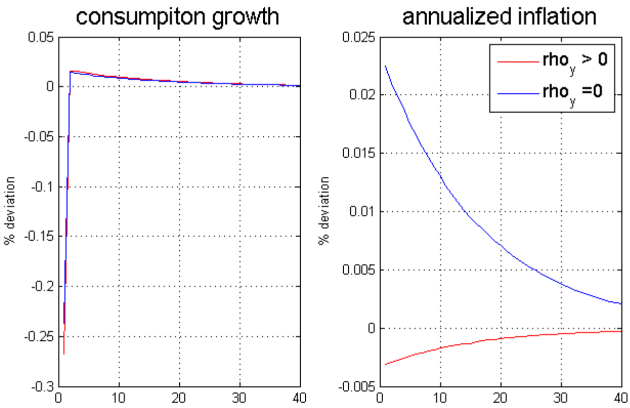

Figure: IR functions to 0.8% shock in G

Back to back.

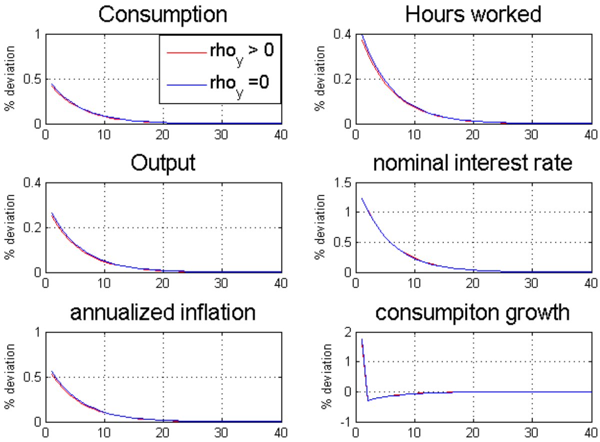

Figure: IR functions to 2% shock in flight to quality

Back to Back.

How do we do things?

EZ preferences

3 cases for C and L Back to back.

1. coin flipped at $t = 0$ determines high or low consumption and leisure at all dates 1,2,3 . . . T
2. T coins flipped at $t = 0$ determine high or low consumption and leisure at all dates 1,2,3 . . . T
3. T coins flipped before each period to determine consumption and leisure that period

- intertemporally smooth path of C and L but big time-zero volatility in V_t
- all info revealed at $t = 0$ thus $E_t(V_{t+1}$ varies over time non-stochastically but features higher variation across time
- timing of uncertainty resolution, when $\gamma < \psi$ agents prefer early resolution of uncertainty

How do we do things?

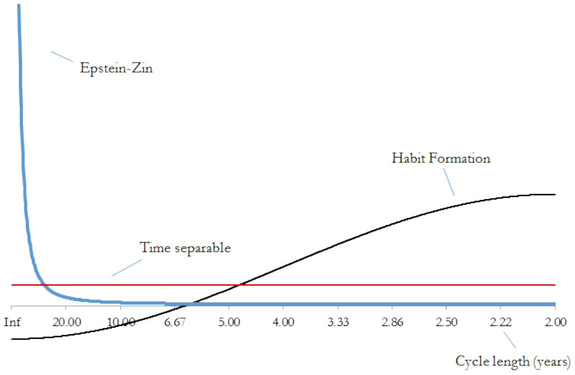

Figure: Demand for insurance over the frequencies (Dew-Becker and Giglio 2013)

Back to back.

Definitions

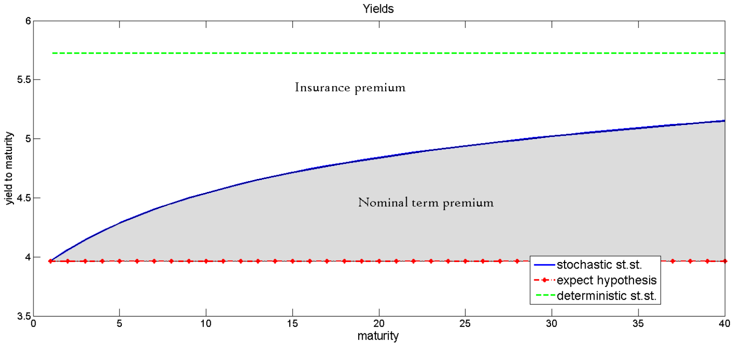

Figure: Defining terms

Back to back.

Calibration

The model is calibrated to match moments of

- macro consumption growth, inflation, one period interest rate
- asset pricing (10Y slope, level and NTP)

- Standard value for US
- based on Rudebush Swanson (2012), Ferman (2012), Andreasen 2012
- we take the parameter and model dependency very seriously

Back to back.

Calibration

Table: Calibration of the model

Monetary Policy Rule				Exogenous processes			
ϕ_π	2.19			ρ_b	0.83	σ_b	0.020
ϕ_y	0.075			ρ_A	0.98	σ_A	0.005
				ρ_λ	0.18	σ_λ	0.051
				ρ_G	0.94	σ_G	0.008
Structural Parameters				The Steady-State			
β	0.99	θ	0.33	$\bar{\Pi}$	1.004		
γ	2	$\bar{\lambda}$	0.2	$\bar{K}/(4\bar{Y})$	2.5		
η	0.40	ζ	233	$\bar{G}/\bar{Y}$	0.2		
$RiskAv$	110	δ	0.02				

Calibration

Quantity of risk

Period	σ_g	std(G)
1947 - 1957	5.83	17
1957 - 1967	1.55	4.53
1967 - 1977	1.61	4.71
1977 - 1987	0.49	1.43
1987 - 1997	0.61	1.79
1997 - 2007	0.9	2.63
1969 - 2009	0.8	2.43

Table: Standard deviation of defense spending and implied innovations. Results are in % deviations from the HP trend

Back to back.

Analytical decomposition

- nominal risk
  - stagflation story $\mathrm{Cov}\left(\Delta^n \hat{\mathbf{c}}_{t+n}, \sum_{j=1}^{n} \hat{\pi}_{t+j}\right)$ high inflation and low consumption means that the bond looses its value exactly when needed the most, empirically Piazzesi Schneider (2006)
  - long run risk $\mathrm{Cov}\left(\sum_{j=1}^{n} \hat{\pi}_{t+n}, S_{t+n}\right)$
  - rise in demand for safe assets accompanied by growth in inflation (Fisher (2015)) $\mathrm{Cov}\left(\sum_{j=1}^{n} \hat{\zeta}_{t,t+j}, \sum_{j=1}^{n} \hat{\pi}_{t+j}\right)$

Analytical decomposition

- real risk
  - $\mathrm{Cov}\left(\Delta^n \hat{\mathbf{c}}_{t+n}, S_{t+n}\right)$ Kaltenbrunner and Lochstoer (2010), if agents dislike shocks to both realized and expected consumption growth, the long run risk component acts as a hedge for shocks to realized consumption growth. chart
  - $\mathrm{Cov}\left(\sum_{j=1}^{n} \hat{\zeta}_{t,t+j}, S_{t+n}(\cdot)\right)$, interaction of the preference for safe assets with the revision in expectation about future consumption growth and leisure. An exogenous increase in demand for safe assets lowers the marginal cost of saving, thereby increasing the incentive to save by buying risk-free bonds. The rise in demand for safe assets is bad news for expected future consumption growth and leisure

Factor Attribution

- not simple to calculate conditional moments
- $E_t Var_{t+1-1} x_{t+j} \neq Var_t x_{t+j}$
- we use the idea of performance attribution to decompose the pricing kernel and to calculate unconditional moments
- lets for the sake of explanation consider only three factors and no steady state inflation

Factor Attribution

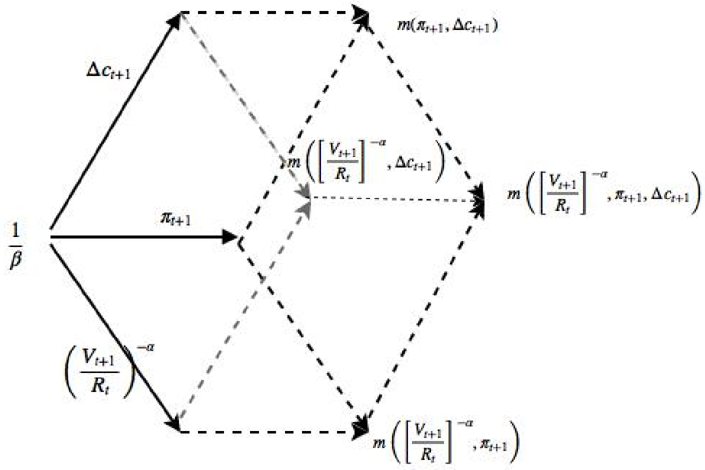

Figure: Diagram demonstrating the Brinson Fachler approach

Back to back.