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

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Introduction

- What drives innovations to the price level?
- Sources of inflation variation
- Focus on unexpected inflation $\Delta E_t \pi_t$
  - Campbell and Ammer (1993)
  - Internal consistency of expectations
- Breakdown of valuation equation of public debt

Fiscal Connection?

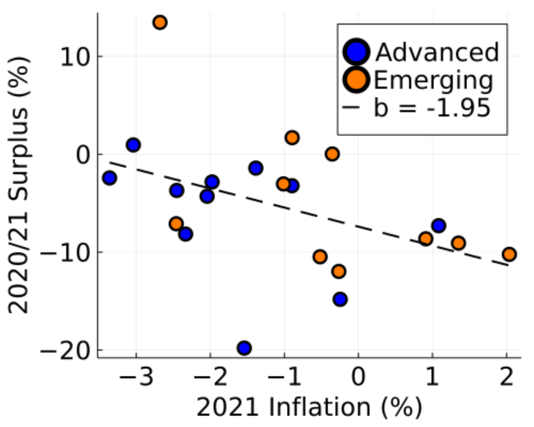

Figure: COVID Inflation - 21 countries in sample

Valuation Equation of Public Debt

- Stock market - Campbell and Ammer (1993)

$$\text{Stock price} = \text{Discounted Dividends}$$

$$\Delta E_t\,[\text{Stock price}] = \Delta E_t\,[\text{Dividends}] - \Delta E_t\,[\text{Disc Rates}]$$

- Micro-founded monetary models

$$\frac{\textbf{Bond Prices} \times \text{Bonds}}{\textbf{Price Level}} = \sum_t \frac{\textbf{Surpluses}_t}{\textbf{Discount}_t}$$

$$\Delta E_t\,[\text{Bond Price}] - \Delta E_t\,[\text{Price}] = \Delta E_t\,[\text{Surplus}] - \Delta E_t\,[\text{Disc}]$$

Exercises

- Generalize Cochrane (2022a)'s decompositions
  - Add real debt
- Public finances model
  - Estimates of bond prices
  - Surpluses consistent with flow equation of debt
  - Par value → Market value of debt
- Bayesian estimation of vector autoregressions
  - 21 countries (advanced, emerging)

Exercises

- Fiscal decompositions
  - Inflation shock: $\Delta E_t \pi_t = 1$
  - Discounted surpluses shock: ΔE_t [Disc Surplus] $= -1$
- New-Keynesian Model
  - Empirically consistent surplus policy rule
  - Persistent output shocks

Motivation + Results

- Measures not structural
- Stylized facts to be matched by theory
- In most countries:
  - Main source of inflation variation: discount rates
  - Main source of disc surplus variation: discount rates
  - GDP growth more important than surplus/GDP ratio

Inflation has fiscal roots, even if fiscal policy is disconnected from the price level.

Motivation + Results

- Surpluses are volatile
- How come no associated inflation?
- Model with partial debt repayment

Why unexpected inflation, not just inflation?

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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)
- **Empirical Finance.** Campbell and Shiller (1988), Cochrane (1992), Campbell and Ammer (1993), Chen and Zhao (2009), Cochrane (2008), Jiang et al. (2019)

Environment

- 1 period = 1 year
- Consumption good price P_t
- Total output Y_t
- Nominal bonds $B^n_{N,t}$, price $Q^n_{N,t}$
  - Pay one unit of currency after *n* years
- Real bonds $B^n_{R,t}$, price $P_t Q^n_{R,t}$
  - Pay one unit of consumption good after *n* years
- Primary Surplus $P_t S_t$

Evolution of Public Debt

$$\overbrace{\left[B^1_{N,t-1} + P_t B^1_{R,t-1}\right]}^{\text{Issued Currency}} = \Delta M_t$$

$$\underbrace{+ \left[P_t S_t + \sum_{n=1}^{\infty} Q^n_{N,t}\left(B^n_{N,t} - B^{n+1}_{N,t-1}\right) + P_t \sum_{n=1}^{\infty} Q^n_{R,t}\left(B^n_{R,t} - B^{n+1}_{R,t-1}\right)\right]}_{\text{Retired Currency}}$$

- This is a budget constraint
- Assumption 1: households do not value currency $M_t = 0$

Evolution of Public Debt

- Assumption 1: households do not value currency $M_t = 0$
- End-of-period debt $V_{N,t}$ and $V_{R,t}$

$$(1 + r_t^N)V_{N,t-1} + (1 + r_t^R)(1 + \pi_t)V_{R,t-1} = P_t S_t + V_{N,t} + V_{R,t}$$

- This is an equilibrium condition
- Price level adjusts so that

currency issued = currency retired

Evolution of Public Debt

- Constant structure of public debt: $\delta = V_{N,t}/V_t$

$$1 + r_t^n = \delta \left[(1 + r_{N,t})\right] + (1 - \delta) \left[(1 + r_{R,t})(1 + \pi_t)\right]$$

- Debt-to-GDP = $v_t = V_t/P_tY_t$
- Surplus-to-GDP = $s_t = S_t/Y_t$

$$\frac{1 + r_t^n}{(1 + \pi_t)(1 + g_t)} v_{t-1} = s_t + v_t$$

Evolution of Public Debt

Linearized equations

$$v_t + \frac{s_t}{V} = \frac{1}{\beta}\left[v_{t-1} + r_t^n - \pi_t - g_t\right]$$

$$r_t^n = \delta\left[r_t^N\right] + (1-\delta)\left[r_t^R + \pi_t\right]$$

- v_t is log debt-to-GDP
- r_t^n is the nominal return on public debt

Valuation Equation of Public Debt

- Assumption 2: debt does not spiral $\lim_{j\to\infty} \beta^j v_{t+j} = 0$
- Solve flow equation forward:

$$\overbrace{v_{t-1} + r^n_t - \pi_t}^{\text{Real market value of debt}} = \underbrace{\frac{\beta}{V} \sum_{j=0}^{\infty} \beta^j \left[E_t s_{t+j} + E_t g_{t+j} \right] - \sum_{j=1}^{\infty} \beta^j \left[E_t r^n_{t+j} - E_t \pi_{t+j} \right]}_{\text{Discounted Surpluses}}$$

Marked-to-Market Decomposition

Take innovation on the valuation equation:

$$\boxed{\epsilon_{r^n,t} - \epsilon_{\pi,t} = \epsilon_{s,t} + \epsilon_{g,t} - \epsilon_{r,t}}$$

Terms:

$\epsilon_{r^n,t} = \Delta E_t r_t^n$

$\epsilon_{\pi,t} = \Delta E_t \pi_t$ (current inflation)

$\epsilon_{s,t} = (\beta / V) \sum_{j=0}^{\infty} \beta^j \Delta E_t s_{t+j}$

$\epsilon_{g,t} = \sum_{j=0}^{\infty} \beta^j \Delta E_t g_{t+j}$

$\epsilon_{r,t} = \sum_{j=1}^{\infty} \beta^j (\Delta E_t r_{t+j}^n - \Delta E_t \pi_{t+j})$

Public Finances Model

Why a public finances model?

1. We can do better: bond prices forecast future inflation
2. No historical data for bond price/return r_t^n
3. No data on market value of debt (only book value)

Public Finances Model

Key Assumptions

- Assumption: constant maturity structure
- Decays geometrically at rate ω:

$$B^n_{N,t} = \omega_N \, B^{n-1}_{N,t}$$
$$B^n_{R,t} = \omega_R \, B^{n-1}_{R,t}$$

- Assumption: constant (or no) risk premium

$$E_t r_{N,t} = E_t r_{R,t} + E_t \pi_t = i_t$$

Break down of bond price variation

Proposition: let $r_t = i_t - E_t\pi_{t+1}$ be the real interest. Then

$$\epsilon_{r^n,t} - \epsilon_{\pi,t} = -\delta \sum_{j=0}^{\infty} (\omega_N \beta)^j \Delta E_t \pi_{t+j} - \sum_{j=1}^{\infty} \beta^j [\delta \omega_N^j + (1-\delta)\omega_R^j] \Delta E_t r_{t+j}$$

- Higher real discount lowers real and nominal bond prices
- Higher inflation lowers nominal bond prices
- No long-term debt $\omega = 0$:

$$\epsilon_{r^n,t} - \epsilon_{\pi,t} = -\delta \Delta E_t \pi_t$$

Total Inflation Decomposition

Replace bond return decomp on marked-to-market decomp:

$$\boxed{-\varepsilon_{\pi,t} = \varepsilon_{s,t} + \varepsilon_{g,t} - \varepsilon_{r,t}}$$

Terms:

$\varepsilon_{\pi,t} = \delta \sum_{j=0}^{\infty} (\omega_N \beta)^j \Delta E_t \pi_{t+j}$ (current and future inflation)

$\varepsilon_{s,t} = \epsilon_{s,t} = (\beta / V) \sum_{j=0}^{\infty} \beta^j \Delta E_t s_{t+j}$

$\varepsilon_{g,t} = \epsilon_{g,t} = \sum_{j=0}^{\infty} \beta^j \Delta E_t g_{t+j}$

$\varepsilon_{r,t} = \sum_{j=1}^{\infty} \beta^j \left[1 - (\delta \omega_N^j + (1 - \delta) \omega_R^j) \right] \Delta E_t r_{t+j}$

Comparison of Decompositions

- **Marked-to-market**: $\boxed{\epsilon_{r^n,t} - \epsilon_{\pi,t} = \epsilon_{s,t} + \epsilon_{g,t} - \epsilon_{r,t}}$
  - Current inflation given current bond prices
  - Highlights effect of monetary policy
- **Total inflation**: $\boxed{-\varepsilon_{\pi,t} = \varepsilon_{s,t} + \varepsilon_{g,t} - \varepsilon_{r,t}}$
  - Path of inflation given path of discount rates
  - Sensitive to future inflation
  - Nets out effect of discount rates on bond prices

Build Market Value of Debt

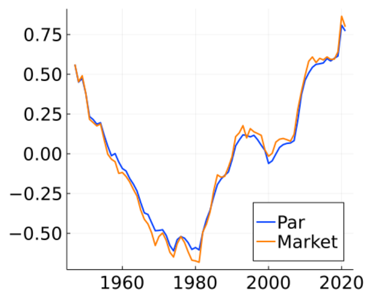
- Converting par to market value of debt
- Dallas Fed, Cox and Hirschhorn (1983) and Cox (1985)

$$V_{j,t} = V^b_{j,t} \times \frac{\text{market value of bonds}}{\text{book value of bonds}} = V^b_{j,t} \frac{Q_{j,t}}{Q^b_{j,t}} \quad \text{for } j = N, R$$

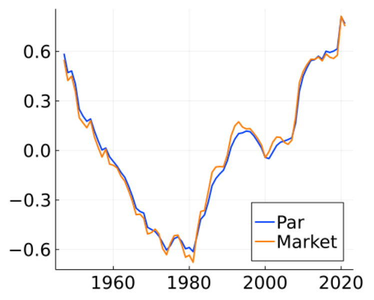
- Book price of bonds evolve according to average interest:

$$\begin{aligned} i^b_{N,t} &= (1 - \omega_N) i_t + \omega_N i^b_{N,t-1} \\ i^b_{R,t} &= (1 - \omega_R)(i_t - E_t \pi_{t+1}) + \omega_R i^b_{R,t-1} \end{aligned}$$

Comparison with Dallas Fed



(a) Dallas Fed



(b) Model

Vector Autoregression

- States X

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

- Bayesian estimates of 21 countries
- Samples end in 2019 (no COVID!)
- Prior centered around US OLS estimates

$$\begin{bmatrix} i_t \text{ Nominal Interest} \\ \pi_t \text{ Inflation Rate} \\ g_t \text{ GDP Growth} \\ v_t \text{ Market Value Debt} \\ r_t^n \text{ Bond Return (model built)} \\ s_t \text{ Primary Surplus (model built)} \end{bmatrix}$$

VAR and Decomposition Measures

- VAR uses time series structure to identify revision of expectations

$$\Delta E_t X_{t+j} = A^j X_t$$

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

The Inflation Shock

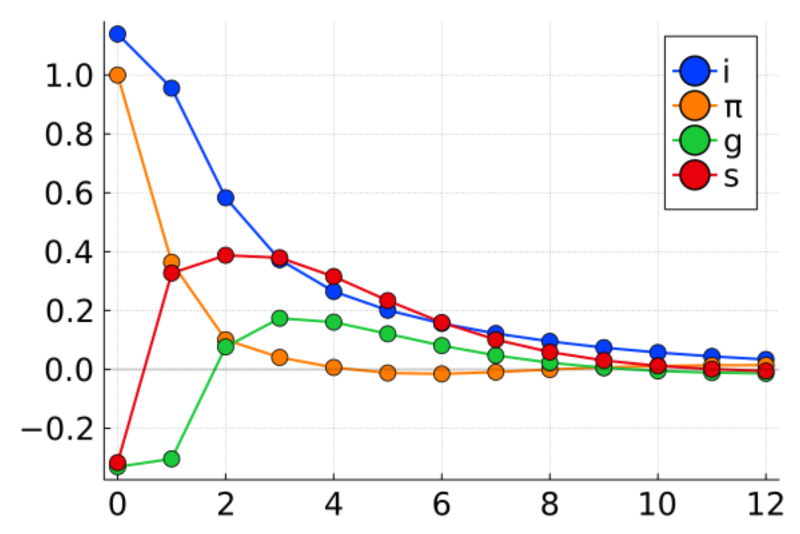
- Source of innovations to inflation $\Delta E_t \pi_t = 1$
- Reduced form shock $e_t = E\left[e \mid \Delta E_t \pi_t = 1\right]$
- Proposition: MtM decomposition

$$\epsilon_{r^n,t} - \epsilon_{\pi,t} = \epsilon_{s,t} + \epsilon_{g,t} - \epsilon_{r,t}$$

same as variance decomposition

$$\frac{\mathrm{cov}(\epsilon_{r^n,t}, \epsilon_{\pi,t})}{\mathrm{var}(\epsilon_{\pi,t})} - 1 = \frac{\mathrm{cov}(\epsilon_{s,t}, \epsilon_{\pi,t})}{\mathrm{var}(\epsilon_{\pi,t})} + \frac{\mathrm{cov}(\epsilon_{g,t}, \epsilon_{\pi,t})}{\mathrm{var}(\epsilon_{\pi,t})} - \frac{\mathrm{cov}(\epsilon_{r,t}, \epsilon_{\pi,t})}{\mathrm{var}(\epsilon_{\pi,t})}$$

IRF - Brazil



IRF to $e_t = E\left[e \mid \Delta E_t \pi_t = 1\right]$

Inflation Shock - Marked-to-Market

Country	ϵ_{r^n}	$-\epsilon_\pi$	=	ϵ_s	$+\epsilon_g$	$-\epsilon_r$
1947 Sample (Advanced)						
United Kingdom	**-0.7	**-1	=	**-2.2	**-0.7	**1.2
United States	**-0.7	**-1	=	-0.3	**-0.5	**-0.9
1960 Sample (Advanced)						
Canada	**-2.8	**-1	=	0.3	*-1.4	**-2.8
Denmark	**-0.9	**-1	=	0.2	-0.2	**-1.9
Japan	**-0.6	**-1	=	**2.8	**-3.0	**-1.4
Norway	**-0.7	**-1	=	0.7	*3.0	**-5.4
Sweden	**-0.6	**-1	=	**0.9	**-0.9	**-1.6
1973 Sample (Advanced)						
Australia	**-2.2	**-1	=	0.2	0.1	**-3.5
New Zealand	**-1.0	**-1	=	*1.2	**-1.4	*-1.8
South Korea	**-0.6	**-1	=	**-2.4	0.2	*0.7
Switzerland	**-2.0	**-1	=	*-0.8	0.1	**-2.3

Inflation Shock

Inflation Shock - Marked-to-Market

Country	ϵ_{r^n}	$-\epsilon_\pi$	=	ϵ_s	$+\epsilon_g$	$-\epsilon_r$
1997 Sample (Emerging)						
Brazil	**-0.7	**-1	=	**2.4	-0.1	**-4.0
Colombia	**-1,4	**-1	=	0.2	**-0.7	**-1.9
Czech Republic	*0.2	**-1	=	*0.7	**-1.3	-0.2
Hungary	**-0.8	**-1	=	0.0	-0.2	**-1.6
India	*-0.2	**-1	=	**-1.0	-0.1	-0.1
Israel	**-0.4	**-1	=	**0.8	*-0.4	**-1.8
Mexico	**-1.4	**-1	=	*-1.2	0.0	*-1.3
Poland	**-1.4	**-1	=	**1.0	*-0.3	**-3.0
South Africa	**-0.6	**-1	=	0.3	**-0.8	**-1.1
Ukraine	**-0.5	**-1	=	**-1.1	0.0	-0.3

Inflation Shock

Inflation Shock - Total Inflation

Country	$-\varepsilon_\pi$	=	ε_s	$+\varepsilon_g$	$-\varepsilon_r$
1947 Sample (Advanced)					
United Kingdom	**-2.8	=	**-2.2	**-0.7	0.1
United States	**-1.5	=	-0.3	**-0.5	**-0.7
1960 Sample (Advanced)					
Canada	**-2.6	=	0.3	*-1.4	**-1.5
Denmark	**-1.6	=	0.2	-0.2	**-1.6
Japan	**-1.5	=	**2.8	**-3.0	**-1.3
Norway	**-2.0	=	0.7	*3.0	**-5.7
Sweden	**-1.6	=	**0.9	**-0.9	**-1.5
1973 Sample (Advanced)					
Australia	**-3.1	=	0.2	0.1	**-3.4
New Zealand	**-2.3	=	*1.2	**-1.4	**-2.1
South Korea	**-2.0	=	**-2.4	0.2	0.2
Switzerland	**-2.0	=	*-0.8	0.1	**-1.3

Inflation Shock

Inflation Shock - Total Inflation

Country	$-\varepsilon_\pi$	=	ε_s	$+\varepsilon_g$	$-\varepsilon_r$
1997 Sample (Emerging)					
Brazil	**-0.8	=	**2.4	-0.1	**-3.1
Colombia	**-0.7	=	0.2	**-0.7	-0.2
Czech Republic	**-0.5	=	*0.7	**-1.3	0.1
Hungary	**-1.4	=	0.0	-0.2	**-1.3
India	**-1.4	=	**-1.0	-0.1	*-0.4
Israel	**-0.6	=	**0.8	*-0.4	**-1.0
Mexico	**-1.4	=	*-1.2	0.0	-0.3
Poland	**-1.4	=	**1.0	*-0.3	**-2.1
South Africa	**-0.8	=	0.3	**-0.8	*-0.3
Ukraine	**-1.2	=	**-1.1	0.0	-0.1

Inflation Shock

Inflation Shock - Averages

Country	ϵ_{r^n}	$-\epsilon_\pi$	=	ϵ_s	$+\epsilon_g$	$-\epsilon_r$
Averages	**-1.0	**-1	=	0.1	**-0.4	**-1.7
1947 (Advanced)	**-0.7	**-1	=	**-1.2	**-0.6	0.1
1960 (Advanced)	**-1.1	**-1	=	*1.0	*-0.5	**-2.6
1973 (Advanced)	**-1.4	**-1	=	-0.4	-0.3	**-1.7
1997 (Emerging)	**-0.7	**-1	=	0.2	**-0.4	**-1.5

Marked-to-Market

Country	$-\varepsilon_\pi$	=	ε_s	$+\varepsilon_g$	$-\varepsilon_r$
Averages	**-1.6	=	0.1	**-0.4	**-1.3
1947 (Advanced)	**-2.2	=	**-1.2	**-0.6	-0.3
1960 (Advanced)	**-1.9	=	*1.0	*-0.5	**-2.3
1973 (Advanced)	**-2.3	=	-0.4	-0.3	**-1.6
1997 (Emerging)	**-1.0	=	0.2	**-0.4	**-0.9

Total Inflation

Inflation Shock - Takeaways

- Discount rates: 80% of inflation variation (average)
- The rest comes mostly from GDP growth
- Positive contribution of surplus-to-GDP 7/21
- Monetary policy reduces inflation in 20/21

Inflation has fiscal roots, even if fiscal policy is disconnected from the price level.

Discounted Surpluses Shock

- Discount rates drive innovations to inflation
- What drives discounted surpluses?

Frametitle

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