FTPL and the Maturity Structure of Government Debt in the New Keynesian Model

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Outline

Motivation

Covid-19 pandemic, large-scale fiscal stimulus packages

Response: US Coronavirus Aid, Relief, Economic Security Act 2020 (CARES)

- Outlays ($\uparrow$ 29.5% or 6.1% of GDP)
- Revenues ($\downarrow$ 11.8%)

Congressionaly Budget Office (2020) projects new USD 1.7 trillion to deficits over the 2020-2030 period

Exploding debt: Funding drastically increases public debt (debt-to-GDP $\uparrow$ 12%) (Kaplan, Moll, Violante 2020, Bayer, Born, Luetticke 2023)

Question: Effects of fiscal shocks (expenditure and debt) on inflation

Caveat: Maturity structure of public debt matters under fiscal dominance (not new, but missing in the evaluation of CARES)

Objective

This paper:

Analysis of CARES through the lense of the fiscal theory (FTPL) and the traditional NK model with realistic maturity structure; compute effects for short term, perpetuities and calibrated maturity of existing public debt

Focus on fiscal regime (fiscal dominance), we also compare to monetary regime; similar implications for regime-switching models

Analysis of zero-probability shocks (can be extended easily extended)

Our contribution

Findings:

1. FTPL works through two channels
   - direct effect (asset pricing)
   - indirect effect (future monetary and fiscal policy)

   clear cut in the continuous-time version because predetermined price level
2. average maturity prominent role for inflation and the term structure, strongest effects on macro dynamics with short-term debt
3. CARES had substantial effects for the post-Covid inflation dynamics because of unfunded fiscal shocks under fiscal dominance, decomposition shows the direct effects in the form of temporary debt shocks are most relevant
4. minor effects on inflation with active monetary policy (only indirect effect); asset prices irrelevant for macro dynamics

Discussion: Policy instruments, Taylor rules, Term structures of interest rates, Temporary vs. permanent fiscal shocks

Literature

Fiscal theory and monetary policy
(Cochrane 2001-2023; Sims 2011, 2013; Leeper 1991; Leeper, Leith 2016)

Post-Covid fiscal emergency packages
(Kaplan et al. 2020; Harding, Lindé, Trabandt 2022; Bayer et al. 2023; Bianchi, Faccini, Melosi 2023; DiGiovanni, Kalemli-Özcan, Silva, Yildirim 2023; Barro, Bianchi 2023)

Monetary and fiscal coordination, and fiscal multipliers
(Leith, von Thadden 2008; Bianchi 2012; Faraglia, Marcet, Oikonomou, Scott 2013; Kliem, Kriwoluzky 2014; Del Negro, Sims 2015; Kliem, Kriwoluzky, Saferaz 2016; Leeper, Traum, Walker 2017; Bianchi, Melosi 2019)

Debt maturity management
(Buera, Nicolini 2004; Shin 2007; Lustig, Sleet, Yeltekin 2008; Debortoli, Nunes, Yared 2017; Bigio, Nuño, Passadore 2019)

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The Model

NK model, linearized around a zero-inflation target rate (or full indexation):
(Werning 2012; Cochrane 2017, Posch 2020)

$$\begin{aligned} dx_t &= (i_t - \rho - \pi_t)dt \\ di_t &= (\phi_\pi(\pi_t - \pi^*) - (i_t - i^*))dt \\ d\pi_t &= (\rho(\pi_t - \pi^*) - \kappa x_t)dt \end{aligned}$$

x_t output gap (or consumption, percentage deviations)
i_t nominal interest rate
κ degree of price stickiness ($\kappa \to \infty$ is the frictionless or flexible price limit)
π_t expected inflation (π^* inflation target, ρ, ϕ_π given parameters)

Fiscal block

$$\begin{aligned} da_t &= ((i_t - \pi_t)a_t - s_t)dt \\ ds_t &= f(s_t, y_t, a_t)dt \end{aligned}$$

a_t real value of public debt (held by households)
s_t primary surplus (f fiscal rule)

Fiscal block

Central in the FTPL-NK model: debt valuation equation

$$a_t = \frac{n_t p_t^b}{p_t} = \mathbb{E}_t \int_t^\infty e^{-\int_t^u (i_v - \pi_v) \mathrm{d}v} s_u \mathrm{d}u, \quad \lim_{T\to\infty} e^{-\int_t^T (i_v - \pi_v) \mathrm{d}v} a_T = 0$$

n_t number of outstanding bonds (p_t^b bond price)
p_t price level (predetermined by past inflation)

Bonds with decaying coupon payments, longer-term bonds at average duration are amortized at rate δ, pay nominal coupon $\chi + \delta$ (sell at par at steady state, $p_{ss}^b = 1$) (Woodford 2001, Sims 2011)

Sufficient statistic for maturity structure: average duration $1/\delta$

Floating debt (short-term): $\delta \to \infty$, $\chi = i_t$ and $p_t^b \equiv 1$
Average maturity: δ calibrated from data, $\chi = i_{ss}$, and $p_{ss}^b = 1$
Perpetuities (long-term): $\delta = 0$, $\chi = i_{ss}$, and $p_{ss}^b = 1$

Match 6.8 years of outstanding US public debt ($\delta = 1/6.8$ and $\chi = i_{ss}$) (Del Negro and Sims 2015)

Direct and indirect FTPL effects

No arbitrage:

$$\mathrm{d}p_t^b = (i_t - ((\chi + \delta)/p_t^b) - \delta) + \mathrm{d}\delta_{p_t^b}, \quad \mathbb{E}_t(\mathrm{d}\delta_{p_t^b}) = 0$$

Linear approximation

$$p_t^b = 1 - \mathbb{E}_t \int_t^\infty e^{-(\chi+\delta)(u-t)}(i_u - i_{ss})\mathrm{d}u$$

Bond price is determined entirely by the discounted (maturity adjusted) future path of nominal interest rate

Definition: We define the direct FTPL effect (on the variables of interest) as the immediate re-evalution of outstanding public debt trough the bond price p_t^b.

Important: direct FTPL effect (asset pricing) requires the presence of longer-term debt because short-term debt $p_t^b \equiv 1$

Duration of public debt determines the strength of the direct FTPL effect

Fiscal policy rules

Simple rules vs. policy inertia

- theoretical papers assume simple fiscal policy rules (Sims 2011; Cochrane 2018)
- empirical papers suggest the presence of a time lag (inertia) (Kliem et al. 2016; Bianchi, Melosi 2019)

Primary surplus

$$s_t = T_t - g_t$$

where

$$\mathrm{d}T_t = \rho_\tau(\tau_y(y_t/y_{ss} - 1) + \tau_a(a_t - a_{ss}) - (T_t - T_t^*))\mathrm{d}t$$

and

$$\mathrm{d}g_t = \rho_g(\varphi_y(y_t/y_{ss} - 1) + \varphi_a(a_t - a_{ss}) - (g_t - g_t^*))\mathrm{d}t$$

ρ_τ degree of inertia (with $\rho_\tau \to \infty$ simple rules, $\rho_\tau = 0$ inelastic $T_t = T^*$)
ρ_g degree of inertia (with $\rho_g \to \infty$ simple rules, $\rho_g = 0$ inelastic $g_t = g^*$)

Equilibrium selection

Equilibrium selection (determinacy) depends on the inflation response in the Taylor rule and the debt response in the fiscal policy rule

- Inflation response in the Taylor rule

$$\mathrm{d}i_t = (\phi_\pi(\pi_t - \pi^*) - (i_t - i^*))\mathrm{d}t$$

- Debt response in the fiscal policy rule

$$\begin{aligned} \mathrm{d}s_t \quad = \quad & \rho_\tau(\tau_y(y_t/y_{ss} - 1) + \tau_a(a_t - a_{ss}) - (T_t - T_t^*))\mathrm{d}t \\ & -\rho_g(\varphi_y(y_t/y_{ss} - 1) + \varphi_a(a_t - a_{ss}) - (g_t - g_t^*))\mathrm{d}t \end{aligned}$$

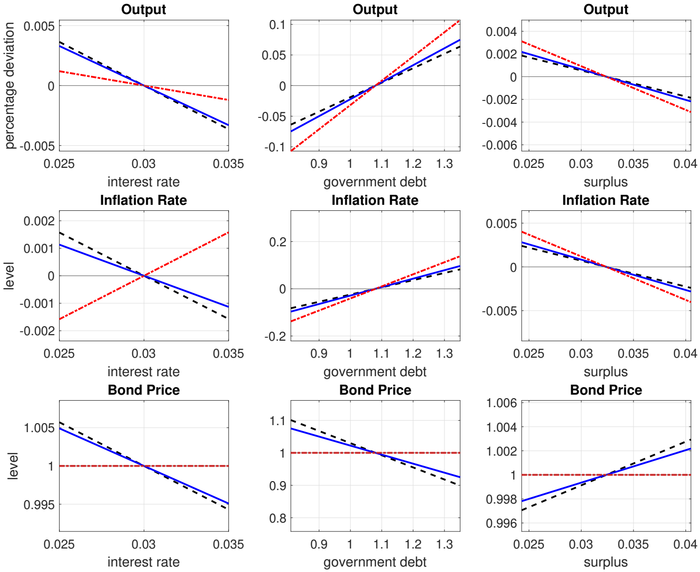
Illustration: Suppose that $\rho_g \equiv 1$ and $\rho_g \equiv 0$, the admissible parameter set for a (locally) determinate solution demands $\tau_a < \rho$ and $\phi_\pi < 1$ (fiscal dominance), whereas $\tau_a > \rho$ and $\phi > 1$ refers to the monetary regime
(Leith, von Thadden 2008)

Parameterization

Table: Parametrization 1 (benchmark, similar to Kliem et al 2014)

ρ	0.03	subjective rate of time preference
κ	0.4421	degree of price stickiness
y_{ss}	1	normalized steady state output
ϕ_π	0.6	inflation response Taylor rule (fiscal regime)
ϕ_y	0	output response Taylor rule
θ	1	inertia Taylor rule
π_{ss}	0	inflation target rate
τ_y	1	output response fiscal tax rule (Sims 2011, Cochrane 2018)
τ_a	0	debt response fiscal tax rule
ρ_τ	1	inertia of fiscal tax rule
φ_y	0	output response fiscal expenditure rule
φ_a	0	debt response fiscal expenditure rule
ρ_g	0	inertia of fiscal expenditure rule
s_g	0.1534	government consumption to output ratio (Bilbiee et al. 2019)
s_{ss}	0.0324	steady-state surplus (to match US debt/GDP 2020Q1)
χ	0.03	net coupon payments
$1/\delta$	6.8	average duration of government bonds (Del Negro, Sims 2015)

Solution to the linearized equilibrium dynamics



Inflation decomposition

Linearized debt valuation equation (Cochrane 2022, 2023)

$$a_t/a_{ss} - 1 = \mathbb{E}_t \int_t^{\infty} e^{-r(u-t)} s_u/a_{ss} \mathrm{d}u - \mathbb{E}_t \int_t^{\infty} e^{-r(u-t)} (i_u - \pi_u) \mathrm{d}u,$$

Real value of debt is the present value of surpluses, discounted at the (steady-state) real interest rate, which can be decomposed into

$$a_t/a_{ss} - 1 = v_t/v_{ss} - 1 + p_t^b/p_{ss}^b - 1,$$

Both yields the identity

$$\begin{aligned} \int_t^{\infty} e^{-r(u-t)} \pi_u \mathrm{d}u \quad = \quad & \int_t^{\infty} e^{-r(u-t)} i_u \mathrm{d}u - \int_t^{\infty} e^{-r(u-t)} s_u/a_{ss} \mathrm{d}u \\ & + p_t^b/p_{ss}^b - 1 + v_t/v_{ss} - 1 \end{aligned}$$

Allows us to decompose the effects of zero-probability shocks on future inflation into changes in future interest rates (monetary policy), and changes in future surpluses (fiscal policy), and the direct FTPL effects (real debt decomposition).

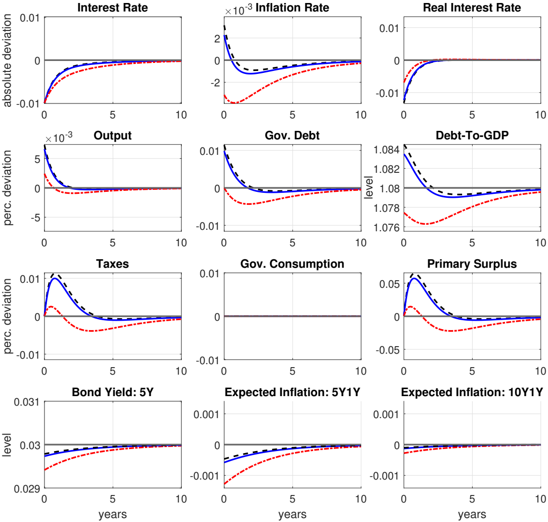
Monetary policy shock

Table: Inflation decomposition for transitory monetary policy shock for the parametrization in Table 1. Decrease in nominal interest rate by 1 percentage point

Debt Maturity	$\int_0^\infty e^{-ru}\pi_v du$ inflation	$\int_0^\infty e^{-ru} i_u du$ interest rate	$\int_0^\infty e^{-rv} s_u / a_{ss} du$ surplus	$p_0^b / p_{ss}^b - 1$ direct effect
Long-Term	-0.29	-1.14	0.29	1.14
Average	-0.48	-1.25	0.21	0.98
Short-Term	-1.62	-1.91	-0.29	0

Solid blue lines show the responses matching average duration, dashed black for perpetuities, and dotted red for short-term debt.

Impulse responses



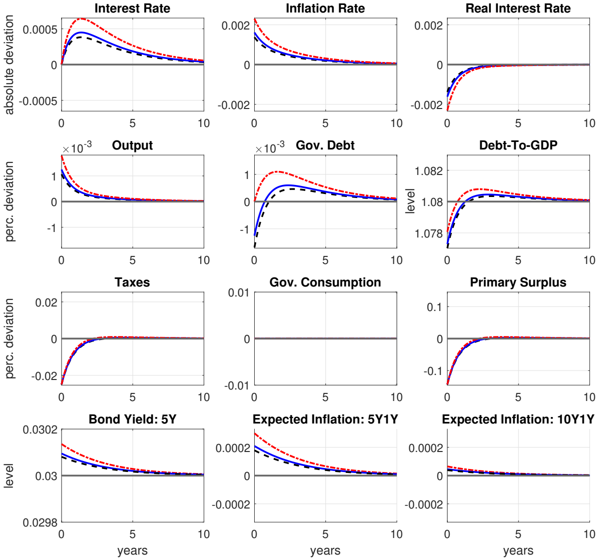
Fiscal policy shock

Table: Inflation decomposition for transitory fiscal policy shock for the parametrization in Table 1. Decrease in taxes (surplus) by 2.5 percent

Debt Maturity	$\int_0^\infty e^{-ru}\pi_u du$ inflation	$\int_0^\infty e^{-ru} i_u du$ interest rate	$\int_0^\infty e^{-ru} s_u / a_{ss} du$ surplus	$p_0^b / p_{ss}^b - 1$ direct effect
Long-Term	0.28	0.17	−0.28	−0.17
Average	0.33	0.19	−0.26	−0.12
Short-Term	0.48	0.28	−0.2	0

Solid blue lines show the responses matching average duration, dashed black for perpetuities, and dotted red for short-term debt.

Impulse responses



Outline

The CARES Act shock

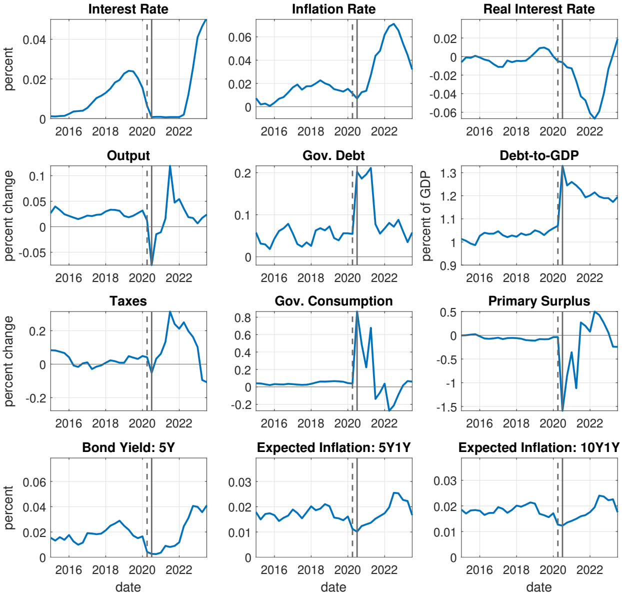
US Coronavirus Aid, Relief, Economic Security Act 2020 (CARES)

- Outlays (↑ 29.5% or 6.1% of GDP)
- Revenues (↓ 11.8%)

CARES Act: Model Variables

			abs. Change	as % of GDP	as % of Steady State Value
A + **B**	≡	Shock g_t	0.061	6.1%	39.8%
C	≡	Shock T_t	−0.019	−1.9%	−10.2%
D	≡	Shock v_t/y_t by 12% (either temporary and/or permanent)			

Data



Interest Rate
Inflation Rate
Real Interest Rate
Output
Gov. Debt
Debt-to-GDP
Taxes
Gov. Consumption
Primary Surplus
Bond Yield: 5Y
Expected Inflation: 5Y1Y
Expected Inflation: 10Y1Y
percent
percent change
percent of GDP
date
2016
2018
2020
2022

Scenario

In order to model a realistic scenario for the US economy in 2020Q1, we use our benchmark parametrization in Table 1, except for two modifications regarding the surplus dynamics and the level of the natural rate.

Persistent shock to government consumption with own dynamics: $\rho_g \equiv 1$ and assume a counter-cyclical output response of $\varphi_y \equiv -s_g$ (Sims 2011; Cochrane 2021)

$$\mathrm{d}g_t = \left(-s_g(y_t/y_{ss} - 1) - (g_t - g_t^*)\right)\mathrm{d}t,$$

A shock to the natural rate such that the economy is close to a liquidity trap (Werning 2012)

$$\mathrm{d}d_t = -\rho_d(d_t - 1)\,\mathrm{d}t$$

Initialize the size of the shock to generate a drop in output in 2020Q1, generating a severe recession in the absence of the fiscal package

The Federal Reserve decreased the federal funds rate in two steps from 1.58% to 0.05%, (an accommodative monetary policy shock of 150 bp)

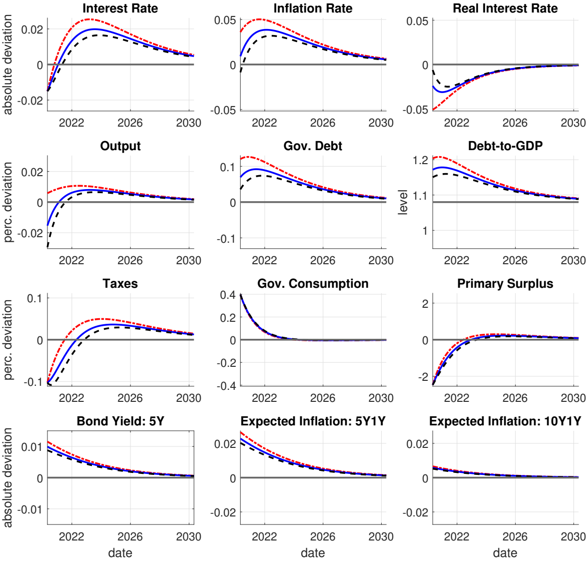
The CARES Act shock

Table: Inflation decomposition for the CARES Act shock

Debt Maturity	$\int_0^\infty e^{-ru}\pi_u du$ inflation	$\int_0^\infty e^{-ru} i_u du$ interest rate	$\int_0^\infty e^{-ru} s_u/a_{ss} du$ surplus	$p_0^b/p_{ss}^b - 1$ direct effect	$v_0/v_{ss} - 1$ debt shock
Long-Term	16.99	8.44	−4.99	−8.44	12.00
Average	20.82	10.67	−3.21	−5.06	12.00
Short-Term	26.55	14.01	−0.54	0	12.00

Solid blue lines show the responses matching average duration, dashed black for perpetuities, and dotted red for short-term debt.

Impulse responses

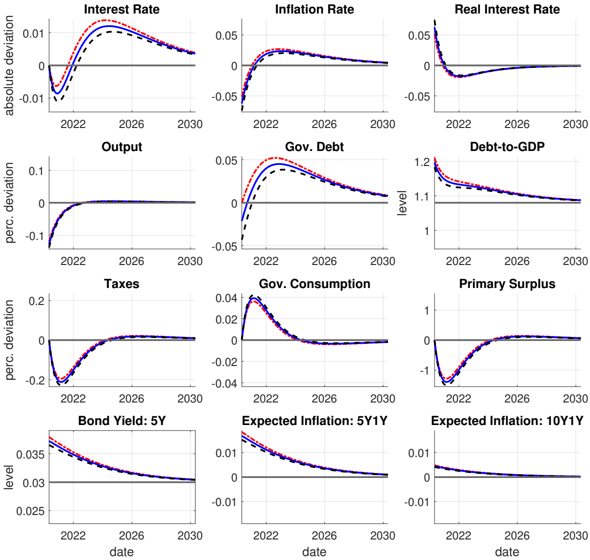


Counterfactual analysis (no CARES Act shock)

Table: Inflation decomposition for the natural rate shock

Debt Maturity	$\int_0^\infty e^{-ru}\pi_u du$ inflation	$\int_0^\infty e^{-ru} i_u du$ interest rate	$\int_0^\infty e^{-ru} s_u/a_{ss} du$ surplus	$p_0^b/p_{ss}^b - 1$ direct effect	$v_0/v_{ss} -$ debt sho
Long-Term	7.39	4.30	−7.39	−4.30	0
Average	9.85	5.74	−6.24	−2.13	0
Short-Term	12.26	7.14	−5.12	0	0

Impulse responses



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Conclusions

Average maturity of existing debt has a prominent role for the propagation of transitory and permanent policy shocks

Decompose inflation into indirect effects (changes in monetary and fiscal policy) and the direct FTPL effect (asset pricing). Neglecting the re-evaluation of existing government bonds has important consequences for the macro dynamics

Our experiment which mimics a low interest rates environment, for the US at the outset of the great pandemic, shows that the fiscal theory identifies the large-scale fiscal package as the source of the recent surge in inflation