A Fiscal Decomposition of Unexpected Inflation: Cross-Country Estimates and Theory

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November 2022

Introduction: The Fiscal Sources of Unexpected Inflation

- Connection between fiscal policy and inflation
- Key Equilibrium Condition: The Valuation Equation of Public Debt

$$\frac{\text{Market Value of Debt } (\textbf{Bond Prices})}{\textbf{Price Level}} = \text{Intrinsic Value } (\textbf{Discounting}, \textbf{Surpluses}).$$

- Unexpected inflation must accompany news about:
    - Bond prices
    - Real surpluses
    - Real discounting
- If unexpected inflation exists, it must nowcast/forecast some of these variables
- What are these forecasts? How do they change across countries? How can theory explain them?

Introduction: Exercises, Motivation, Results

- **Motivation.** Valuation equation requires very weak assumptions (no bubbles!)
  - Stylized facts to discipline theory
  - Relevance for policy: is unexpected inflation "fiscal"?
    - Fixed country: +1% inflation $\implies$ +1% deficit/debt?
    - Cross country: +1% inflation in A relative to B $\implies$ +1% deficit/debt in A compared to B?
    - Fiscal role to monetary policy?
- **This paper.** Estimates for multiple countries and conditions for NK models to reproduce them
  1. Estimate a Bayesian-VAR for 25 countries to measure the following decompositions:
     - Unexpected Inflation: *"What does +1% unexpected inflation forecast?"*
     - Unexpected Demand: *"What does +1% unexpected inflation and +1% GDP growth forecast?"*
     - Unexpected Surpluses: *"What does -1% unexpected discounted surpluses forecast?"*
  2. Estimate New-Keynesian model by GMM to reproduce BVAR decompositions

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Introduction: Related Literature

- **Monetary-Fiscal Interaction.**
  Cagan (1956), Sargent and Wallace (1981), Hall and Sargent (1997), Hall and Sargent (2011), Jiang et al. (2019), Corsetti et al. (2019), Sunder-Plassmann (2020), Du et al. (2020), Akhmadieva (2022)
- **Fiscal Theory of the Price Level.** Leeper (1991), Sims (1994), Woodford (1995), Cochrane (1998), Cochrane (2005), Sims (2011), Leeper and Leith (2016), Bassetto and Cui (2018), Cochrane (2022c), Brunnermeier et al. (2022), Cochrane (2022a), Cochrane (2022b)
  - Analysis of multiple countries
  - Estimated NK model with productivity shocks
- **Empirical Finance** (Drivers of Unexpected Returns)
  Campbell and Shiller (1988), Cochrane (1992), Campbell and Ammer (1993), Chen and Zhao (2009), Cochrane (2008), Jiang et al. (2019).
  - Unexpected return on basket of public debt

The Fiscal Decomposition of Unexpected Inflation

Fiscal Decomposition: The Valuation Equation

- Environment with discrete time + single good (price P_t) + households and government
- One-period nominal public bonds (price Q_t)
- In each period, the government:
  - redeems bonds B_{t-1} for currency
  - soaks up currency through primary surpluses $P_t s_t$ and bond sales $Q_t B_t$
- Market clearing + No Currency Holdings $M = 0$:

$$\boxed{B_{t-1} = P_t s_t + Q_t B_t}$$

Fiscal Decomposition: The Valuation Equation

- *Ex-post* real discounting $\beta_t = Q_t(P_{t+1}/P_t)$ $\beta_{t,t+k} = \prod_{\tau=t}^{t+k} \beta_\tau$
- Iterate law of motion forward:

$$\frac{B_{t-1}}{P_t} = \sum_{k=0}^{p} \beta_{t,t+k-1} s_{t+k} + \beta_{t,t+p} \frac{B_{t+p}}{P_{t+p+1}}$$

- **Key Assumption:** $\lim_{\tau\to\infty} \beta_{t,\tau} \frac{B_\tau}{P_{\tau+1}} = 0$
- Valuation equation of public debt:

$$\boxed{\frac{B_{t-1}}{P_t} = \sum_{k=0}^{\infty} E_t\left[\beta_{t,t+k-1} s_{t+k}\right]}$$

"A prince who should enact that a certain proportion of his taxes should be paid in a paper money of a certain kind might thereby give a certain value to this paper money" - Adam Smith

Fiscal Decomposition: In the Simplest Environment

- End-of-period real debt v_t
- Linearized flow condition + valuation equation

$$\underbrace{\frac{1}{\beta} v_{t-1} + \frac{v}{\beta}\left(i_{t-1} - \pi_t\right)}_{B_{t-1}/P_t} = s_t + v_t \qquad = \sum_{k=0}^{\infty} \beta^k E_t s_{t+k} - \frac{v}{\beta} \sum_{k=1} \beta^k E_t r_{t+k}$$

- Take innovations $\Delta E_t = E_t - E_{t-1}$:

$$\boxed{\Delta E_t \pi_t = -\frac{\beta}{v} \sum_{k=0}^{\infty} \beta^k \Delta E_t s_{t+k} + \sum_{k=0}^{\infty} \beta^k \Delta E_t r_{t+k}}$$

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Fiscal Decomposition: Generalizing

- GDP Growth
- Nominal, inflation-linked and dollar-denominated bonds
- Long-term bonds

$$\frac{\textbf{Bond Price in Home Currency} \times \text{Bonds}}{\textbf{Price Level}} = \sum_t \frac{\textbf{Surplus-to-GDP} \times \Delta\textbf{GDP}}{\textbf{Discounting}}$$

$$\frac{v_{t-1}}{\beta} + \frac{v}{\beta}\sum_j \delta_j \left(rx_{j,t} + i_{j,t-1} + \Delta h_{j,t} - \pi_{j,t} \right) = \sum_{k=0}^{\infty} \beta^k E_t s_{t+k} + \frac{v}{\beta}\sum_{k=0}^{\infty} \beta^k E_t g_{t+k} - \frac{v}{\beta}\sum_{k=1}^{\infty}\sum_j \delta_j \beta^k E_t r_{j,t+k}$$

Details Currency Table

Fiscal Decomposition of Unexpected Inflation

- *Ex-post* real return $r_{j,t} = rx_{j,t} + i_{j,t-1} + \Delta h_{j,t} - \pi_{j,t}$

$$\Delta E_t \pi_t = \underbrace{\left[\Delta E_t rx_t + \sum_{j \neq N} \frac{\delta_j}{\delta} \Delta E_t r_{j,t} \right]}_{\text{Innovation to Bond Prices}} - \frac{\beta}{\delta v} \underbrace{\left[\sum_{k=0}^{\infty} \beta^k \Delta E_t s_{t+k} + \frac{v}{\beta} \sum_{k=0}^{\infty} \beta^k \Delta E_t g_{t+k} - \frac{v}{\beta} \sum_{k=1}^{\infty} \sum_{j} \delta_j \beta^k \Delta E_t r_{j,t+k} \right]}_{\text{Innovation to Discounted Surpluses}}$$

$$\equiv d(rx) + d(r_0) - d(s) - d(g) + d(r)$$

Fiscal Decomposition: VAR-Based Measures

- General VAR system

$$X_t = AX_{t-1} + Ke_t \qquad e_t \sim N(0, \Omega)$$

  e_t can be reduced form or structural

- **How to measure terms of decomposition?**
  - Innovation to endogenous variables j periods ahead $\Delta E_t X_{t+j} = A^j K e_t$
  - Therefore:

$$\sum_{j=0}^{\infty} \beta^j \Delta E_t X_{t+j} = \sum_{j=0}^{\infty} (\beta A)^j K e_t = (I - \beta A)^{-1} K e_t$$

- **How to build decomposition scenarios?**
  - Suppose we are interested in $\Delta E_t X_t = x$ (e.g. $\Delta E_t \pi_t = 1$)
  - Start by calculating the expected value of shocks e_t conditional on $\Delta E_t X_t = x$

$$E[e \mid \Delta E_t X_t = x] = \Omega K' (K \Omega K')^{-1} x$$

  - And then calculate the terms of the decomposition using $e_t = E[e \mid \Delta E_t X_t = x]$

BVARs: Empirical Estimates

Bayesian-VAR: Data and Model

- Annual data on observables x_t^{OBS}

$$x_t^{OBS} = \begin{bmatrix} i_t & \text{(Nominal Interest)} \\ \pi_t & \text{(CPI Inflation)} \\ v_t^b & \text{(Par-Value Debt-to-GDP)} \\ g_t & \text{(GDP growth)} \\ \Delta h_t & \text{(}\Delta\text{ Real Exchange to US Dollar)} \end{bmatrix}$$

- 25 countries (samples starting at 1945, 1960, 1973, 1998)
- General VAR

$$X_t = AX_{t-1} + Ke_t$$

- Decompose $X_t' = [x_t^{OBS'} \ x_t^{NOT'}]$

$$\begin{aligned} x_t^{OBS} &= a\, x_{t-1}^{OBS} + e_t \\ x_t^{NOT} &= b\, x_{t-1}^{OBS} + c\, x_{t-1}^{NOT} + k\, e_t \end{aligned}$$

Bayesian-VAR: Empirical Challenges and Solutions

1. Explosive debt dynamics in 1960-2020 implies unstable OLS VARs

$$x_t^{OBS} = a\, x_{t-1}^{OBS} + e_t$$

   - **United States**: Estimate model by OLS (stable!)
   - **Others**: Estimate model with a Bayesian Linear Regression Bayesian Prior Hyperparameters

$$a^{BAY} = (X'X + \lambda^{-1})^{-1}(X'X\, a^{OLS} + \lambda^{-1}\, a^{PRIOR})$$

   λ maximizes the marginal distribution $p(\text{data})$ (Giannone et al. (2015)) and ensures stability

2. Public finance data do not respect law of motion of public debt
   - Define surplus from the law of motion: $s_t = \frac{v_{t-1}}{\beta} - v_t + \frac{v}{\beta}\left[-g_t + \sum_j \delta_j \left(rx_{j,t} + i_{j,t-1} + \Delta h_{j,t} - \pi_{j,t}\right)\right]$
3. No data on the market value of debt, only its par value (v_t^b) Public Finances Model
   - Model for market *vs* par value (Cox (1985)): $v_t = v_t^b + \frac{v}{\beta} \sum_j \delta_j \left(q_{j,t} - q_{j,t-1}^b\right)$
4. No data on bond prices Geometric Term Structure
   - Geometric maturity structure + constant risk premia: $q_{j,t} = (\omega_j \beta) E_t q_{j,t+1} - i_{j,t}$

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Bayesian-VAR: Unexpected Inflation Decomposition

- "Given 1% unexpected inflation, how do we change expectations over surplus, discounting, bond prices?"
- Reduced-form shock $e_t = E[\, e \mid \Delta E_t \pi_t = 1\,]$

Country	$\Delta E_t \pi_t =$	ΔE_t(Bond Prices)		$-\Delta E_t$(Disc Surpluses)		
		$d(r_0)$	$d(rx)$	-$d(s)$	-$d(g)$	$d(r)$
United States	1	0	* -0.8	0.6	0.2	1.0
1960 Sample						
Canada	1	* -0.1	* -1.6	0.6	* 1.2	0.9
Denmark	1	* -0.3	-0.3	0.4	0	1.2
Japan	1	0	* -0.5	* 1.6	-0.4	0.3
Norway	1	0	* -0.4	0.6	0.5	0.3
Sweden	1	-0.2	* -0.9	-0.3	* 1.0	* 1.4
United Kingdom	1	* 0.5	* -0.7	* 2.9	* 1.0	* -2.7
1973 Sample						
Australia	1	* 0.1	* -0.8	* 2.1	0.7	-1.1
New Zealand	1	-0.1	* -0.9	0.4	* 0.9	0.7
South Korea	1	0	* -0.5	* 1.9	0.2	-0.6
Switzerland	1	0	* -0.7	0.9	* 0.9	-0.1

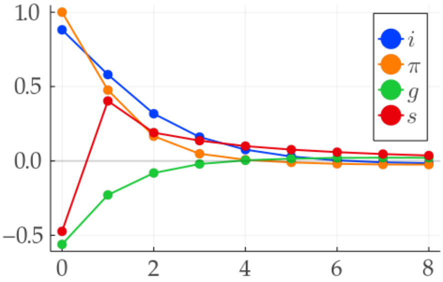
Advanced Markets

Country	$\Delta E_t \pi_t =$	ΔE_t(Bond Prices)		$-\Delta E_t$(Disc Surpluses)		
		$d(r_0)$	$d(rx)$	-$d(s)$	-$d(g)$	$d(r)$
1998 Sample						
Brazil	1	-0.3	* -0.2	-1.5	1.1	1.9
Chile	1	-3.8	-1.3	9.0	-5.7	2.9
Colombia	1	1.5	* -1.0	1.4	-1.1	0.2
Czech Republic	1	* -0.2	* -0.4	-2.3	2.4	1.4
Hungary	1	* -0.6	* -0.9	-1.0	1.6	1.9
India	1	* 0.2	* -0.5	1.5	0.1	-0.3
Indonesia	1	* -2.6	* -1.1	1.7	* 2.6	0.4
Israel	1	-0.1	* -0.8	-0.6	* 1.5	0.9
Mexico	1	0	* -0.7	1.4	0	0.3
Poland	1	* -0.5	* -1.2	0.9	-0.4	* 2.1
Romania	1	-0.4	* -1.0	2.2	0.4	-0.3
South Africa	1	0.4	* -0.5	1.6	0.3	-0.7
Turkey	1	0.4	* -0.4	-1.2	-0.2	* 2.3
Ukraine	1	0	* -0.8	0.7	0.4	* 0.7

Emerging Markets

Decomposition 2 Proposition

Bayesian-VAR: Unexpected Inflation Decomposition - Takeaways



IRF - Brazil

$d(rx) < 0$ $\quad -d(g) > 0$

$d(r) > 0$ $\quad -d(s) < 0$

- $\Delta E\pi$ accounted for by discounted surpluses
- Surplus-to-GDP, GDP growth and real discounting...
  - ...account for unexpected inflation alone in 0/25
  - ...have a positive contribution in 18+/25
- Is inflation "fiscal"? Yes, but not only.
- Is inflation "fiscal" **cross-country**? Not at all.
- Bond price dynamics reduce $\Delta E\pi$ in 25/25

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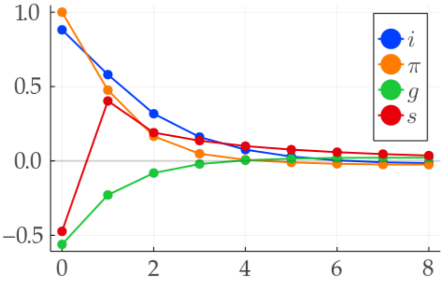

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Bayesian-VAR: Unexpected Demand Decomposition

- Environments of ”strong aggregate demand”: high inflation, high GDP and high surpluses.
- ”Given +1% unexpected inflation and +1% GDP growth, how do we change forecast?”
- Reduced-form shock $e_t = E\left[\, e \mid \Delta E_t \pi_t = 1, \Delta E_t g_t = 1 \,\right]$

Country	$\Delta E_t \pi_t =$	ΔE_t(Bond Prices)		$-\Delta E_t$(Disc Surpluses)		
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United States	1	0	* -1.4	1.0	* -1.3	* 2.8
1960 Sample						
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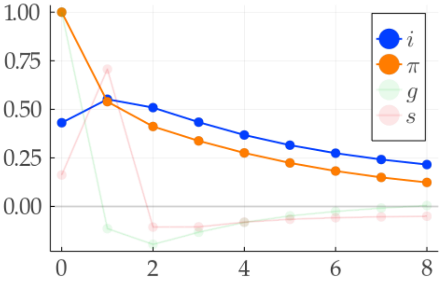
Denmark	1	* -0.4	* -1.1	3.0	* -2.9	2.3
Japan	1	0	* -1.2	* 2.4	* -2.1	* 1.8
Norway	1	0	* -0.9	1.8	* -1.7	1.8
Sweden	1	* -0.5	* -1.7	0.5	-0.4	* 3.1
United Kingdom	1	0.1	* -3.2	* 3.7	-0.4	0.8
1973 Sample						
Australia	1	0	* -2.1	2.6	-0.5	1.0
New Zealand	1	* -0.3	* -1.3	1.1	-0.3	1.9
South Korea	1	* -0.1	* -1.0	* 4.4	* -1.9	-0.4
Switzerland	1	0	* -1.3	* 1.3	0.6	0.4

Advanced Markets

Country	$\Delta E_t \pi_t =$	ΔE_t(Bond Prices)		$-\Delta E_t$(Disc Surpluses)		
		$d(r_0)$	$d(rx)$	$-d(s)$	$-d(g)$	$d(r)$
1998 Sample						
Brazil	1	* -0.6	* -0.2	-2.9	0.2	4.3
Chile	1	* -18.4	* -3.7	36.4	-34.9	21.7
Colombia	1	-1.3	* -1.2	12.3	-8.6	-0.3
Czech Republic	1	* -0.5	* -0.8	-1.0	0.9	2.4
Hungary	1	* -1.3	* -1.1	-12.2	6.5	9.2
India	1	0.1	-0.4	2.0	-0.8	0
Indonesia	1	* -9.9	0.1	* 12.6	-0.2	-1.6
Israel	1	* -2.1	* -0.8	3.4	-0.7	1.1
Mexico	1	* -1.9	* -1.2	* 5.6	-2.1	0.6
Poland	1	* -1.0	* -1.5	0.6	-1.3	* 4.3
Romania	1	* -2.1	* -0.7	* 8.7	-1.7	-3.2
South Africa	1	0.3	-0.6	* 32.2	* -11.6	* -19.3
Turkey	1	-0.7	* -0.4	-1.2	-0.6	* 3.9
Ukraine	1	0	0.5	* 4.1	* -2.1	-1.4

Emerging Markets



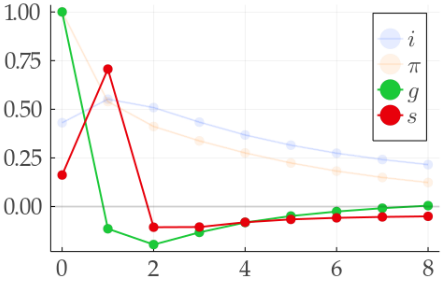
United States - IRF

$d(rx) < 0 \qquad -d(g) < 0$

$d(r) > 0 \qquad -d(s) > 0$

- Higher inflation follows from...
  - higher discounting (monetary policy) in 19/25
  - lower surplus-GDP **ratios**, current or in the future in 21/25
- (Level) Surpluses increase in 23/25
- COVID inflation: decline in $\{s\}$?

Bayesian-VAR: Unexpected Demand Decomposition - Takeaways



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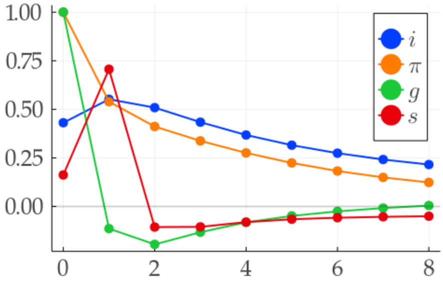

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Bayesian-VAR: Unexpected Surpluses Decomposition

- Unexpected inflation forecasts lower discounted surpluses. Is the converse true?
- "Given -1% discounted surpluses, how do we change forecast?"
  Reduced-form shock $e_t = E\,[\,e \mid \Delta E_t \text{ Disc Surpluses} = -1\,]$
- $\Delta E_t\{\text{Disc Surpluses}\} = \Delta E_t\{\text{Bond Prices}\} - \Delta E\pi = \Delta E_t\{\text{Real Return on Public Debt}\}$

Country	$\Delta E_t \pi_t =$	ΔE_t(Bond Prices)		$-\Delta E_t$(Disc Surpluses)		
		$d(r_0)$	$d(rx)$	-$d(s)$	-$d(g)$	$d(r)$
United States	*0.4	0	*-0.6	0.2	0	*0.8
1960 Sample						
Canada	*0.2	*-0.1	*-0.8	-0.1	0	*1.2
Denmark	*0.2	*-0.2	*-0.6	0.2	*-0.6	*1.4
Japan	*0.5	0	*-0.5	0.7	-0.2	*0.5
Norway	*0.4	0	*-0.6	-0.3	-0.1	*1.4
Sweden	*0.2	*-0.3	*-0.5	-0.1	0.1	*1.0
United Kingdom	*0.1	-0.1	*-0.8	0.2	-0.1	0.9
1973 Sample						
Australia	*0.2	0	*-0.8	-0.3	0	*1.3
New Zealand	*0.3	*-0.1	*-0.5	-0.3	0.4	*0.9
South Korea	*0.5	0	*-0.5	1.5	-0.2	-0.3
Switzerland	*0.3	0	*-0.7	0.3	0.2	*0.5

Advanced Markets

Country	$\Delta E_t \pi_t =$	ΔE_t(Bond Prices)		$-\Delta E_t$(Disc Surpluses)		
		$d(r_0)$	$d(rx)$	-$d(s)$	-$d(g)$	$d(r)$
1998 Sample						
Brazil	*0.4	*-0.4	*-0.1	*-2.4	0.3	*3.1
Chile	0	*-0.9	*-0.1	0.6	-0.4	0.9
Colombia	0	*-0.9	*-0.1	*1.7	-0.7	0
Czech Republic	*0.4	*-0.2	*-0.4	-1.0	0.8	1.1
Hungary	*0.2	*-0.4	*-0.3	-4.1	2.6	*2.6
India	*0.5	0	*-0.5	0.6	0.1	0.2
Indonesia	0	*-0.9	-0.1	0.5	0.2	0.3
Israel	*0.1	*-0.6	*-0.3	-0.9	0.1	*1.8
Mexico	*0.1	*-0.7	*-0.2	*1.4	-0.4	0.1
Poland	*0.2	*-0.4	*-0.3	-0.2	0.1	*1.0
Romania	*0.1	*-0.9	0	*1.6	-0.2	-0.4
South Africa	*0.2	*-0.5	*-0.3	-0.2	0.3	0.9
Turkey	*0.1	*-0.8	*-0.1	-0.1	0.1	*1.0
Ukraine	*0.4	0	*-0.6	0	*0.3	*0.6

Emerging Markets

Bayesian-VAR: Unexpected Surpluses Decomposition

- Unexpected inflation forecasts lower discounted surpluses. Is the converse true?
- ”Given -1% discounted surpluses, how do we change forecast?”
  Reduced-form shock $e_t = E\,[\,e \mid \Delta E_t \text{ Disc Surpluses} = -1\,]$
- $\Delta E_t\{\text{Disc Surpluses}\} = \Delta E_t\{\text{Bond Prices}\} - \Delta E\pi = \Delta E_t\{\text{Real Return on Public Debt}\}$

Country	$\Delta E_t \pi_t =$	ΔE_t(Bond Prices)		$-\Delta E_t$(Disc Surpluses)		
		$d(r_0)$	$d(rx)$	-$d(s)$	-$d(g)$	$d(r)$
United States	*0.4	0	*-0.6	0.2	0	*0.8
1960 Sample						
Canada	*0.2	*-0.1	*-0.8	-0.1	0	*1.2
Denmark	*0.2	*-0.2	*-0.6	0.2	*-0.6	*1.4
Japan	*0.5	0	*-0.5	0.7	-0.2	*0.5
Norway	*0.4	0	*-0.6	-0.3	-0.1	*1.4
Sweden	*0.2	*-0.3	*-0.5	-0.1	0.1	*1.0
United Kingdom	*0.1	-0.1	*-0.8	0.2	-0.1	0.9
1973 Sample						
Australia	*0.2	0	*-0.8	-0.3	0	*1.3
New Zealand	*0.3	*-0.1	*-0.5	-0.3	0.4	*0.9
South Korea	*0.5	0	*-0.5	1.5	-0.2	-0.3
Switzerland	*0.3	0	*-0.7	0.3	0.2	*0.5

Advanced Markets

Country	$\Delta E_t \pi_t =$	ΔE_t(Bond Prices)		$-\Delta E_t$(Disc Surpluses)		
		$d(r_0)$	$d(rx)$	-$d(s)$	-$d(g)$	$d(r)$
1998 Sample						
Brazil	*0.4	*-0.4	*-0.1	*-2.4	0.3	*3.1
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Hungary	*0.2	*-0.4	*-0.3	-4.1	2.6	*2.6
India	*0.5	0	*-0.5	0.6	0.1	0.2
Indonesia	0	*-0.9	-0.1	0.5	0.2	0.3
Israel	*0.1	*-0.6	*-0.3	-0.9	0.1	*1.8
Mexico	*0.1	*-0.7	*-0.2	*1.4	-0.4	0.1
Poland	*0.2	*-0.4	*-0.3	-0.2	0.1	*1.0
Romania	*0.1	*-0.9	0	*1.6	-0.2	-0.4
South Africa	*0.2	*-0.5	*-0.3	-0.2	0.3	0.9
Turkey	*0.1	*-0.8	*-0.1	-0.1	0.1	*1.0
Ukraine	*0.4	0	*-0.6	0	*0.3	*0.6

Emerging Markets

Bayesian-VAR: Taking Stock

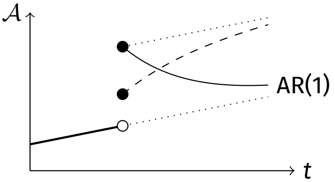
BVAR: $X_t = AX_{t-1} + Ke_t$

		ΔE (Bond Prices)		-ΔE (Discounted Surpluses)		
	$\Delta E_t \pi_t =$	$\sum_{j \neq N} \delta_j \Delta E_t r_{j,t}$	$\Delta E_t rx_t$	$-\sum_k \beta^k \Delta E_t s_{t+k}$	$-\sum_k \beta^k \Delta E_t g_{t+k}$	$\sum_k \beta^k \Delta E_t r_{t+k}$
Unexpected Inflation	1	< 0		mostly > 0	mostly > 0	mostly > 0
Unexpected Demand	1	< 0		> 0	< 0	> 0
Unexpected Surplus	0.3	-0.7				> 0

Theory: The New Keynesian Model

- BVAR decompositions not structural
- Closed-economy New-Keynesian model
- **Trend Shocks.** Production function $\mathcal{T}_t\, A_t\, N$

$$\text{Trend component:} \quad \log \mathcal{T}_t = \log \mathcal{T}_{t-1} + u_{g,t}$$
$$\text{AR(1) component:} \quad a_t = \rho_a a_{t-1} + \varepsilon_{a,t}$$



$$\begin{aligned}
y_t &= E_t y_{t+1} - \gamma\,(i_t - E_t\pi_{t+1}) + E_t u_{g,t} \\
\pi_t &= \beta\, E_t\pi_{t+1} + \kappa\, y_t - \kappa_a\, a_t \\
g_t &= \Delta y_t + u_{g,t} \\
i_t &= \phi_\pi\, \pi_t + \phi_g\, g_t + u_{i,t} \\
s_t &= \tau_\pi\, \pi_t + \tau_g\, g_t + u_{s,t} \\
\beta(v_t + s_t) &= v_{t-1} + v \sum_j \delta_j \left[rx_{j,t} + i_{j,t-1} + \Delta h_{j,t} - \pi_{j,t}\right]
\end{aligned}$$

$$\begin{aligned}
q_{j,t} &= (\omega_j\beta)\, E_t q_{j,t+1} - i_{j,t} \\
rx_{j,t} &= (\omega_j\beta)\, q_{j,t} - q_{j,t-1} - i_{j,t-1}
\end{aligned}$$

- Structural shocks: $\varepsilon = [\varepsilon_a\ \varepsilon_g\ \varepsilon_i\ \varepsilon_s]$
- Method of moments:

$$\text{Min}_\Psi \quad \alpha_1 \|\mathcal{D}_{VAR} - \mathcal{D}_{NK}(\Psi)\| + \alpha_2 \|\mathcal{M} - \mathcal{M}_{NK}(\Psi)\|$$

Parameters | Why Trend? Growth | Equilibrium Selection

The New-Keynesian Model: Measuring the Fiscal Decomposition

- In the NK model, flow equation of public debt holds, so does fiscal decomposition
- Solution to NK model

$$X_t = AX_{t-1} + K\varepsilon$$

  but ε is now structural
- So given innovation $\Delta E_t X_t = x$ (e.g. $\Delta E_t \pi_t$ = 1), we compute

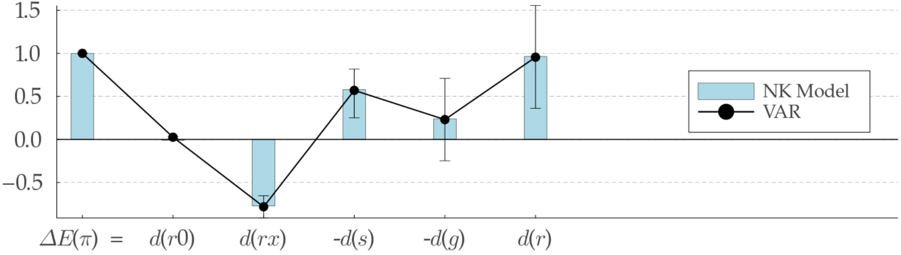
$$\varepsilon_t = E[\, \varepsilon \mid \Delta E_t X_t = x \,],$$

  calculate the IFRs and the terms of the decomposition

The New-Keynesian Model: Reproducing the Unexpected Inflation Decomposition

Simple version of the model. Target: unexpected inflation decomposition ($\Delta E_t \pi_t = 1$)

- **Result.** AR(1) productivity shocks $\varepsilon_{a,t}$ alone reproduce the US **unexpected inflation decomposition**
- **Result.** Monetary, fiscal and trend shocks do not, even if combined.



Target: United States. AR(1) productivity shocks. All others.

Simple version of the model. Target: unexpected inflation decomposition ($\Delta E_t \pi_t = 1$)

- **Result.** AR(1) productivity shocks $\varepsilon_{a,t}$ alone reproduce the US **unexpected inflation decomposition**
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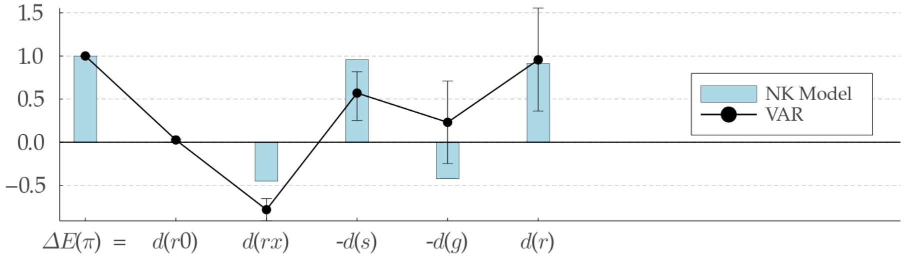


Target: United States. AR(1) productivity shocks. All others.

The New-Keynesian Model: Reproducing the Unexpected Inflation Decomposition

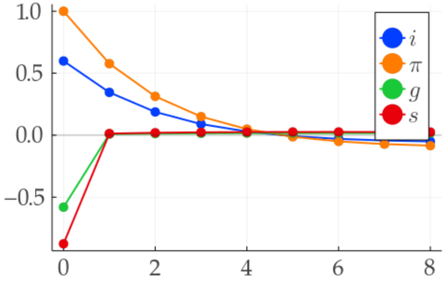
$$\boxed{1 = \Delta E_t \pi_t = d(rx) - d(s) - d(g) + d(r)}$$

- Story: negative productivity shock

$$E[\ \varepsilon_a \mid \Delta E_t \pi_t = 1\ ] = -0.85$$

- Persistent shock: $\boxed{\rho_a = 0.96}$ $\quad -d(g) > 0$
- Procyclical surpluses: $\boxed{\tau_g = 1.5}$ $\quad -d(s) > 0$
- Strong Taylor rule: $\boxed{\phi_\pi = 0.6}$

$$d(rx) < 0$$
$$d(r) > 0$$

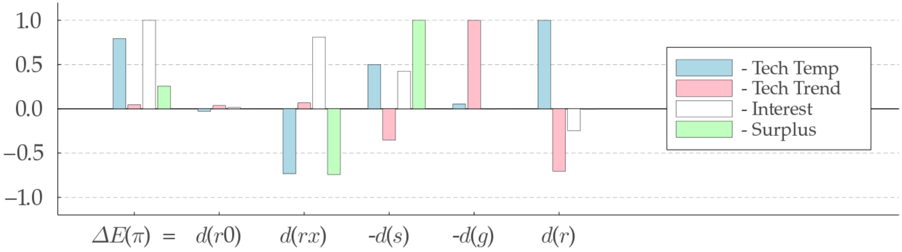


IRF to $\varepsilon_{a,t} = -0.85$

Marginal Costs vs B-VAR IRF

Targets: three decompositions + second moments

- **Result.** Trend shocks are necessary to reproduce unexpected demand decomposition.



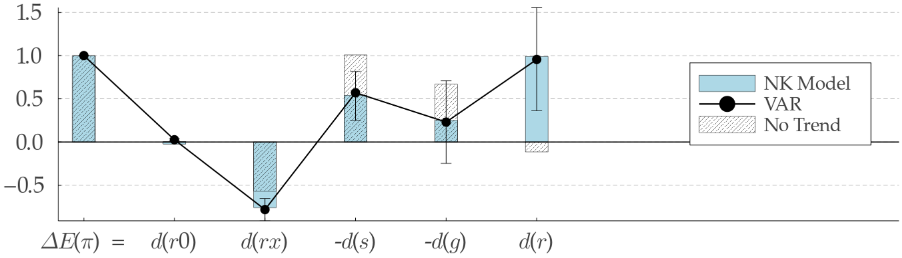
Structural Shocks Target: United States - Unexpected Inflation Demand Surpluses

Moments Parameters

The New-Keynesian Model: Complete Model

Targets: three decompositions + second moments

- **Result.** Trend shocks are necessary to reproduce unexpected demand decomposition.



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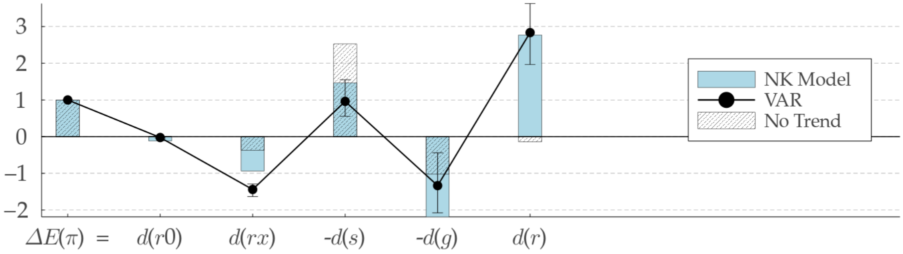

Structural Shocks Target: United States - Unexpected Inflation Demand Surpluses

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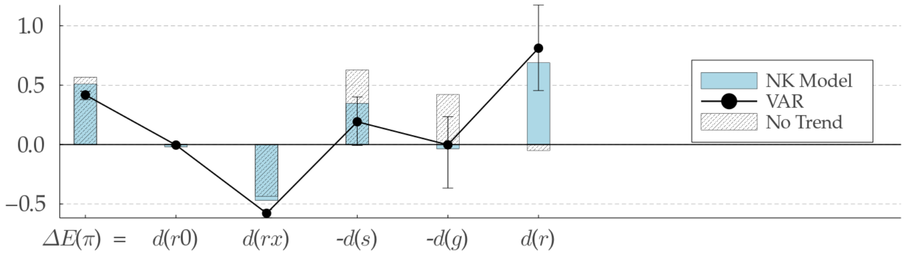
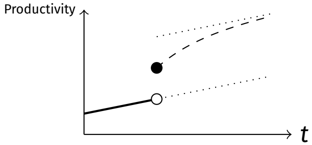


Structural Shocks Target: United States - Unexpected Inflation Demand Surpluses

Moments Parameters

The New-Keynesian Model: Reproducing the Unexpected Demand Decomposition

$$\boxed{1 = \Delta E_t \pi_t = d(rx) - d(s) - d(g) + d(r)}$$



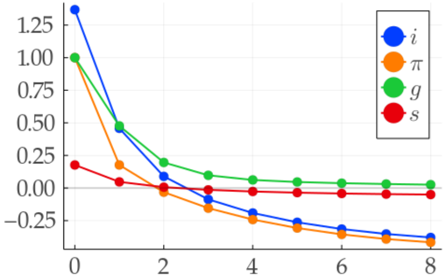
- High Marginal Costs + Positive Growth?
- Protracted productivity growth

$$E[\,\varepsilon_g \mid .\,] = 1.49 \qquad E[\,\varepsilon_a \mid .\,] = -0.76$$

- Marginal costs high relative to trend

$$\pi_t = \beta E_t \pi_{t+1} + \kappa y_t - \kappa_a a_t \qquad a_t < 0$$
$$g_t = \Delta y_t + u_{g,t} \qquad u_{g,t} > 0$$

vs B-VAR IRF



IRF to $\Delta E_t g_t = 1$, $\Delta E_t \pi_t = 1$

The New-Keynesian Model: Reproducing the Unexpected Surplus Decomposition

$$\boxed{1 = \Delta E_t \pi_t = d(rx) - d(s) - d(g) + d(r)}$$

Shock	Decomposition		
	Surplus		Inflation
ε_a	-0.40		-0.72
ε_g	0.05		-0.13
ε_i	**-0.01**	$<$	**-0.12**

Expected Structural Shocks

Why discount rates?

- Monetary policy

vs B-VAR IRF

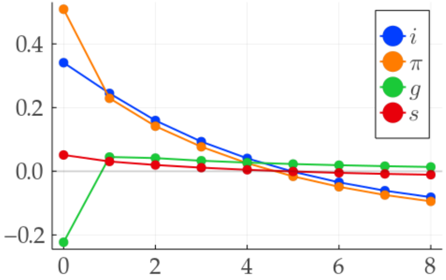


Figure: Disc Surp Variance

The New-Keynesian Model: Reproducing the Unexpected Surplus Decomposition

$$\boxed{1 = \Delta E_t \pi_t = d(rx) - d(s) - d(g) + d(r)}$$

Shock	Decomposition		
	Surplus		Inflation
ε_a	-0.40		-0.72
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Expected Structural Shocks

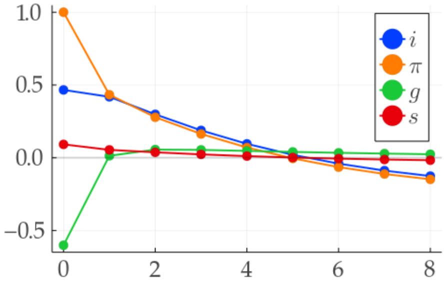


Figure: Disc Surp Variance

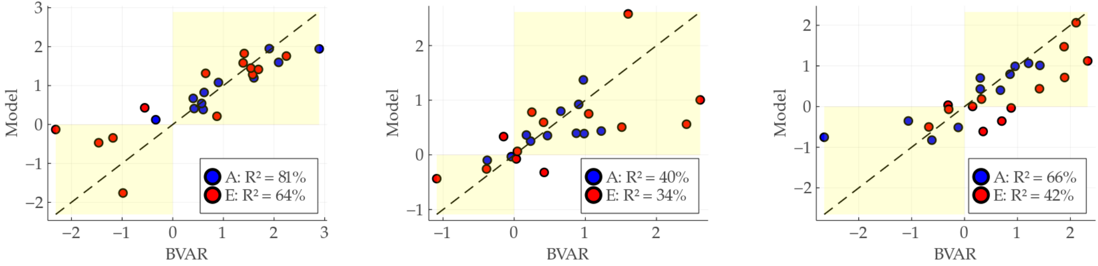
Why discount rates?

- Monetary policy

vs B-VAR IRF

The New-Keynesian Model: Unexpected Inflation Decomp. (Cross-Country)

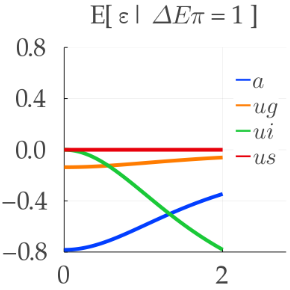
- Can cross-country differences in policy rules explain differences in unexpected inflation forecasts?
- **Estimation.** Solve optimization problem to all countries; keep productivity parameters constant

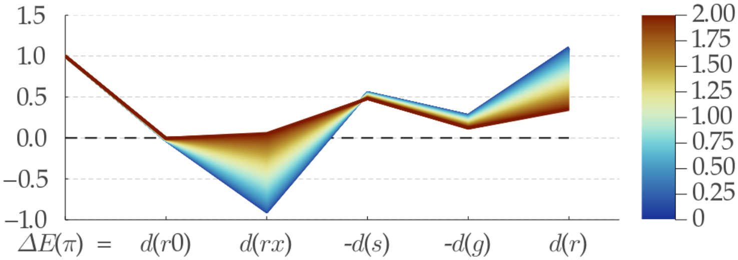


(a) $-d(s)$ ($R^2 = 0.7$) (b) $-d(g)$ ($R^2 = 0.35$) (c) $d(r)$ ($R^2 = 0.6$)

The New-Keynesian Model: Some Comparative Statics

1. **(Discretionary Monetary Policy)** $\sigma_i \uparrow \implies$ Unexpected inflation forecasts higher bond prices
2. **(Central Bank Dual Mandate)** $\phi_g \uparrow \implies$ No "agg. demand" inflation; $\Delta E\pi = 1$ forecasts lower growth





Comparative Statics: σ_i ϕ_g

Parameters

The New-Keynesian Model: Some Comparative Statics

1. **(Discretionary Monetary Policy)** $\sigma_i \uparrow \implies$ Unexpected inflation forecasts higher bond prices
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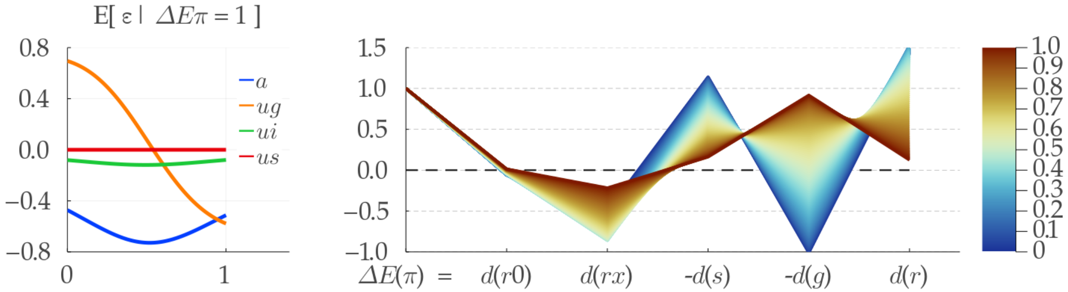


Comparative Statics: σ_i ϕ_g

Parameters

$$y_t = E_t y_{t+1} - \gamma \left[i_t - E_t \pi_{H,t+1} + \alpha(\bar{\omega} - 1)\, E_t \Delta z_{t+1} \right] + E_t u_{g,t+1}$$

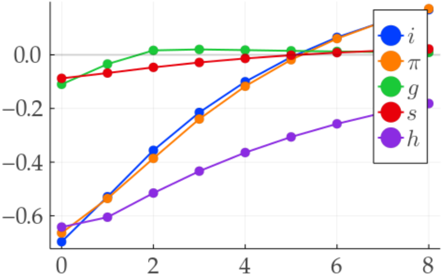
$$\pi_{H,t} = \beta\, E_t \pi_{H,t+1} + \kappa\, y_t - \kappa_a\, a_t - \kappa_z\, z_t$$

$$\gamma_\alpha\, z_t = y_t - y_t^*$$

$$\pi_t = \pi_{H,t} + \alpha\, \Delta z_t$$

$$h_t = (1 - \alpha)\, z_t$$

- Complete markets
- **Home**: small and open ($\alpha = 0.45$)
- **Foreign**: large and ”closed”
- Same United States parameters:
  - Variance decomposition ✓ ($\varepsilon_a = -0.6$, $\varepsilon_a^* = -0.7$)
  - ”Aggregate Demand” shock ✓
- Terms of trade dynamics and marginal costs:
  - ε_a and ε_a^*: same impact on Home’s MC
  - Foreign Mon. Shocks: opposite $\Delta E_t \pi^*$ and $\Delta E_t \pi$



Shock to **Foreign**’s Productivity Interest

Foreign Policy Shocks New Zealand Decomp

$$y_t = E_t y_{t+1} - \gamma\ [i_t - E_t \pi_{H,t+1} + \alpha(\bar{\omega} - 1)\ E_t \Delta z_{t+1}] + E_t u_{g,t+1}$$
$$\pi_{H,t} = \beta\ E_t \pi_{H,t+1} + \kappa\ y_t - \kappa_a\ a_t - \kappa_z\ z_t$$
$$\gamma_\alpha\ z_t = y_t - y_t^*$$
$$\pi_t = \pi_{H,t} + \alpha\ \Delta z_t$$
$$h_t = (1 - \alpha)\ z_t$$

- Complete markets
- **Home**: small and open ($\alpha = 0.45$)
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  - ε_a and ε_a^*: same impact on Home’s MC
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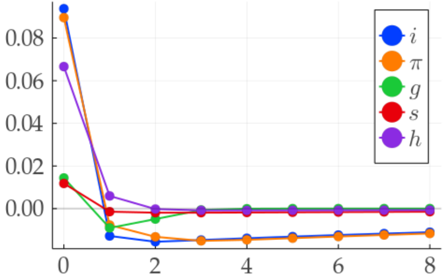

Shock to **Foreign**’s ~~Productivity~~ Interest

Foreign Policy Shocks New Zealand Decomp

Conclusion

Conclusion

- **Unexpected inflation** forecasts lower discounted surpluses
  - Lower surpluses or higher discounting? Depends on the country
  - Unexpected inflation is partially ”fiscal”, but not cross-country
- **Unexpected demand** inflation justified in part by lower future surpluses
- **Unexpected discounted surpluses** driven by discount rates
- New-Keynesian models reproduce BVAR decompositions
  - Relevance of productivity shocks
  - Relevance of policy rules

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Appendix: Debt Instruments and Growth

Return

- Real **market value** debt-to-GDP v_t, surplus-to-GDP s_t and GDP growth g_t (stationarity!)
- Bonds (j, n) promisses one unit of currency j after n periods
  - Nominal bonds
  - Real bonds (currency denomination = final goods)
  - US Dollar bonds

  Constant structure $\{\delta_j\}$, $\{\omega_j^n\}$
- Bond price $Q_{j,t}^n$, excess return $rx_{j,t}$ $\qquad 1 + \text{return}_{j,t} = 1 + rx_{j,t} + i_{j,t-1} = \frac{\sum_n Q_{j,t}^{n-1} B_{j,t-1}^n}{\sum_n Q_{j,t-1}^n B_{j,t-1}^n}$

  (one-period bonds $\implies rx = 0$)
- Debt law of motion:

$$\frac{v_{t-1}}{\beta} + \frac{v}{\beta}\left[-g_t + \sum_j \delta_j \left(rx_{j,t} + i_{j,t-1} + \Delta h_{j,t} - \pi_{j,t}\right)\right] = v_t + s_t$$

Appendix: Debt Instruments and Growth

Return

- Law of motion:

$$\sum_j \mathcal{E}_{j,t} B^1_{j,t-1} = P^s_t S_t + \sum_j \mathcal{E}_{j,t} \sum_{n=2}^{\infty} Q^{n-1}_{j,t} \left(B^{n-1}_{j,t} - B^n_{j,t-1} \right),$$

- $\mathcal{V}_{j,t} = \sum_{n=0}^{\infty} Q^n_{j,t} B^n_{j,t}$ (end-of-period market value of debt)

$$\sum_j (1 + rx_{j,t} + i_{j,t-1}) \mathcal{E}_{j,t} \mathcal{V}_{j,t-1} = P^s_t S_t + \sum_j \mathcal{E}_{j,t} \mathcal{V}_{j,t}$$

- $V_{j,t} = \mathcal{V}_{j,t} / P_{j,t} Y_t$ (real value of j-indexed debt)

$$V_{t-1} \sum_j \frac{(1 + rx_{j,t} + i_{j,t-1})(1 + \Delta h_{j,t})}{(1 + \pi_{j,t})(1 + g_t)} \delta_j = s_t + V_t.$$

Appendix: Public Debt Currency Denomination

Return

Symbol	Description	Nominal Debt	Real Debt	Dollar Debt
j	Index Symbol	N	R	D
	Notation	δ, ω	δ_R, ω_R	δ_D, ω_D
P_j	Price per Good	P	1	P_t^{US}
$\mathcal{E}_j$	Nominal Exchange Rate	1	P	Dollar NER
H_j	Real Exchange Rate	1	1	Dollar RER
π_j	Log Variation in Price	π	0	π_t^{US}
Δh_j	Log Real Depreciation	0	0	Δh_t

Table: Public Debt Denomination

Appendix: Bayesian Prior

Return

- Complete model (with US variables):

$$x_t^{OBS} = a\, x_{t-1}^{OBS} + b\, u_{t-1}^{OBS} + e_t$$
$$u_t^{OBS} = a_u\, u_{t-1}^{OBS} + e_{u,t}$$

- Group $\theta = [\text{vec}(a)' \ \text{vec}(b)']'$
- $\Sigma \sim IW(\Phi; d) \qquad \theta|\Sigma \sim N(\bar{\theta}, \Sigma \otimes \Omega)$
- $\Phi =$ Identity and $d = 7$ sets a loose prior
- $\bar{\theta}$ sets the mean of the prior for a to be OLS estimate of a_u

$$\text{cov}\left(a_{ij}, a_{kl} \mid \Sigma\right) = \begin{cases} \lambda^2 \frac{\Sigma_{ij}}{\Phi_{jj}} & \text{if } j = l \\ 0 & \text{otherwise.} \end{cases} \qquad \text{cov}\left(b_{ij}, b_{kl} \mid \Sigma\right) = \begin{cases} (\xi\lambda)^2 \frac{\Sigma_{ij}}{\Phi_{u,jj}} & \text{if } j = l \\ 0 & \text{otherwise} \end{cases}$$

Set $\xi = (1/3)$

Appendix: Hyperparameters + Debt Structure

Return

Country	v (%)	δ_N (%)	δ_R (%)	δ_D (%)	Avg. Term (Years)	λ	$\sigma(\Delta E_t \pi)$ (%)
United States	60	93	7	0	5	10	1.9
Advanced - 1960 Sample							
Canada	71	92	5	3	6.5	0.21	1.0
Denmark	37	84	0	16	5.6	0.18	1.2
Japan	98	100	0	0	5.5	0.01	2.2
Norway	35	99	0	1	3.7	0.19	1.5
Sweden	46	69	16	14	4.8	0.16	1.5
United Kingdom	61	76	24	0	12.3	0.17	2.0
Advanced - 1973 Sample							
Australia	24	90	10	0	7.2	0.18	1.5
New Zealand	41	82	6	13	4.3	0.15	2.0
South Korea	21	97	0	3	4	0.15	2.8
Switzerland	43	100	0	0	6.9	0.23	1.0

(a) Advanced Economies

Country	v (%)	δ_N (%)	δ_R (%)	δ_D (%)	Avg. Term (Years)	λ	$\sigma(\Delta E_t \pi)$ (%)
Emerging - 1998 Sample							
Brazil	70	70	25	5	2.6	0.12	1.4
Chile	14	10	57	33	12.8	0.27	1.0
Colombia	41	45	23	32	5.6	0.13	0.8
Czech Republic	31	91	0	9	5.6	0.15	1.1
Hungary	68	76	0	23	4.1	0.14	1.3
India	73	90	3	7	10.1	0.25	1.1
Indonesia	43	44	0	56	9.2	0.21	1.2
Israel	77	43	34	23	6.6	0.13	1.3
Mexico	45	65	10	26	5.5	0.15	1.0
Poland	47	79	1	20	4.2	0.10	1.3
Romania	28	50	0	50	4.8	0.10	1.9
South Africa	41	70	20	10	12.9	0.25	1.0
Turkey	43	47	23	30	3.6	0.13	2.1
Ukraine	43	100	0	0	9.1	0.07	5.7

(b) Emerging Economies

Appendix: Public Finances Model

Return

- Convert par to market value of debt (Cox and Hirschhorn (1983))

$$\mathcal{V}_{j,t} = \mathcal{V}^b_{j,t} \times \frac{\text{market price of debt}}{\text{book price of debt}} = \mathcal{V}^b_{j,t} \times \frac{Q_{j,t}}{Q^b_{j,t}}.$$

- Linearized average interest follows

$$i^b_{j,t} = \omega_j i^b_{j,t-1} + (1-\omega_j) i_{j,t} = (1-\omega_j) \sum_{k=0}^{\infty} \omega_j^k i_{j,t-k}$$

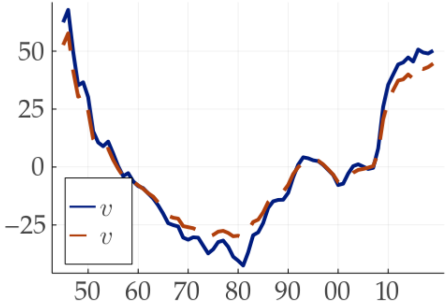
  since government rolls over share ω_j of public debt in steady state

- Linearized book price of debt:

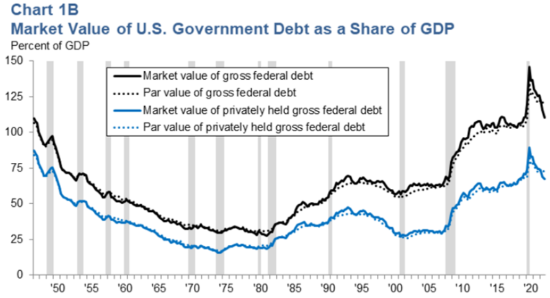
$$q^b_{j,t} = (\omega_j \beta) E_t q^b_{j,t+1} - i^b_{j,t}$$

Appendix: Public Finances Model

Return



(a) Model



(b) Emerging Economies

Appendix: Geometric Term Structure

Return Decomposition 2

- To each currency portfolio j, fixed geometric maturity structure:

$$B^n_{j,t} = \omega_j B^{n-1}_{j,t}$$

- Total return on currency-j portfolio:

$$1 + rx_{j,t} + i_{j,t-1} = \frac{1 + \omega_j Q_{j,t}}{Q_{j,t-1}} \qquad \Longrightarrow \qquad \boxed{rx_{j,t} + i_{j,t-1} = (\omega_j \beta) q_{j,t} - q_{j,t-1}}$$

- Assume **constant risk premia** $E_t rx_{j,t+1} = 0$

$$\boxed{q_{j,t} = (\omega_j \beta) E_t q_{j,t+1} - i_{j,t}} = -\sum_{k=0}^{\infty} (\omega_j \beta)^k E_t i_{j,t+k}$$

Appendix: Second Decomposition

Return

- From geometric maturity structure Geometric Term Structure

$$\Delta E_t rx_{j,t} = -\sum_{k=1}^{\infty} (\omega_j \beta)^k \left[\Delta E_t r_{j,t+k} + \Delta E_t \pi_{j,t+k} - \Delta E_t \Delta h_{j,t+k}\right]$$

- Replace on the original fiscal decomposition

$$\Delta E_t \pi_t = \overbrace{\left[-\sum_{k=1}^{\infty} (\omega\beta)^k \Delta E_t \pi_{t+k} - \frac{\delta_D}{\delta} \sum_{k=0}^{\infty} (\omega_D \beta)^k \Delta E_t \pi_{t+k}^{US}\right]}^{\text{Innovation to Nominal Variables}}$$
$$\underbrace{- \frac{\beta}{\delta v} \left[\sum_{k=0}^{\infty} \beta^k \Delta E_t s_{t+k} + \frac{v}{\beta} \sum_{k=0}^{\infty} \beta^k \Delta E_t g_{t+k} - \frac{v}{\beta} \sum_{k=1}^{\infty} \sum_{j} \delta_j \beta^k (1 - \omega^k) \Delta E_t r_{j,t+k} - \frac{\delta_D v}{\beta} \sum_{k=0}^{\infty} (\omega_D \beta)^k \Delta E_t \Delta h_{t+k}\right]}_{\text{Innovation to Real Variables}}$$
$$\equiv -d_2(\pi) - d_2(\pi^{US}) - d_2(s) - d_2(g) + d_2(r) + d_2(\Delta h)$$

Appendix: Second Decomposition

Return

Country	$\Delta E_t \pi_t =$	$-\Delta E_t$(Future Inflation)		$\pm\, \Delta E_t$(Real Variables)			
		$-d_2(\pi)$	$-d_2(\pi^{US})$	$-d_2(s)$	$-d_2(g)$	$d_2(r)$	$d_2(\Delta h)$
United States	1	***-1.12**	-	**0.57**	0.23	***1.32**	0
Advanced - 1960 Sample							
Canada	1	***-1.53**	***-0.07**	0.62	***1.22**	**0.78**	**-0.03**
Denmark	1	***-0.49**	***-0.20**	0.42	-0.04	**1.23**	0.08
Japan	1	***-1.14**	0	***1.60**	-0.38	***0.91**	0
Norway	1	***-0.70**	0	**0.60**	**0.47**	**0.64**	0
Sweden	1	***-1.02**	**-0.10**	-0.34	***0.98**	***1.54**	-0.07
United Kingdom	1	***-2.34**	0	***2.89**	***0.97**	**-0.52**	0
Advanced - 1973 Sample							
Australia	1	***-1.47**	0	***2.09**	***0.66**	-0.27	0
New Zealand	1	***-1.02**	***-0.08**	0.40	***0.87**	**1.04**	**-0.21**
South Korea	1	***-0.74**	***-0.03**	***1.91**	0.17	-0.33	**0.01**
Switzerland	1	***-0.79**	0	**0.90**	***0.91**	-0.02	0

(a) Advanced Economies

Country	$\Delta E_t \pi_t =$	$-\Delta E_t$(Future Inflation)		$\pm\, \Delta E_t$(Real Variables)			
		$-d_2(\pi)$	$-d_2(\pi^{US})$	$-d_2(s)$	$-d_2(g)$	$d_2(r)$	$d_2(\Delta h)$
Emerging - 1998 Sample							
Brazil	1	***-0.11**	0	**-1.46**	**1.05**	**1.46**	0.07
Chile	1	-0.76	**-2.75**	8.95	-5.71	-0.35	1.62
Colombia	1	***-0.61**	-0.04	1.39	-1.09	0.02	**1.34**
Czech Republic	1	-0.02	**-0.05**	-2.31	**2.42**	0.98	-0.03
Hungary	1	***-0.69**	***-0.15**	-0.98	1.60	1.83	***-0.61**
India	1	***-1.05**	***0.09**	**1.54**	0.05	0.41	-0.04
Indonesia	1	***-0.79**	***-1.33**	1.69	***2.61**	0.26	**-1.45**
Israel	1	***-0.54**	0.10	-0.55	***1.51**	0.61	-0.12
Mexico	1	***-0.60**	**0.17**	**1.41**	0.03	0.52	**-0.52**
Poland	1	***-0.59**	***-0.21**	0.87	-0.39	***1.43**	-0.11
Romania	1	***-1.14**	***-0.53**	2.24	0.42	-0.54	0.55
South Africa	1	0.05	-0.01	1.58	0.25	-0.79	-0.07
Turkey	1	***-0.76**	***-0.40**	-1.18	-0.15	***3.35**	0.14
Ukraine	1	**-0.29**	0	**0.65**	***0.41**	**0.23**	0

(b) Emerging Economies

Appendix: Variance Decomposition

Return

- **Proposition.** The variance decomposition

$$1 = \frac{\text{cov}_\pi\left[d(rx)\right]}{\text{var}\left[\Delta E_t \pi_t\right]} + \frac{\text{cov}_\pi\left[d(r_0)\right]}{\text{var}\left[\Delta E_t \pi_t\right]} - \frac{\text{cov}_\pi\left[d(s)\right]}{\text{var}\left[\Delta E_t \pi_t\right]} - \frac{\text{cov}_\pi\left[d(g)\right]}{\text{var}\left[\Delta E_t \pi_t\right]} + \frac{\text{cov}_\pi\left[d(r)\right]}{\text{var}\left[\Delta E_t \pi_t\right]}$$

is equivalent to the innovations decomposition applied to VAR shock $\text{Proj}(e \mid \Delta E_t \pi_t = 1)$

$$1 = \Delta E_t \pi_t \equiv d(rx) + d(r_0) - d(s) - d(g) + d(r)$$

- Proof:

$$1 = -\beta \overbrace{\mathbf{1}_s'(I - \beta A)^{-1} K\Omega K' \mathbf{1}_\pi}^{\text{cov}\left[\Delta E_t \pi_t, \sum_k \beta^k \Delta E_t s_{t+k}\right]} \overbrace{\left(\mathbf{1}_\pi' K\Omega K' \mathbf{1}_\pi\right)^{-1}}^{\text{var}(\Delta E_t \pi_t)^{-1}} + \mathbf{1}_r'(I - \beta A)^{-1} K\Omega K' \mathbf{1}_\pi \left(\mathbf{1}_\pi' K\Omega K' \mathbf{1}_\pi\right)^{-1}$$

$$= -\beta \mathbf{1}_s'(I - \beta A)^{-1} K \, \text{Proj}(e_t \mid \Delta E_t \pi_t = 1) + \mathbf{1}_r'(I - \beta A)^{-1} K \, \text{Proj}(e_t \mid \Delta E_t \pi_t = 1).$$

Appendix: NK Model Parameters

Equations NK Complete Comparative Statics

Parameter	Value
β	0.98
γ	0.4
φ	3
θ	0.25
α	0.45
$\bar{\omega}$	γ^{-1}

Table: Fixed Parameters

Parameter	Simple	Complete
ρ_a	0.96	0.84
ρ_g		0.29
ρ_i		0
ρ_s		0.39
ϕ_π	0.60	0.95
ϕ_g		0.61
τ_π		0.12
τ_g	1.51	0.05
σ_a	1	1
σ_g		1.79
σ_i		0.53
σ_s		0

Table: Estimated Parameters

Appendix: Why Trend Shocks? The Growth Component

Return

- Empirical decompositions: often $d(g) \neq 0$
- But in the absence of trend shocks:

$$g_t = (1-L)y_t = \mathbf{1}_y'(1-L)a(L)e_t \equiv \mathbf{1}_y' b(L)e_t$$

- Stationary model $a(L)^{-1}X_t = e_t \implies$ the roots of $a(L)^{-1}$ are outside the unit circle
- Therefore $||a(1)|| < \infty$ and $b(1) = 0$
- Finally, note that

$$d(g) \propto \mathbf{1}_y' b(\beta)e_t \approx \mathbf{1}_y' b(1)e_t = 0$$

- With trend shocks:

$$g_t = (1-L)y_t + u_{g,t}$$

Appendix: FTPL vs Spiral Threat

Return

- In NK models, private sector equations do not determine $\Delta E_t \pi_t$.

$$y_t = E_t y_{t+1} - \gamma \left(\bar{i} - E_t \pi_{t+1} \right)$$
$$\pi_t = \beta E_t \pi_{t+1} + \kappa y_t$$

- In FTPL models, the valuation equation of public debt determines unexpected inflation

$$\Delta E_t \pi_t = \Delta E_t r x_t - \sum_{k=0}^{\infty} \beta^k \Delta E_t s_{t+k} + \sum_{k=1}^{\infty} \beta^k \Delta E_t r_{t+k}$$

- In Spiral Threat models, fiscal decomposition determines $\Delta E_t s_t$, not $\Delta E_t \pi_t$

$$i_t = i_t^* + \phi(\pi_t - \pi_t^*) \qquad \phi > 1 \qquad \Longrightarrow \qquad \Delta E_t \pi_t = \Delta E_t \pi_t^*$$

- Observational Equivalence Theorem: FTPL and Spiral Threat generate the same set of equilibria

Appendix: Estimated Moments

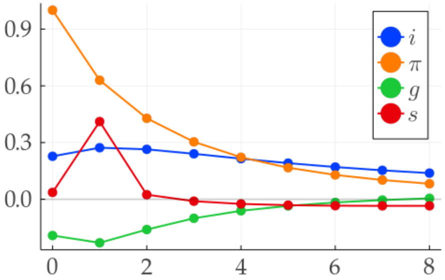
NK Simple NK Complete

Moments	Data	Model	Moments	Data	Model
σ_i/σ_g	1.00	1.16	cor(π, i)	0.54	0.84
σ_π/σ_g	1.01	1.24	cor(π, g)	-0.24	-0.25
$\sigma_{\Delta v}/\sigma_g$	1.43	0.90	cor(g, i)	0.16	0.27
a-cor(i)	0.92	0.75	cor(i, Δv)	0.02	-0.60
a-cor(π)	0.69	0.79	cor(π, Δv)	-0.29	-0.42
a-cor(g)	0.27	0.25	cor(g, Δv)	-0.39	-0.36
a-cor(Δv)	0.50	-0.13			

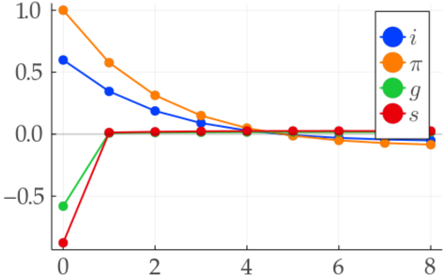
Table: Second Moment Fit - Complete Model ($\alpha_2 = 0.05$)

Appendix: Simple Model - US Data vs Model

NK Simple



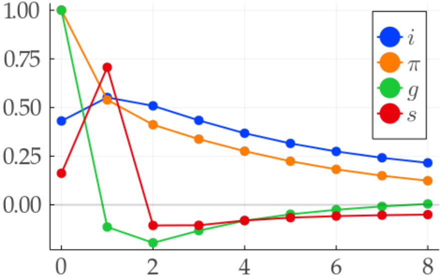
(a) B-VAR



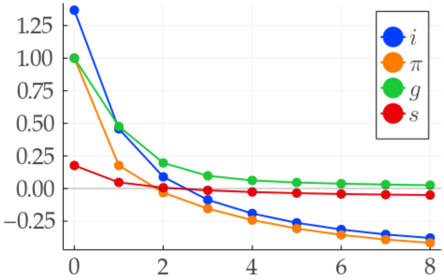
(b) NK Model (Only Prod. Shocks)

Appendix: ”Agg Demand” Shock - US Data vs Model

Return



(a) B-VAR



(b) NK Model