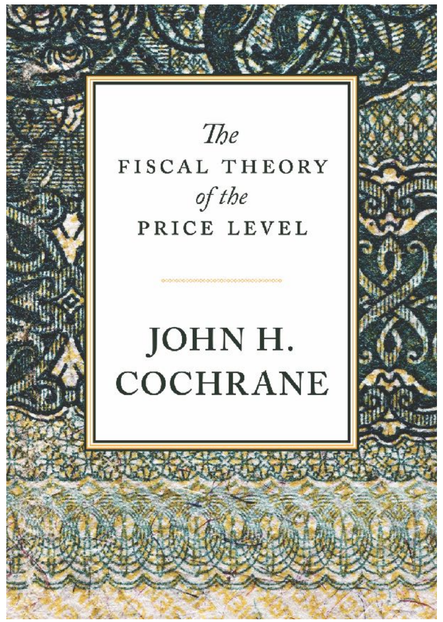
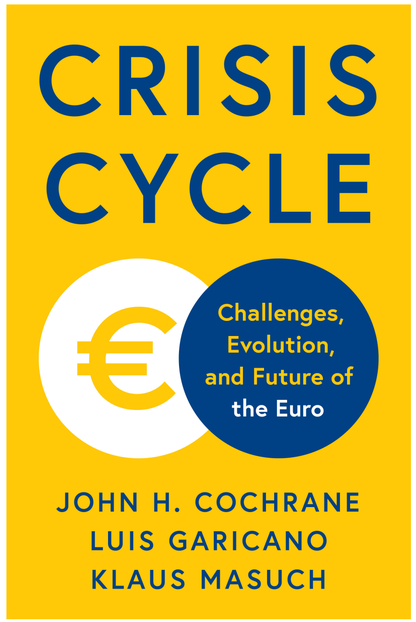
Inflation

John H. Cochrane
Hoover Institution

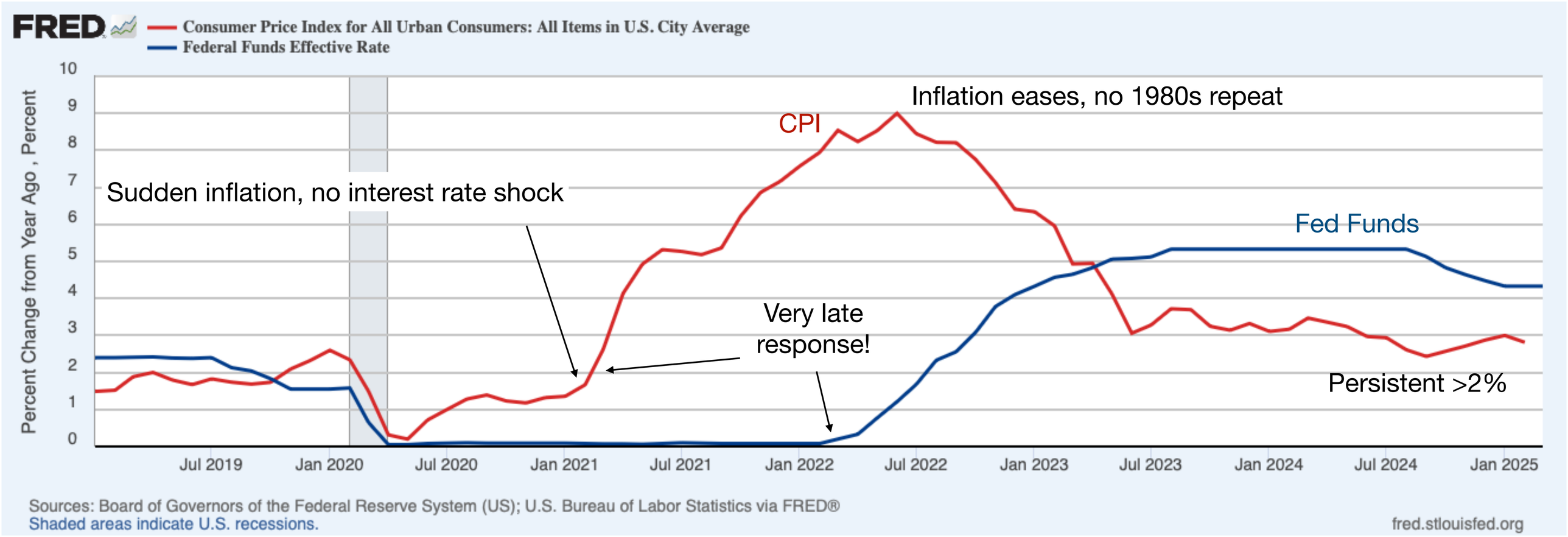




Theme

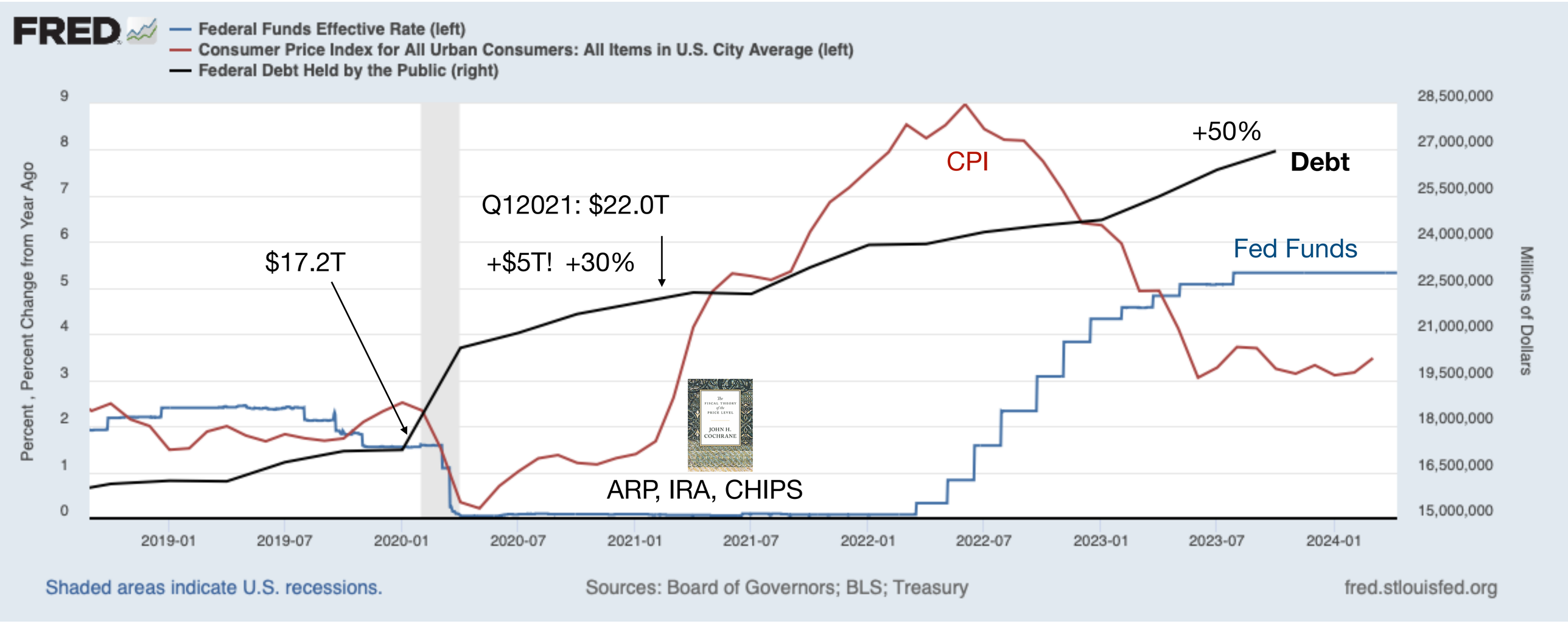
- What is the source of inflation in today's economy, institutional framework? (Interest rate target, ample reserves, liquid assets no money supply control?)
- How do central banks, by changing interest rates, control inflation?
- Seems old, settled. It is not. A chasm between policy doctrine and actual equations of today's models.
- An answer is emerging; Exciting ``paradigm shift" moment.

I. Recent Inflation



- Why did inflation start?
- Why did inflation plateau and ease? No spiral? No recession?
- What happens next?
- How can we avoid a repetition?

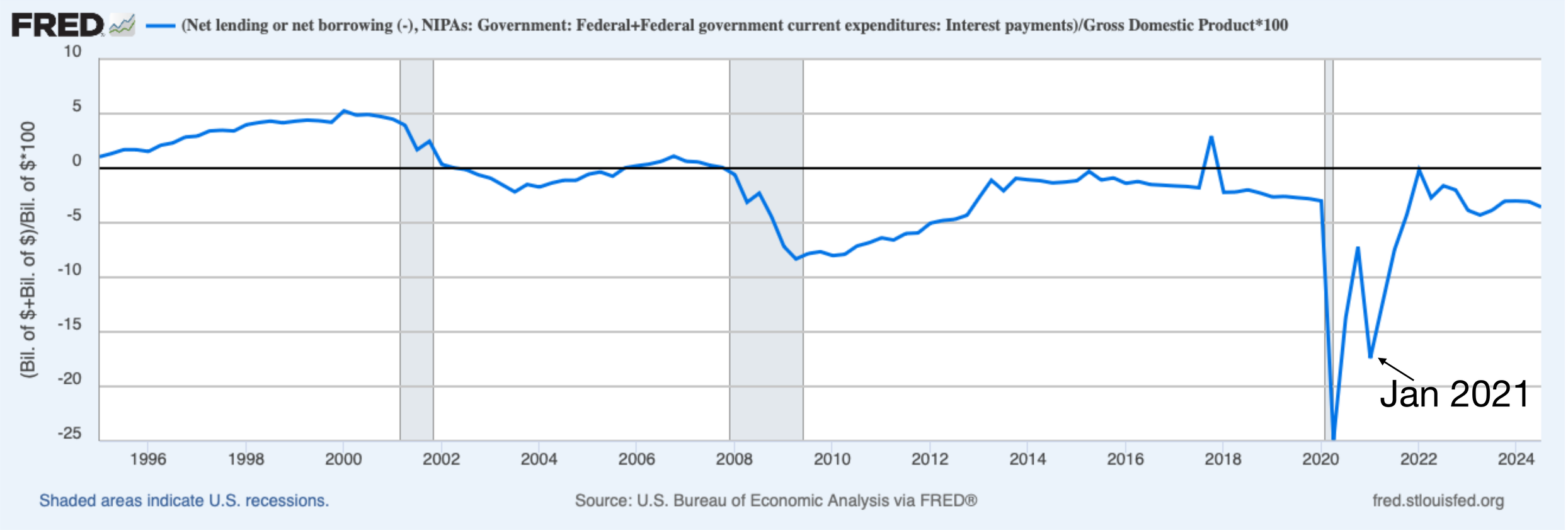
Recent Inflation



Why did inflation break out?

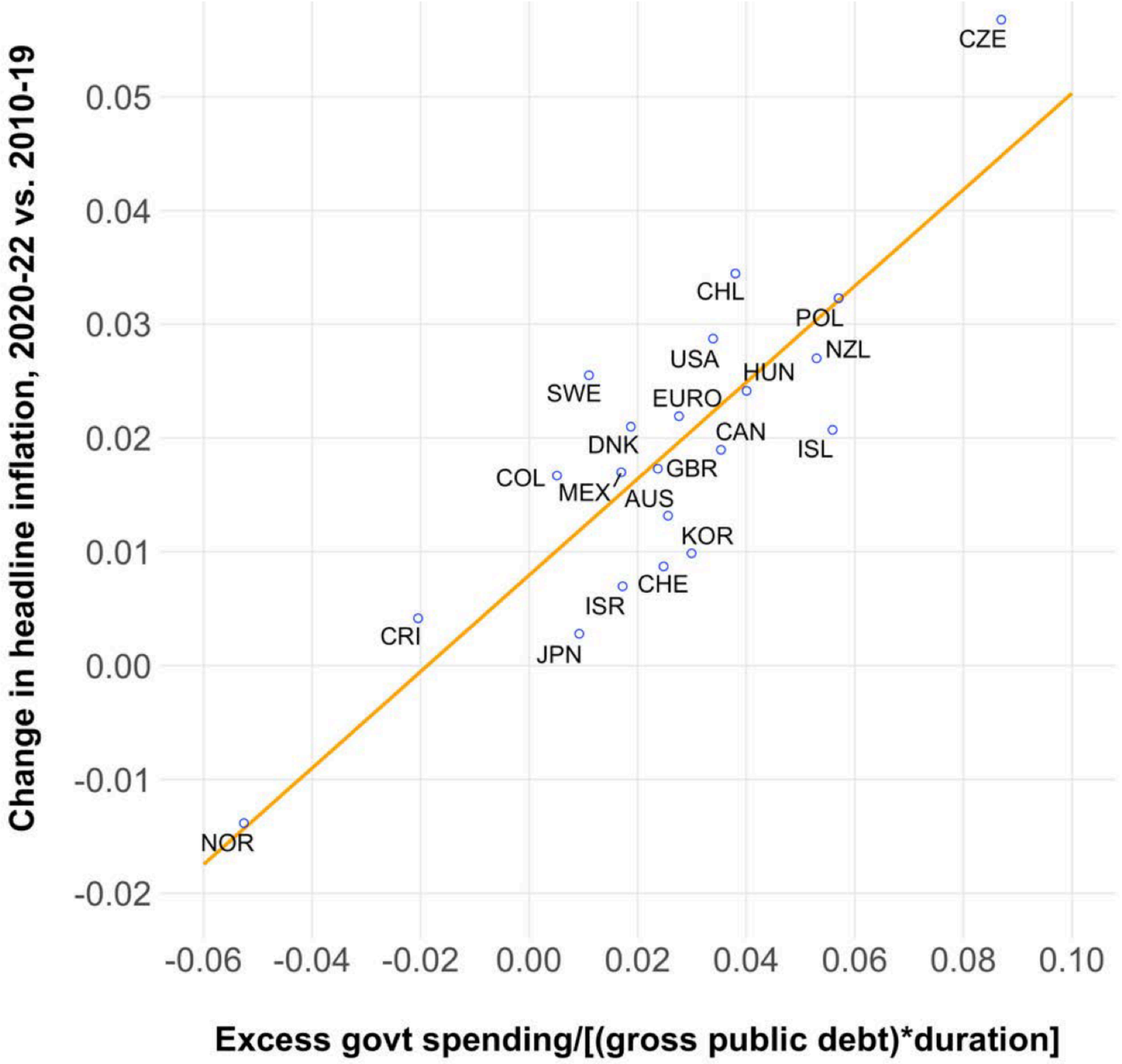
- +$5T debt to public. ($3T monetized). Checks to people, businesses.
- Move to huge deficits/spending even after Covid ended.

Primary surplus / GDP



“One time” shock raises price level. Back to regular levels of dysfunction in 2022.

Countries with bigger spending got more inflation

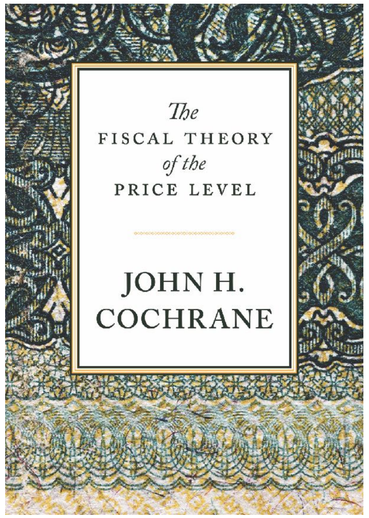


Source: Barro and Bianchi 2024

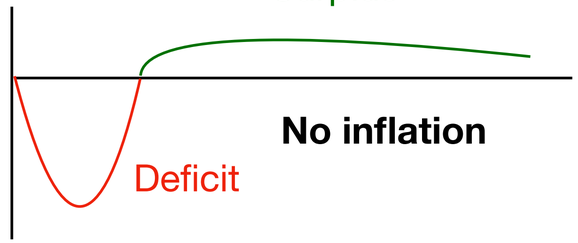
II. Fiscal theory of the price level

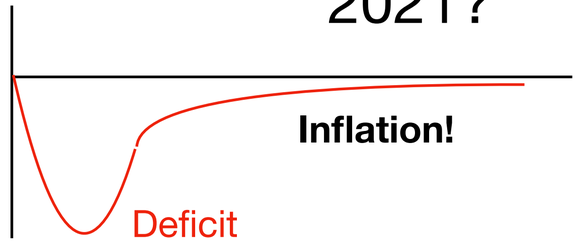
$$\frac{\text{Nominal government debt}}{\text{price level}} = \text{E present value of primary government surpluses}$$

$$\frac{B_{t-1}}{P_t} = E_t \sum_{j=0}^{\infty} \frac{s_{t+j}}{R_{t,t+j}}$$

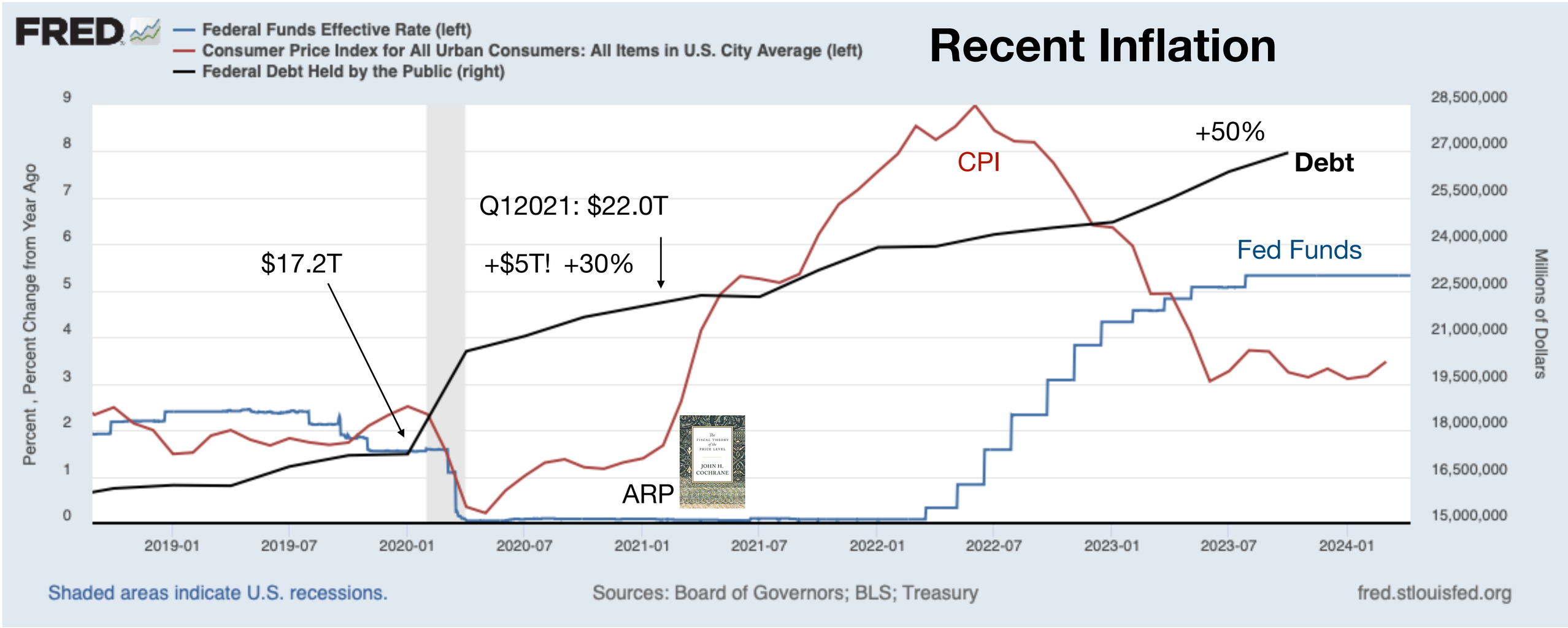


- Like stock, or taxes soak up money.
- Debt vs. *long run* repayment . Not *today's* deficits /debt.
- Lots of debt/deficit with no inflation. Typical and good policy.
- Debt *that people do not believe can/will be repaid* = inflation.
- Imposed in current formal models.
- Or, inflation can be a surprise with little current deficit.
- Discount rates/interest costs on the debt.





Recent Inflation



Debt *vs. expected repayment.* Why this time, not 2008?

- No talk of repayment. Spending rules suspended. “Go big, interest costs are low.” r<g, MMT. ARA, IRA. NextGenEU/SuperBonus. 2022 end.
- Need models, not just stories.…

Fiscal theory of monetary policy

- Need a theory of inflation with interest rate targets.
- To start, flexible prices, constant real rate

$$\frac{1}{1+i_t} = \beta E_t\left(\frac{P_t}{P_{t+1}}\right)$$

Nominal rate = real rate + expected inflation

$$\frac{B_t}{P_{t+1}} = E_{t+1}\sum_{j=0}^{\infty}\beta^j s_{t+j}$$

News to surpluses = news to prices (like dividend)

$$\frac{B_t}{P_t}\left(E_{t+1}-E_t\right)\left(\frac{P_t}{P_{t+1}}\right) = \left(E_{t+1}-E_t\right)\sum_{j=0}^{\infty}\beta^j s_{t+j}$$

- *Interest rate target sets expected inflation.* Central banks matter!
- *Fiscal policy sets unexpected inflation.* Lower surplus → higher price level.
- Interest rates *raise* inflation? Price jump? Add sticky prices.

Sticky prices, long debt

$$x_t = E_t x_{t+1} - \sigma(i_t - E_t \pi_{t+1})$$

$$\pi_t = \beta E_t \pi_{t+1} + \kappa x_t$$

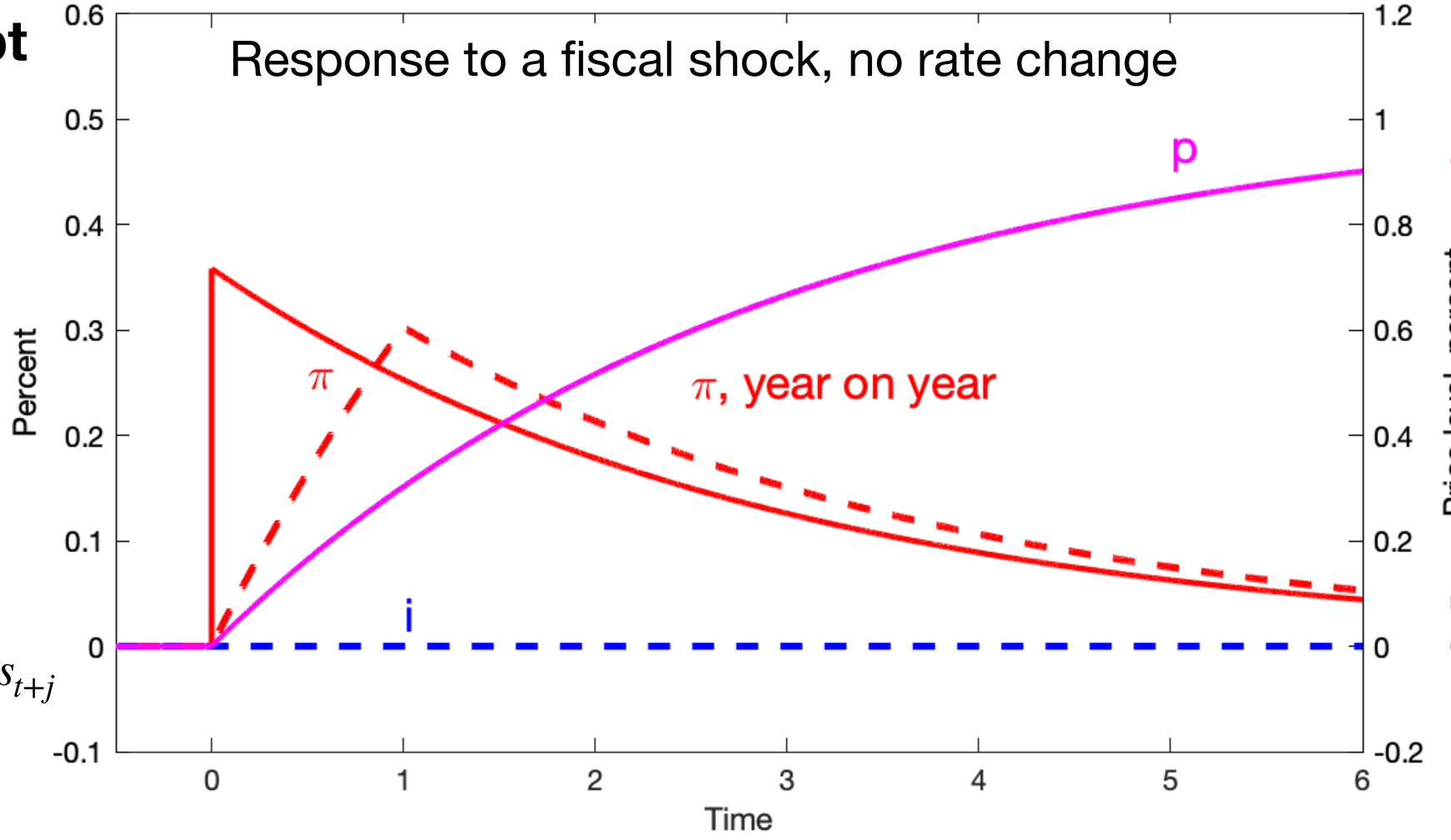
$$\rho v_{t+1} = v_t + r^n_{t+1} - \pi_{t+1} - \tilde{s}_{t+1}$$

$$E_t r^n_{t+1} = i_t$$

$$r^n_{t+1} = \omega q_{t+1} - q_t$$

Implements

$$\frac{Q_t' B_{t-1}}{P_t} = E_t \sum_{j=0}^{\infty} \frac{1}{R_{t,t+j}} s_{t+j}$$



- Textbook sticky price + FTPL model.
- Shock: One-time deficit $\tilde{s}_t < 0$, no repayment. No change in interest rate.
- Result: Inflation surge. Bondholders pay.
- One time shock. Inflation eases, with no Fed action, no high real rates, no recession.

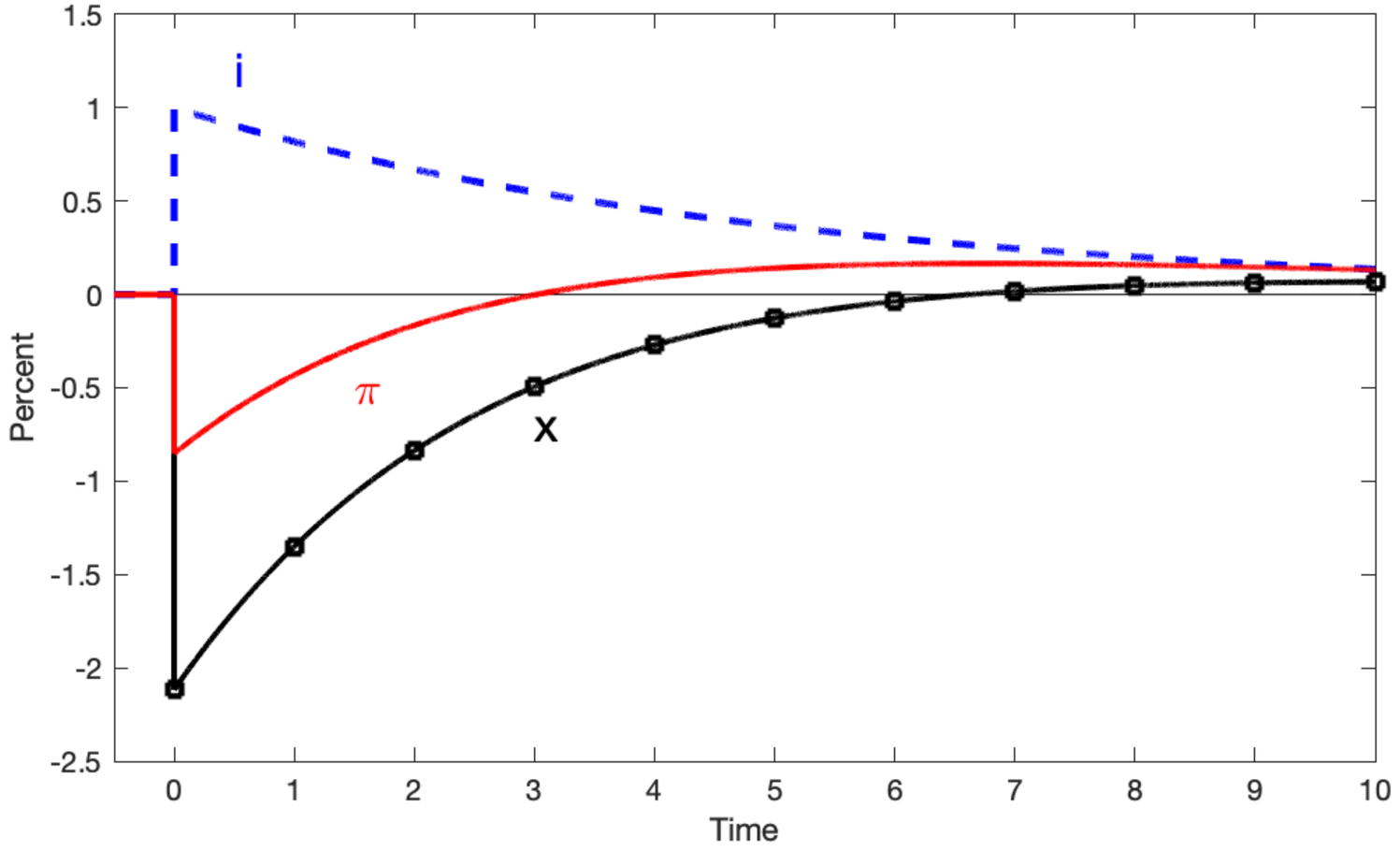
What about central banks and interest rates?

- Shock: persistently higher interest rate, *no change in fiscal policy.*
- Good response. Taylor rule.
- Flex price case:

$$E_t \sum_{j=0}^{\infty} \frac{B_{t-1}^{(t+j)}}{P_{t+j}} = E_t \sum_{j=0}^{\infty} \beta^j s_{t+j} = \text{no change.}$$

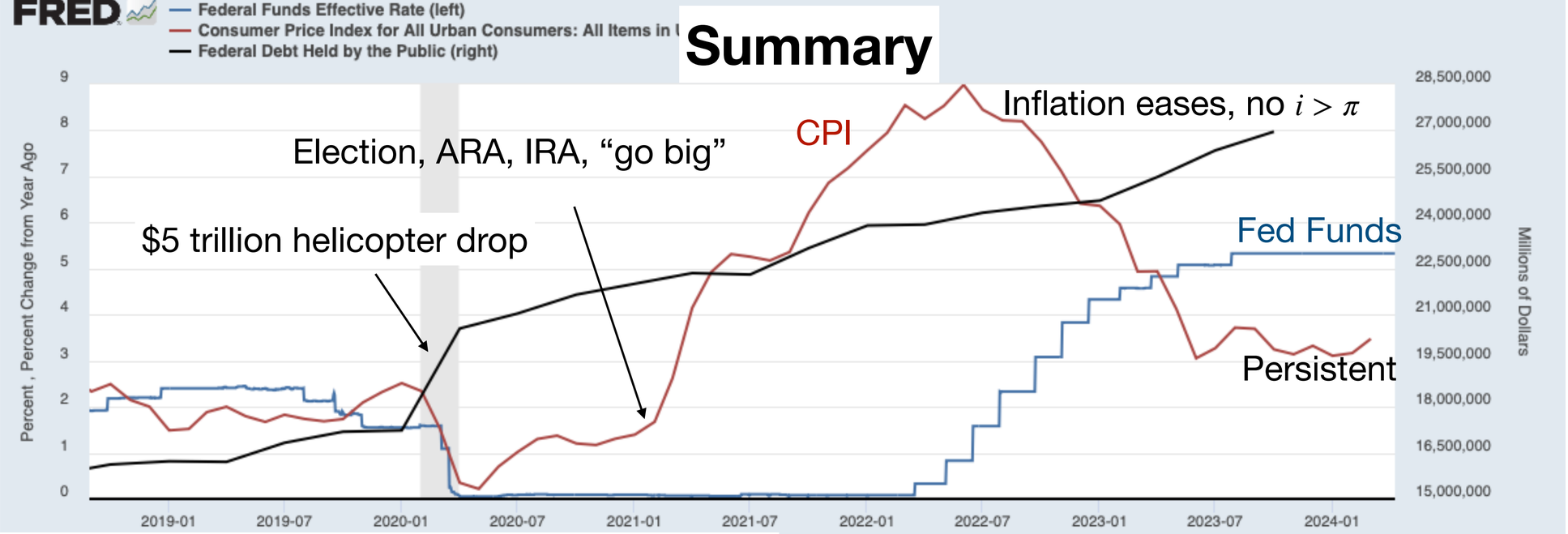
Higher i_{t+j} means higher P_{t+j} thus lower P_t

Response to interest rate shock, no fiscal change

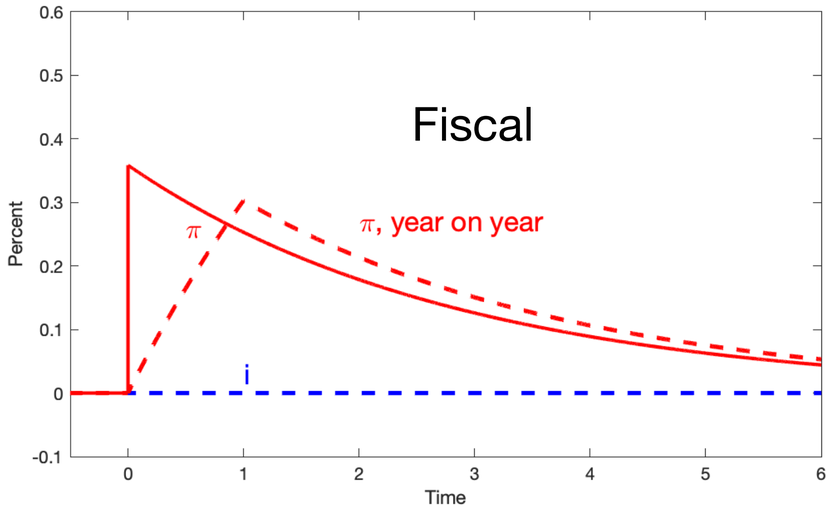


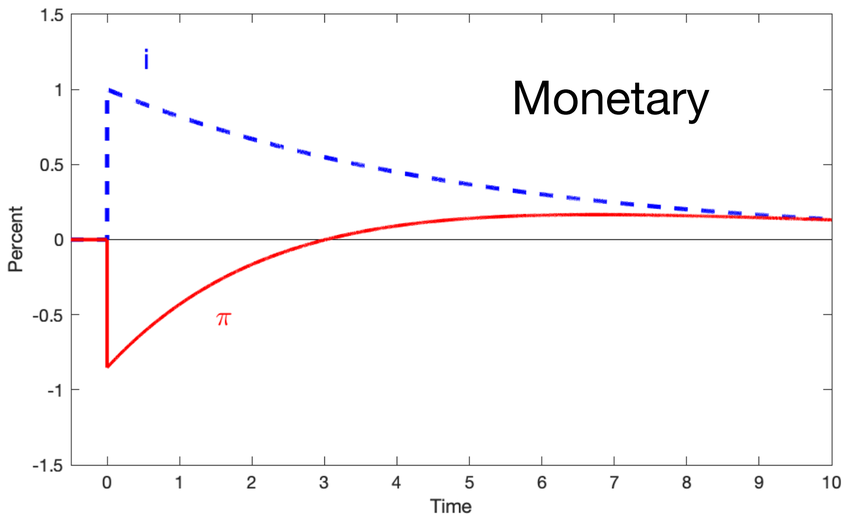
Summary

Fact



Theory





- Not necessarily bad. Classic war finance: spend, monetize, hold down rates.
- Inflation lessons. ~~Chronic insufficient demand, r<g, MMT, secular stagnation, endless debt appetite~~.

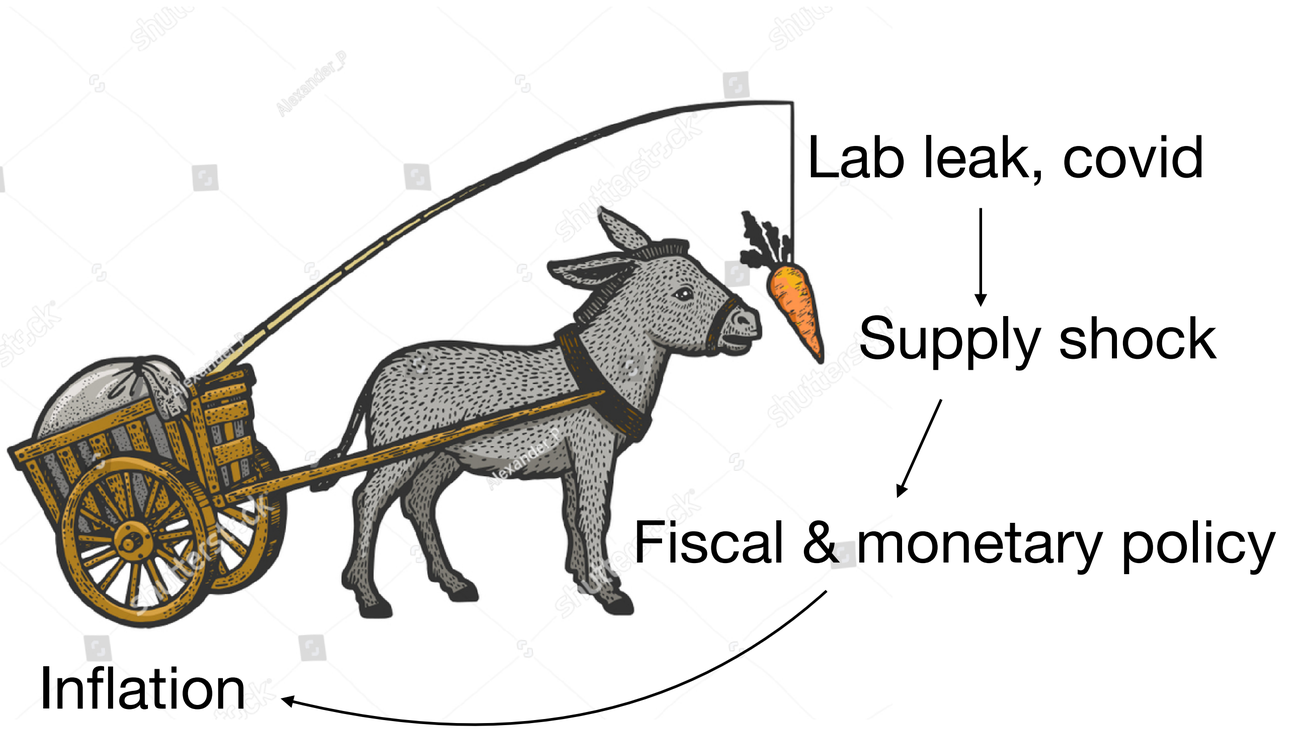
III. Distinguishing theories of inflation

- Theory: NK+FTPL is the only known complete economic theory of inflation under interest rate targets consistent with current institutions.
- Facts: Recent history provides a clean set of experiments to distinguish the known theories of inflation.

Supply, Relative Demand Shocks?

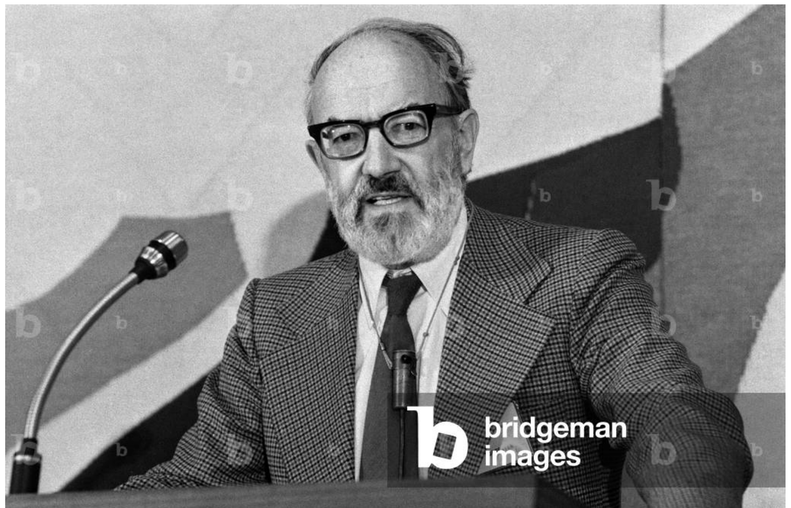
- "Supply," "relative demand."
- "Greed," "monopoly," "price gouging," "hoarders," "speculators."
- All *relative* prices. *The price level is not the sum of relative prices*. "Nominal anchor."
- "Supply" etc. shocks alone do not cause inflation. All "supply shock" calculations include induced fiscal or monetary policy to raise demand. (Look in footnotes.)

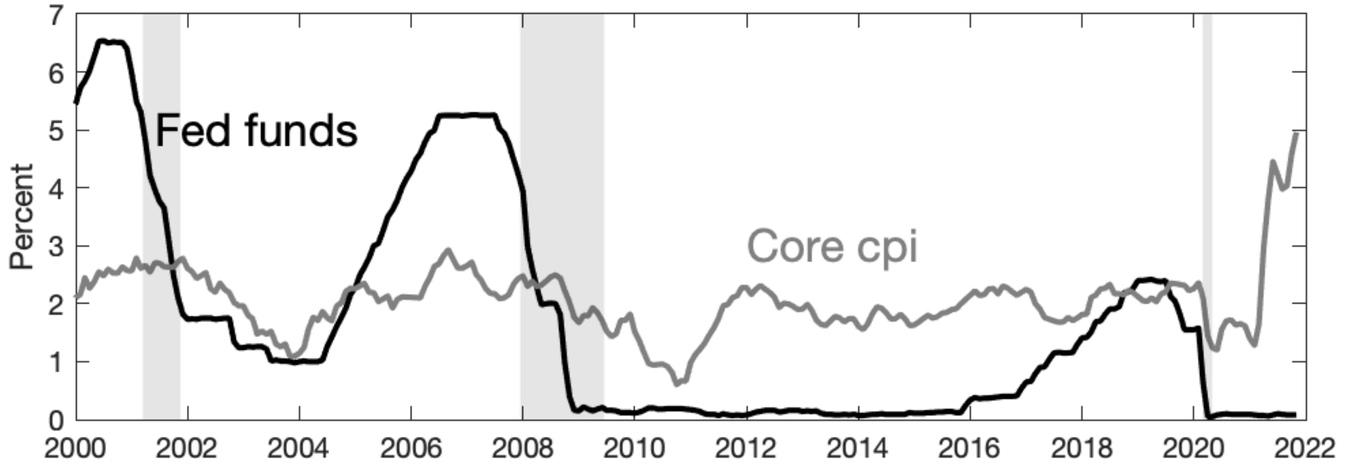
- FTPL agrees.
- "Shocks" might be a reason, but they are not an excuse.
- Inflation is a *choice*. If not desired, choose better next time.

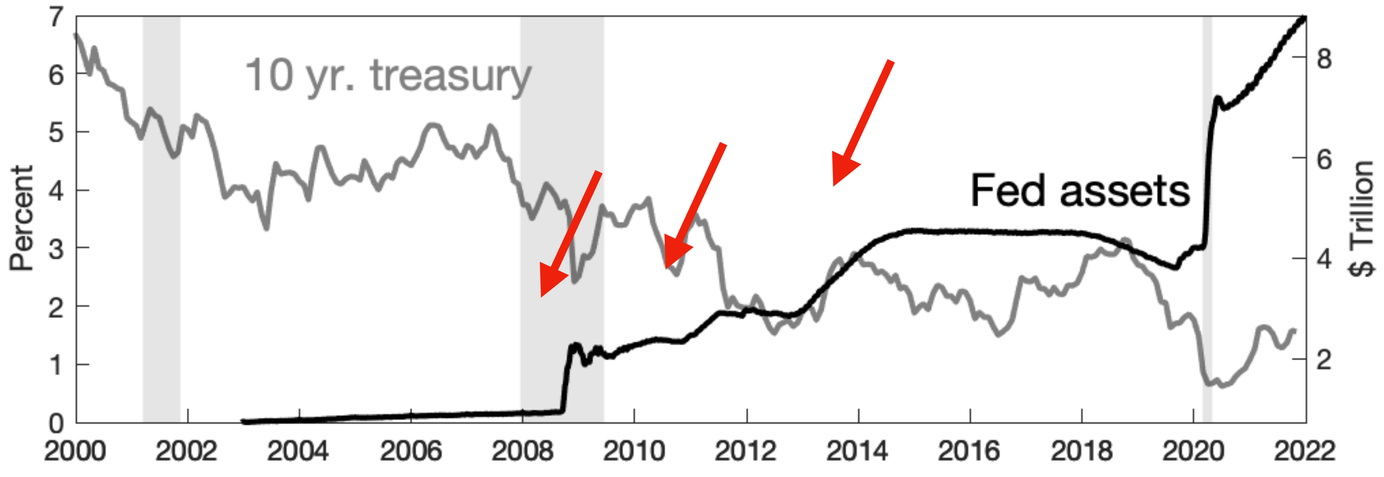


Money?

- Great theory. But c*entral banks do not control money supply*.
- Facts: FTPL & MV=PY agree, helicopter drops cause inflation (2021).
- Money *vs.* bonds? “Wealth” vs. “portfolio.” QE vs. 2021-2023 a nearly ideal experiment!







Interest rates: Standard policy view

(ISLM, old Keynesian, slow moving expectations)

- Rates → demand→employment→(Phillips)→ inflation.
- Inflation is inherently *unstable.*
- Fed, Taylor rule *stabilizes* inflation.
- Higher rates *lower* future inflation.
- Theory: *Requires* adaptive/nonreactive expectations. No economic theory of inflation.
- Facts? *Prediction:* at a peg or zero bound, inflation or deflation will spiral out of control. Constant fear 2010s.

Model $x_t = -\sigma(i_t - \pi_{t-1})$

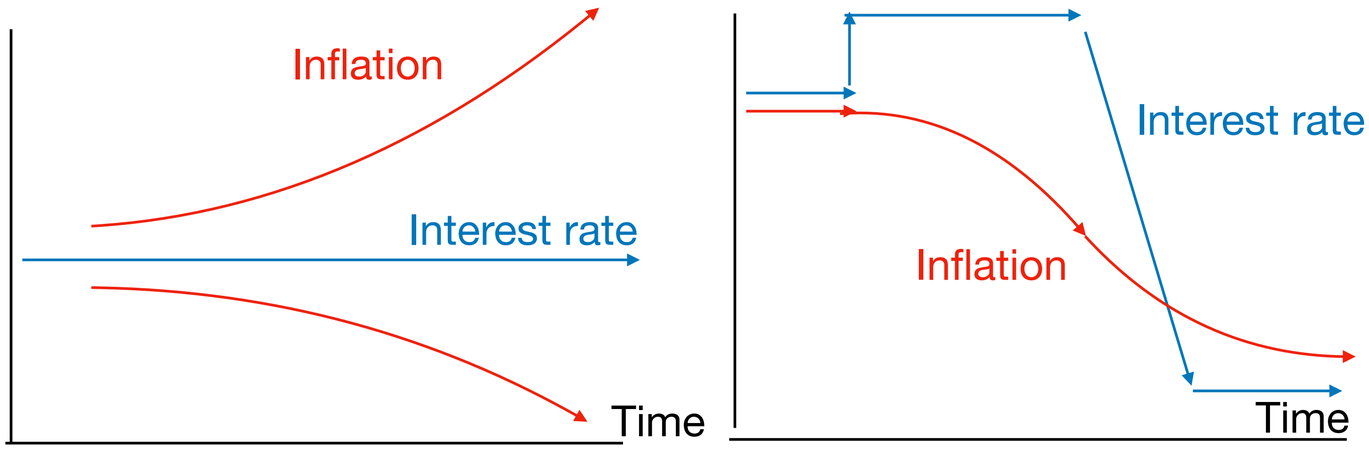
$\pi_t = \pi_{t-1} + \kappa x_t$ (Or π^e)

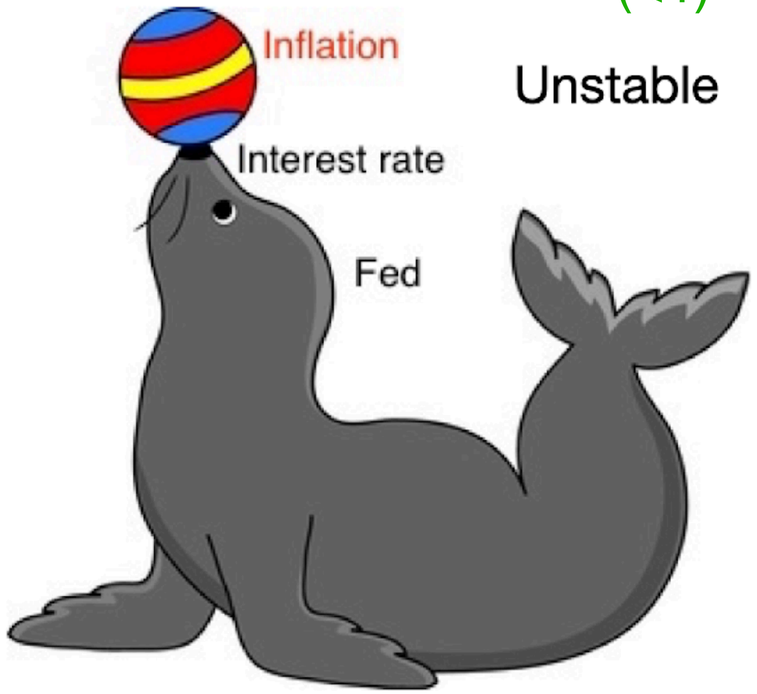
Inflation $\pi_t = (1 + \sigma\kappa)\pi_{t-1} - \sigma\kappa i_t$.

(>1)

Taylor $i_t = \phi\pi_t \rightarrow \pi_t = \dfrac{1+\sigma\kappa}{1+\sigma\kappa\phi}\pi_{t-1}$.

(<1)





New Keynesian Model

- Rational expectations. Economics!
- Interest peg is *stable,* but *indeterminate, multiple equilibria.*
- Taylor. Fed *destabilizes* the economy to select equilibrium.
- Higher rates *raise* π. "Eq. selection" lowers π.
- Theory: Central banks don't do that!
- Facts? *Prediction:* Interest rate peg or ZLB leads to "sunspot" volatility. (Central)

Flex prices:

$$i_t = E_t\pi_{t+1} \,.\, \Delta E_{t+1}\pi_{t+1}\,?$$

$$i_t = \phi\pi_t,\ \phi > 1.\ E_t\pi_{t+1} = \phi\pi_t\,.$$

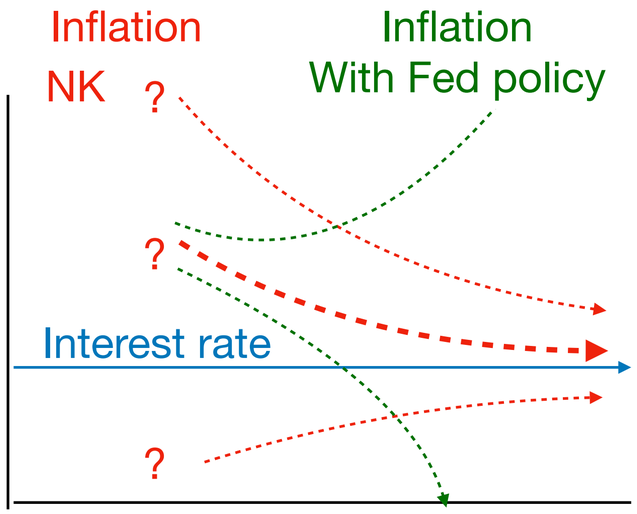
Sticky prices:

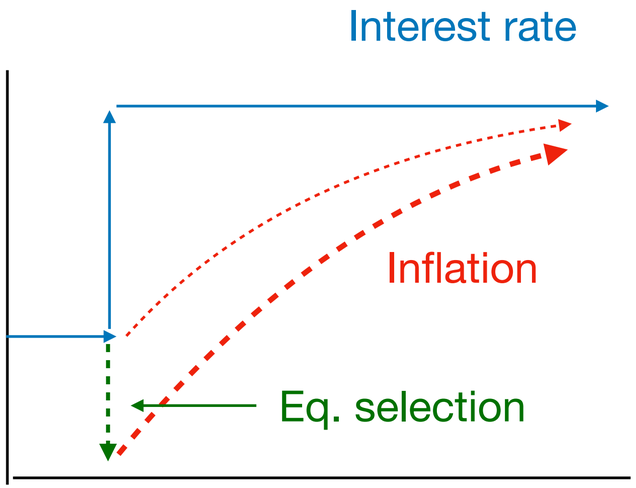
$$x_t = -\sigma(i_t - E_t\pi_{t+1})$$

$$\pi_t = E_t\pi_{t+1} + \kappa x_t$$

$$E_t\pi_{t+1} = \underset{(<1)}{\frac{1}{1+\sigma\kappa}}\pi_t + \frac{\sigma\kappa}{1+\sigma\kappa} i_t$$

$$i_t = \phi\pi_t \ \rightarrow\ E_t\pi_{t+1} = \frac{1 + \phi\sigma\kappa}{1+\sigma\kappa}\pi_t \quad (>1)$$





+ equilibrium selection

FTPL + NK sticky price

- FTPL +NK picks one equilibrium of NK model.
- Theory: FTPL is *stable, determinate, and long-run neutral*. (Like MV=PY). The only complete economic model of inflation under an interest rate target consistent with current institutions.
- *Prediction:* a peg or zero bound can be stable, determinate, quiet (with no fiscal news).
- Experiment to tell FTPL, old and new Keynesian apart: Hold interest rates constant for a decade or three and see what happens.They just did!

Flex prices:

$$i_t = E_t\pi_{t+1} \,.\, \Delta E_{t+1}\pi_{t+1}\,?$$

~~$i_t = \phi\pi_t,\ \phi > 1.\ E_t\pi_{t+1} = \phi\pi_t\,.$~~

Sticky prices:

$$x_t = -\sigma[i_t - E_t\pi_{t+1}]$$

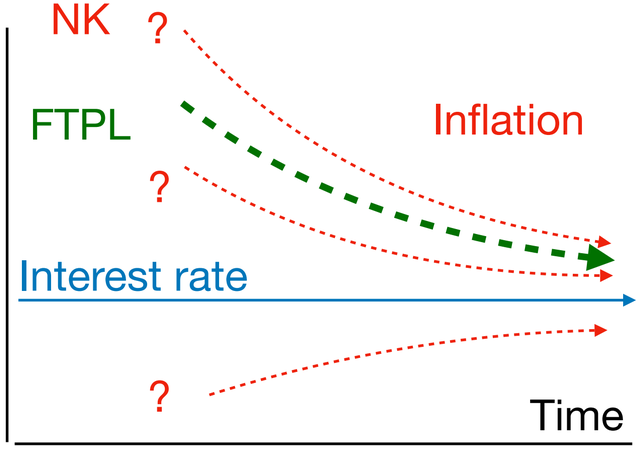
$$\pi_t = E_t\pi_{t+1} + \kappa x_t$$

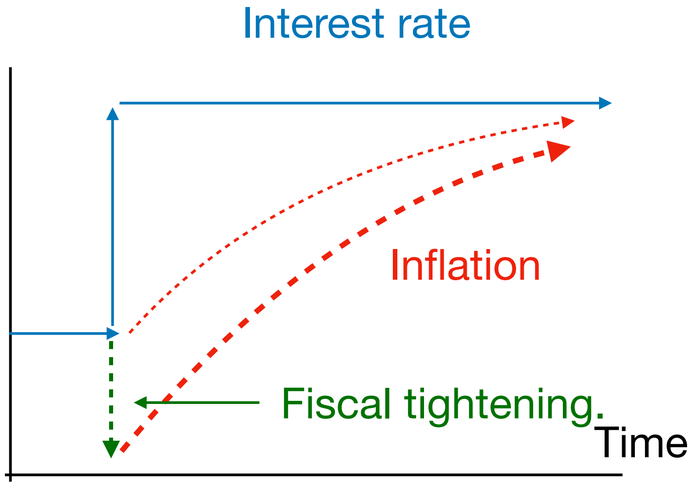
$$E_t\pi_{t+1} = \frac{1}{1+\sigma\kappa}\pi_t + \frac{\sigma\kappa}{1+\sigma\kappa} i_t$$

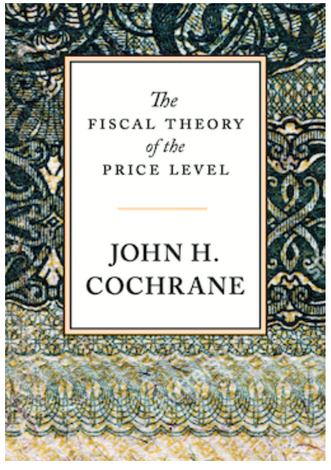
(<1)

~~$i_t = \phi\pi_t \ \rightarrow\ E_t\pi_{t+1} = \frac{1+\phi\sigma\kappa}{1+\sigma\kappa}\pi_t$~~

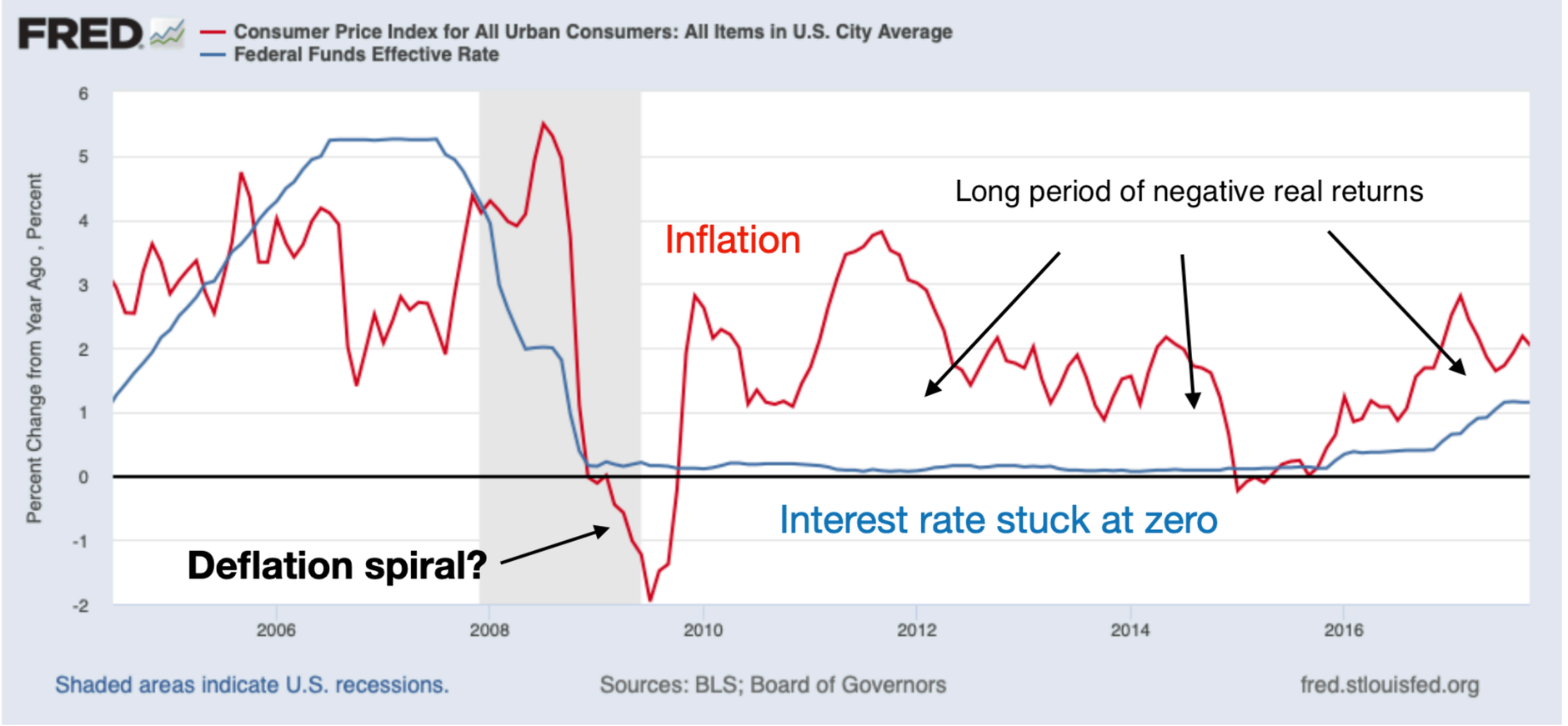
$$\Delta E_{t+1}\pi_{t+1} \approx -\Delta E_{t+1}\sum_{j=0}^{\infty}\rho^j(\tilde{s}_{t+1+j} - r_{t+1+j})$$





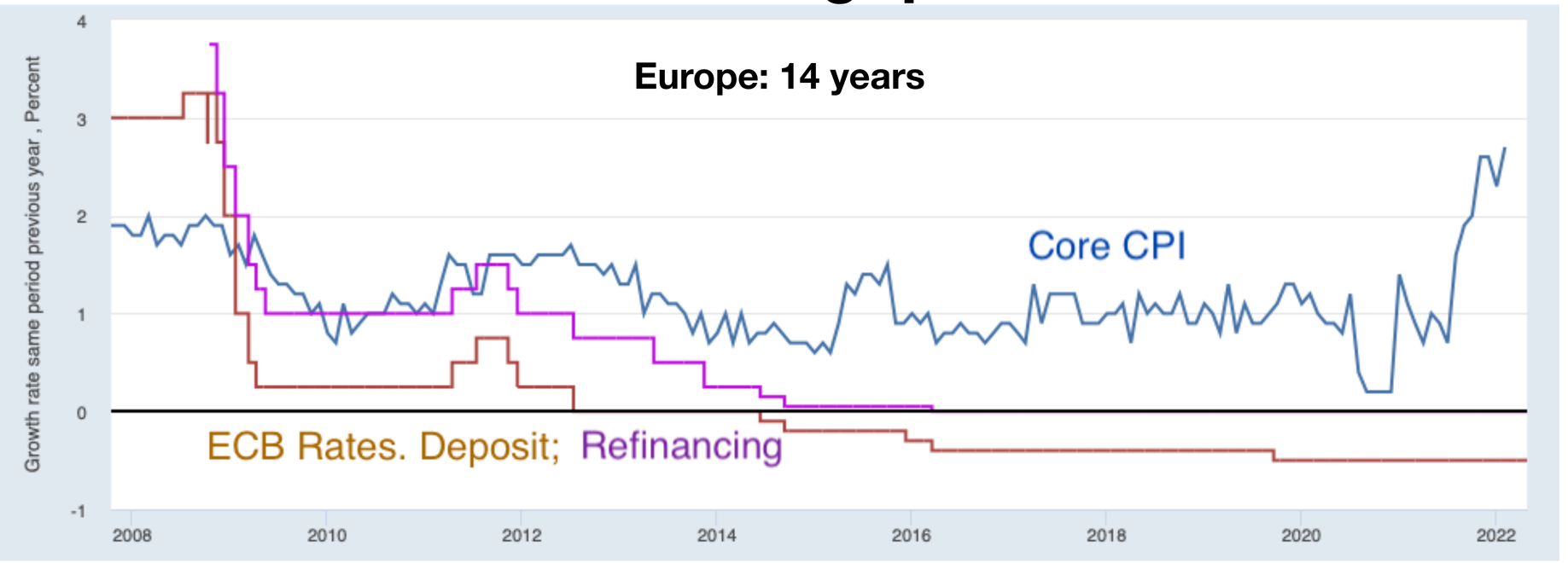


A test of theories: 2008 and zero bound



- Experiment: What if interest rates are stuck (at zero) for a decade or more?
- Old Keynesian/policy view: Inflation is *unstable*, spirals.
- New Keynesian: Inflation is *indeterminate.* Multiple equilibria, sunspot *volatility*.
- FTPL: Inflation is *stable* and *determinate. Quiet* if no fiscal/discount news.

The long quiet stable zero bound

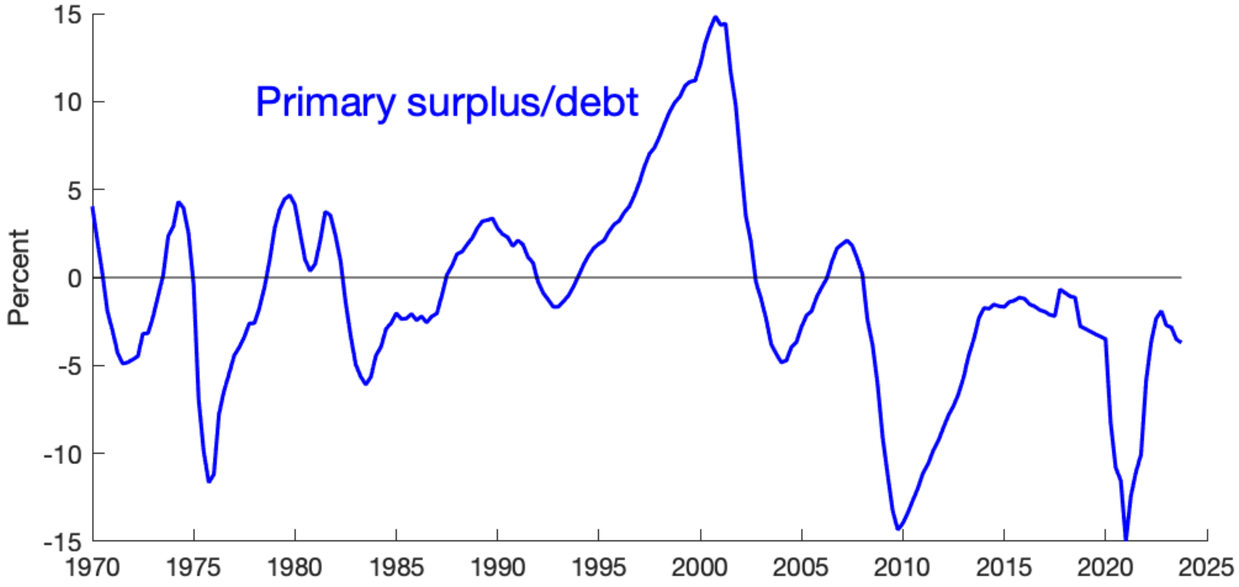


- As good an experiment as we ever get in macro!

Big news, unknown 2007:

- *Inflation can be stable and quiet at a long lasting peg/zero bound.*
- *Inflation can be stable and quiet with abundant reserves that pay market rate, liquidity satiation*. Friedman rule.

1980s? A joint monetary, fiscal, and microeconomic disinflation

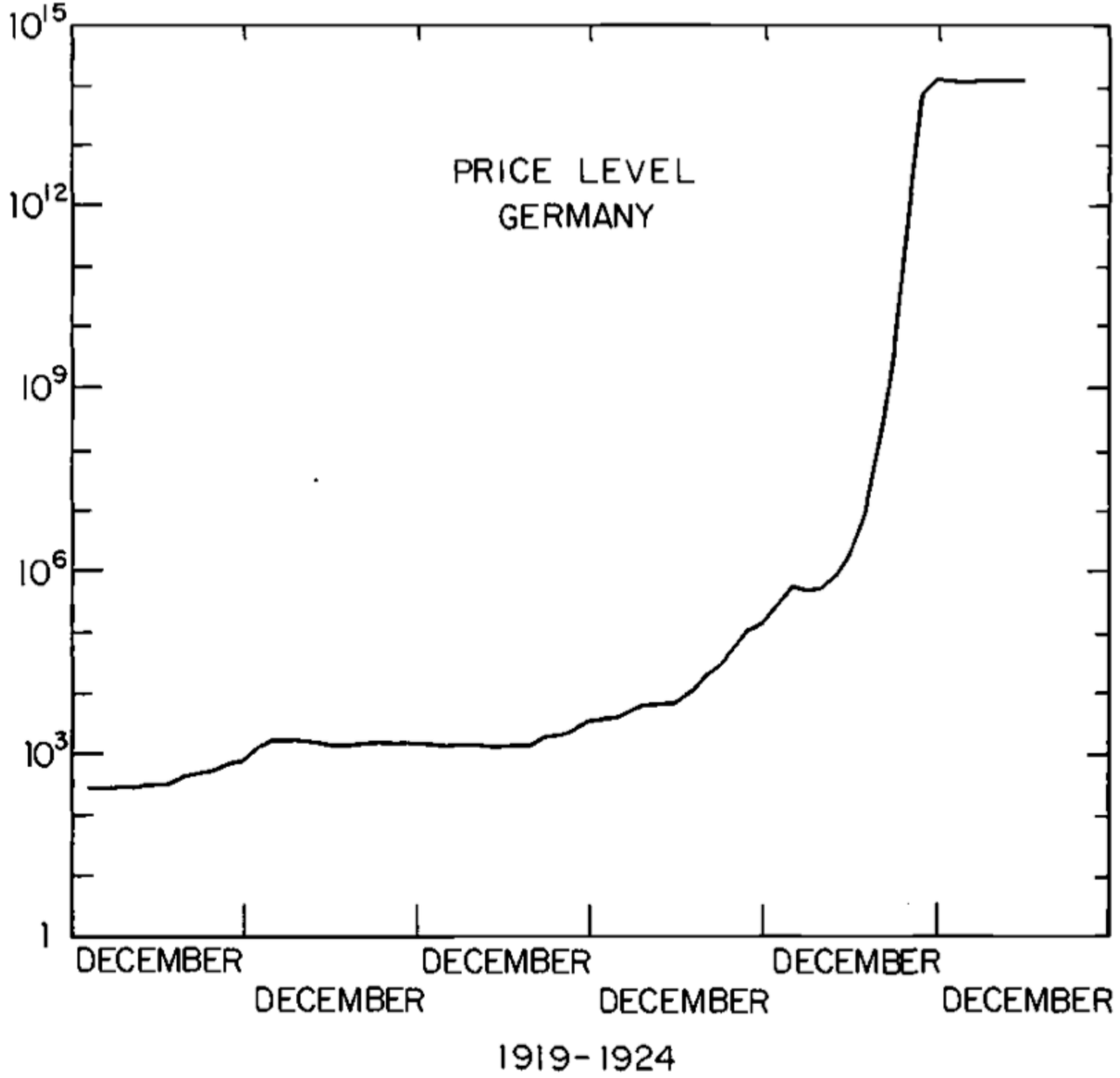


1970s: Big deficits relative to debt.

1982-1986: Tax, Social Security reform, deregulation, Growth!
PV of surpluses (to 2000!) did pay for disinflation.

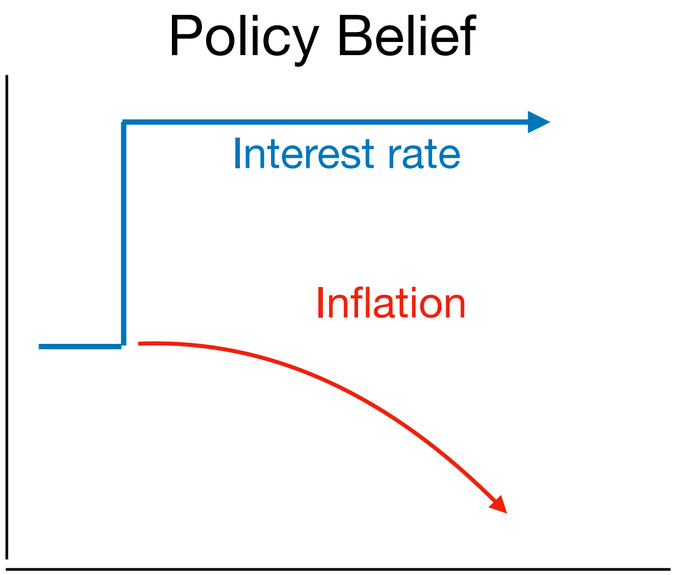
(Standard NK cannot explain 1980s. Persistent rates raise inflation.)

Painless disinflation is possible with joint fiscal-monetary and usually micro reform

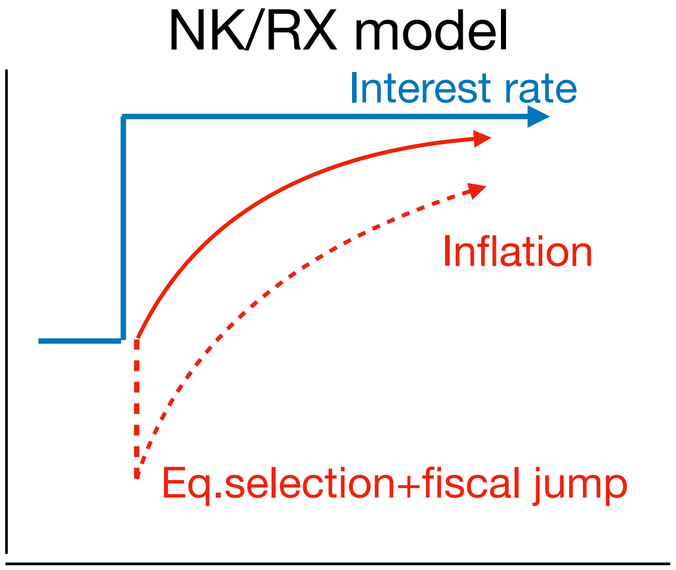


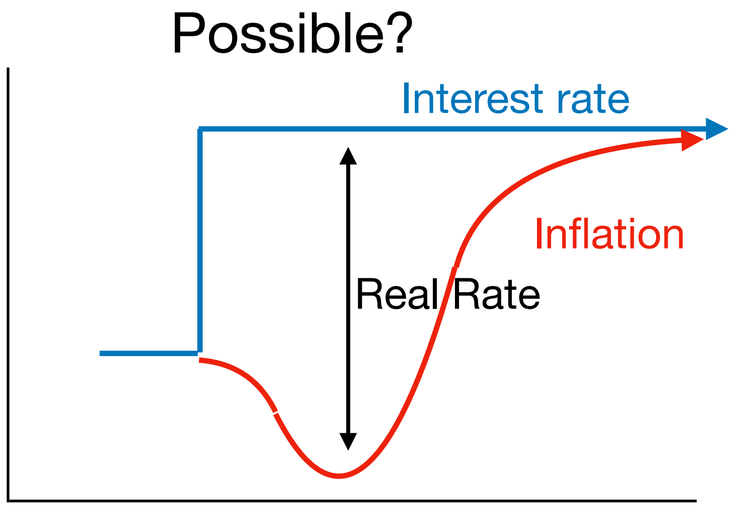
- Sargent (1982)
- Inflation ends with long-run *fiscal* reform.
- Interest rates *decline*.
- Money growth *rises*.
- Economy *booms*.
- Many similar episodes. Latin America; Inflation targets.

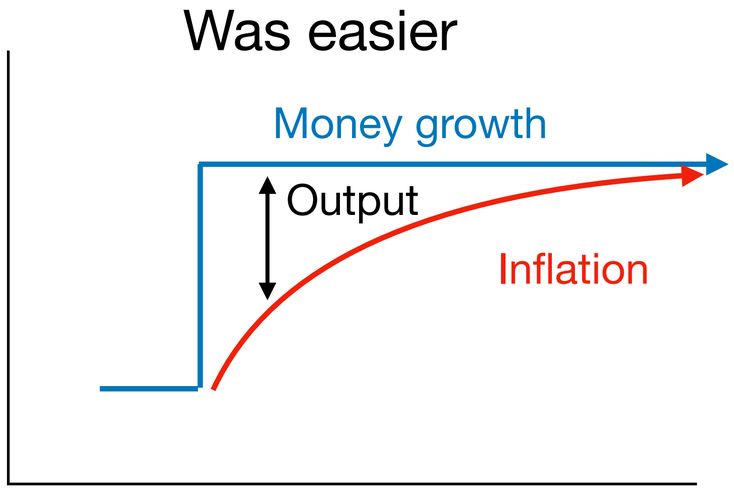
IV: The Big Puzzle: Can central banks, by raising rates, lower inflation? How?



- Huge difference between all economic theory and policy beliefs.
- Fix theory?
- Inflation is stable, long-run neutral: higher interest must eventually mean *higher* inflation.
- Possibility: go down in the short run?
  - Challenge 1: higher rates lower inflation *at all*.
  - Challenge 2: higher rates lower *future* inflation, not just one jump.
- Modify the rest of the model (IS and Phillips).
- Goal: Not 100 epicycles. Simple economic to get sign of policy “right.”

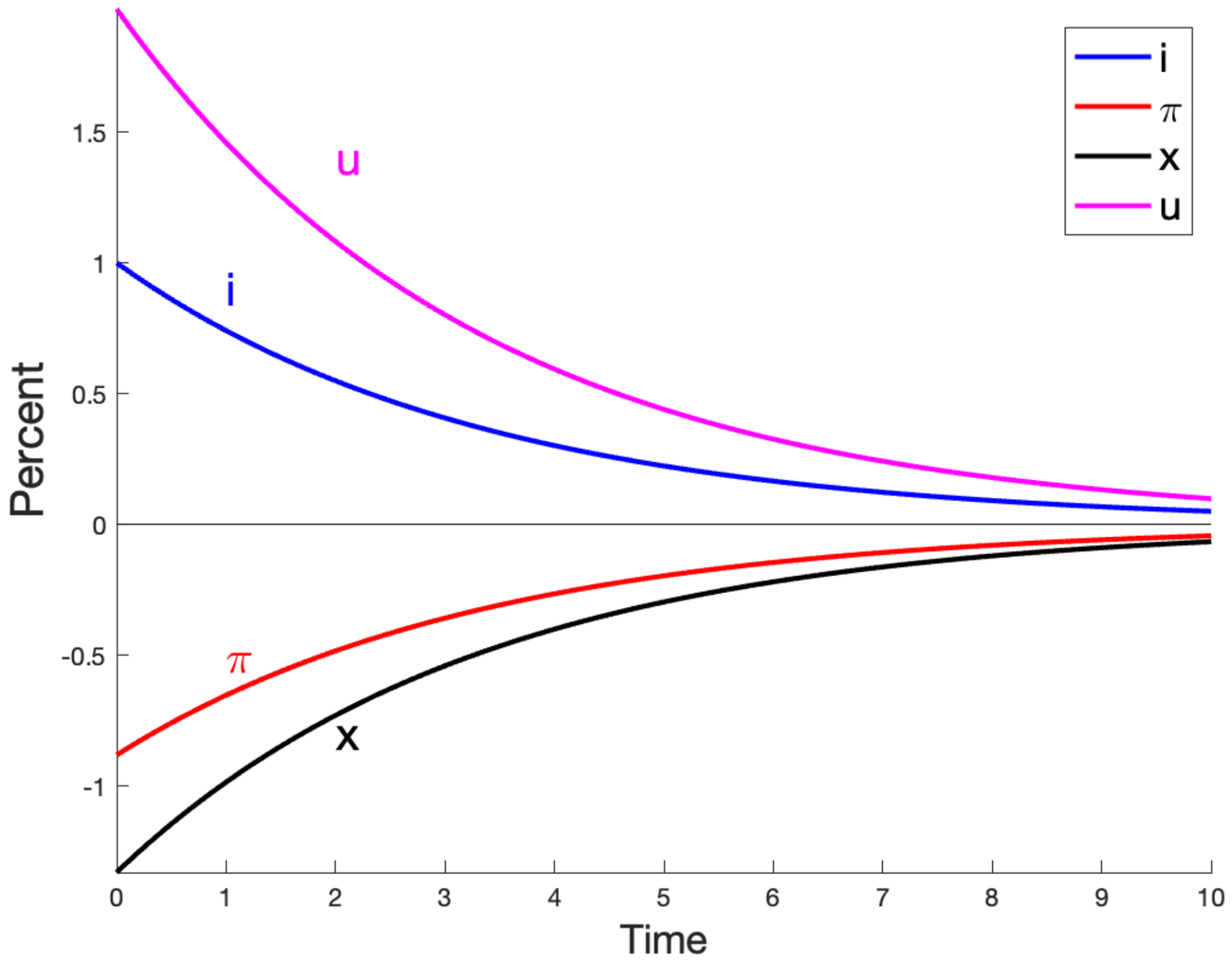






The Big Puzzle: NK model?

- “There is no textbook economic model by which higher interest rates lower inflation, especially future inflation?”
- What about textbook NK model?

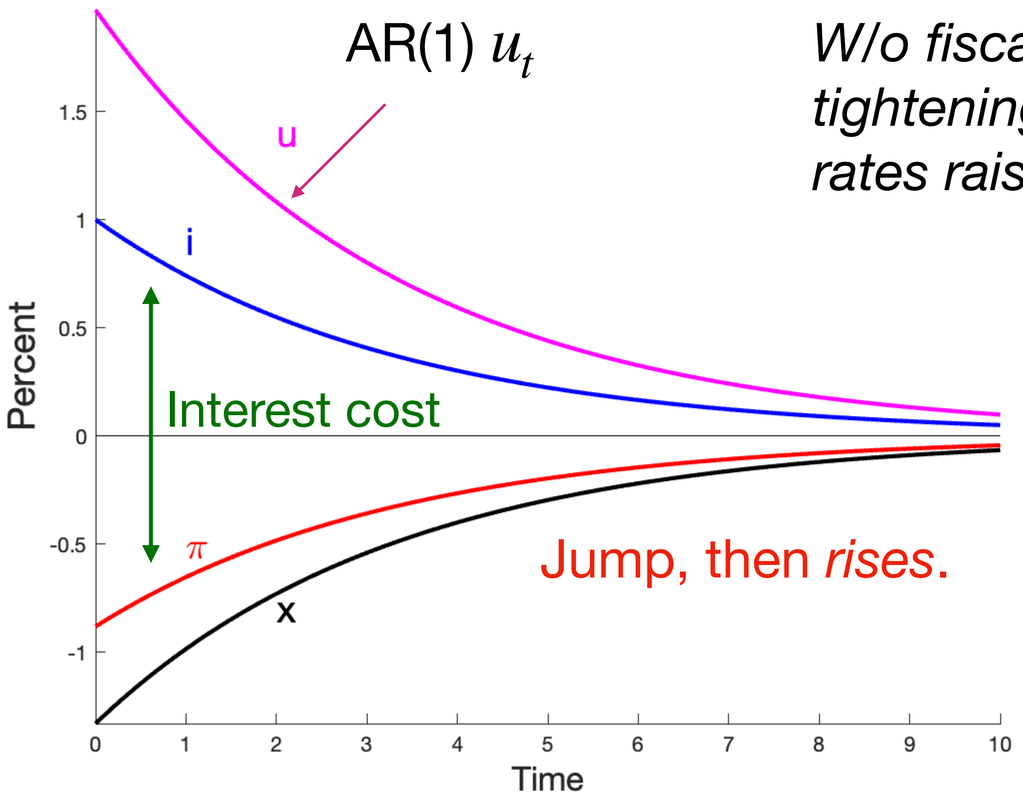


$$x_t = E_t x_{t+1} - \sigma(i_t - E_t \pi_{t+1})$$
$$\pi_t = \beta E_t \pi_{t+1} + \kappa x_t$$
$$i_t = \phi \pi_t + u_t$$
$$u_t = \eta u_{t-1} + \varepsilon_t$$

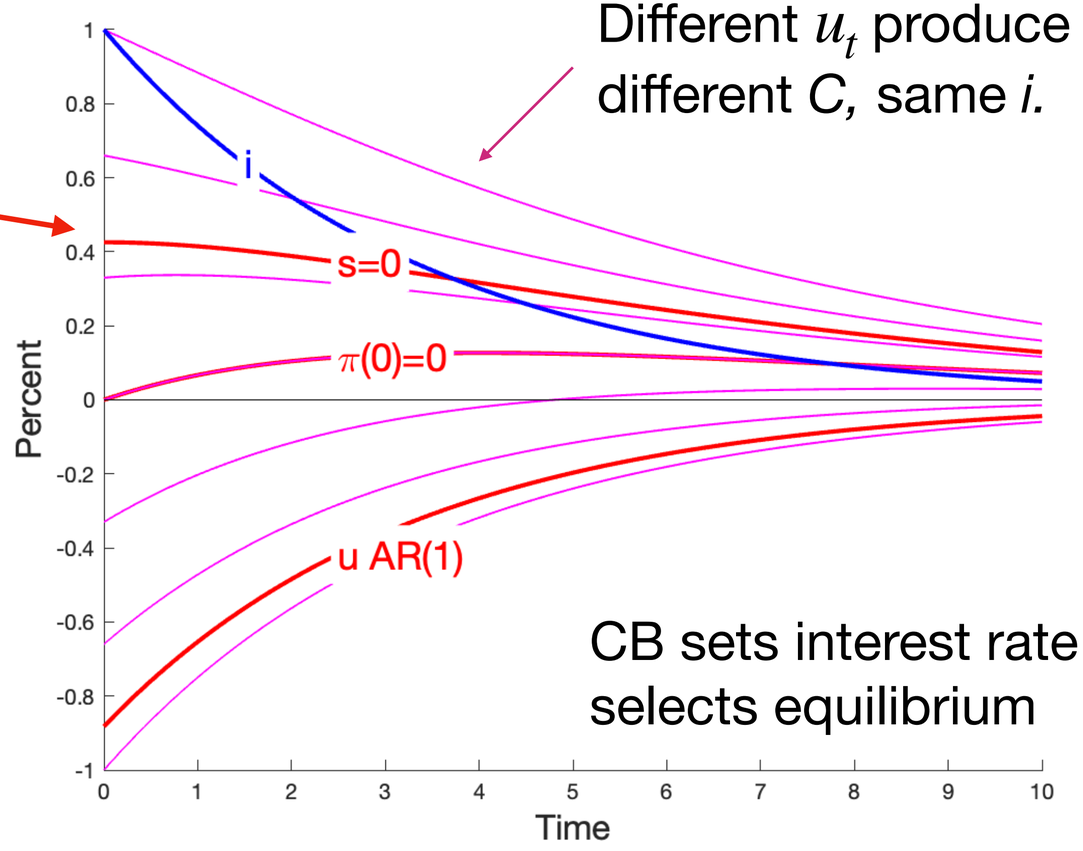
Or

$$dx_t = \sigma(i_t - \pi_t)dt$$
$$d\pi_t = (r\pi_t - \kappa x_t)dt$$
$$i_t = \phi \pi_t + u_t$$
$$u_t = u_0 e^{-\eta t}$$

The Big Puzzle: NK model?



W/o fiscal tightening, higher rates raise inflation



A fiscal + monetary shock!

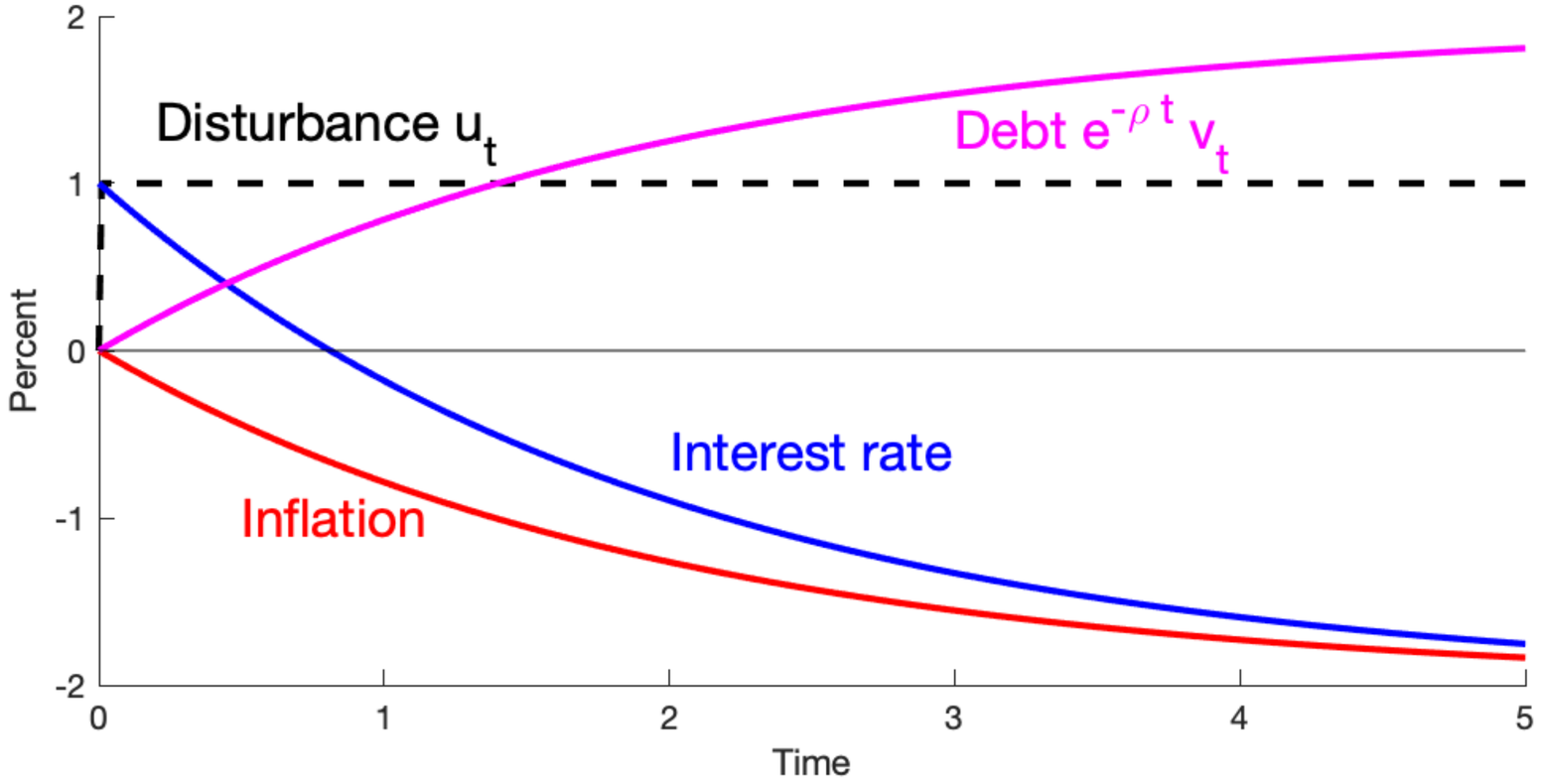
$$\pi_t = (\text{const.}) \times \left[Ce^{-\lambda_1 t} + \int_{s=0}^{t} e^{-\lambda_1 (t-s)} i_s ds + \int_{s=t}^{\infty} e^{-\lambda_2 (s-t)} i_s ds \right]$$

Equilibrium selection/fiscal shock does all the work of lowering inflation.

Positive weights.
Interest rates *raise* inflation.

- Does not embody standard story! Hope for Lucas Holy Water on ISLM, but end is totally different.

Not even adaptive expectations works.



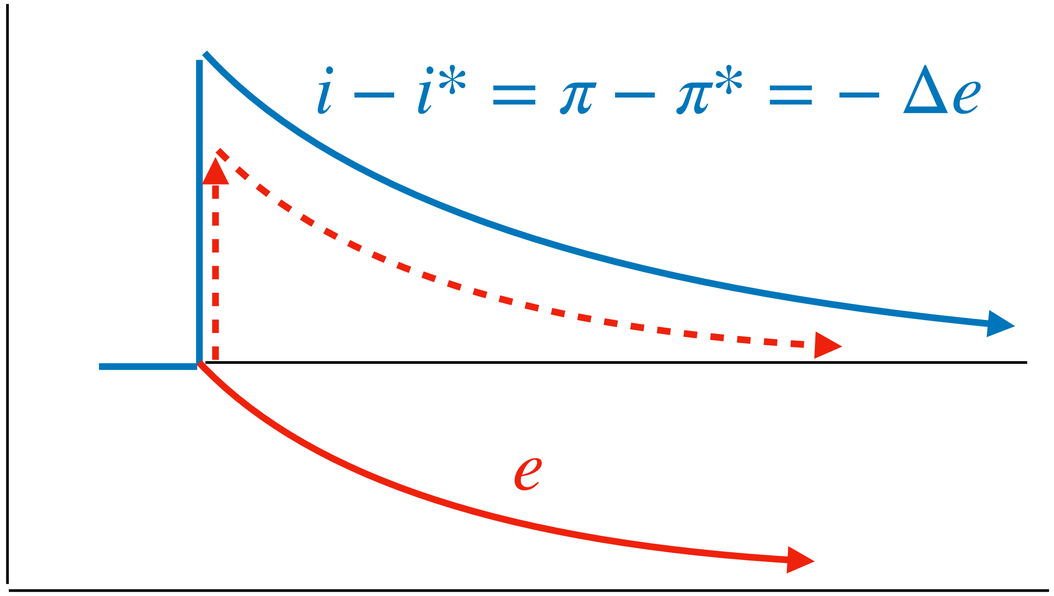
- Disinflation requires interest costs on debt.
- Also joint fiscal/monetary fiscal tightening.
- Interest rates with no change in fiscal policy *cannot* change long-run inflation even in the adaptive model.

$$x_t = -\sigma(i_t - \pi_{t-1})$$
$$\pi_t = \pi_{t-1} + \kappa x_t$$
$$\rho v_{t+1} = v_t + i_t - \pi_{t+1}$$
$$i_t = \phi \pi_t + u_t$$
$$\sigma\kappa = 1;\ \phi = 1.5\ \rho = 0.99$$

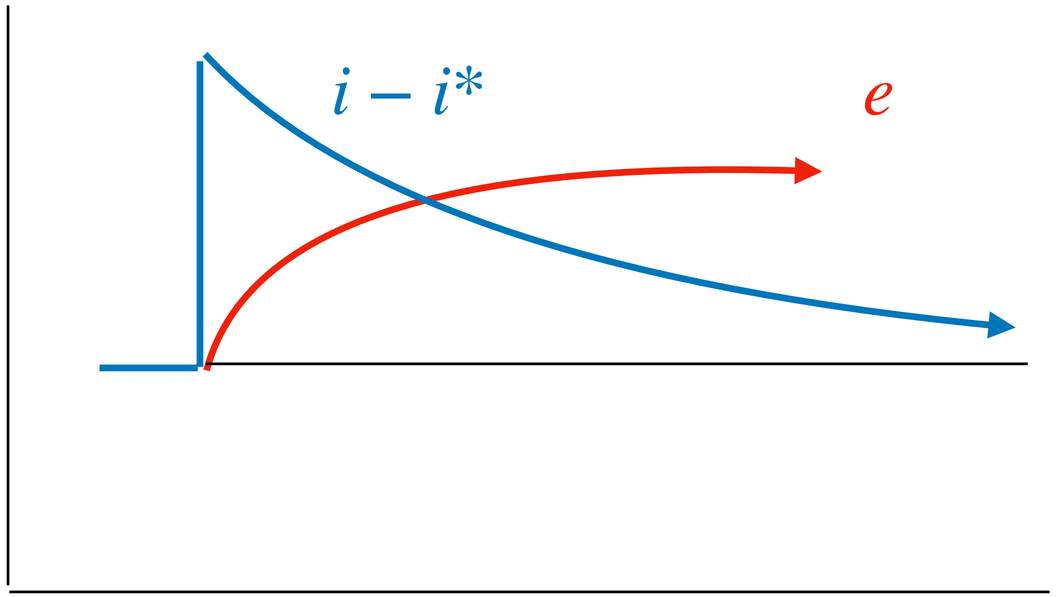
(Continuous time)

How do higher interest rates raise the exchange rate?

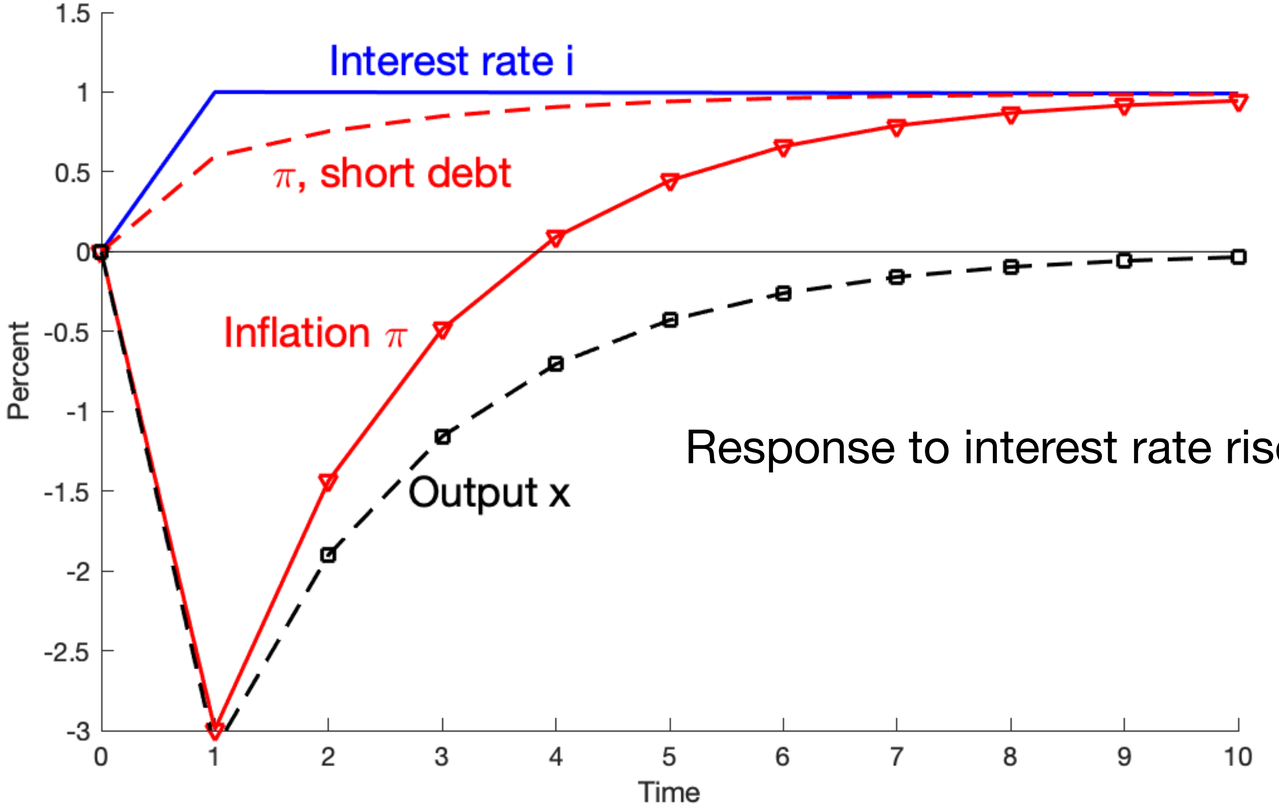
Flexible prices, rational expectations



Policy view



The only model I know that (sort of) works: FTPL + Long run debt



Response to interest rate rise *with no change in surplus*

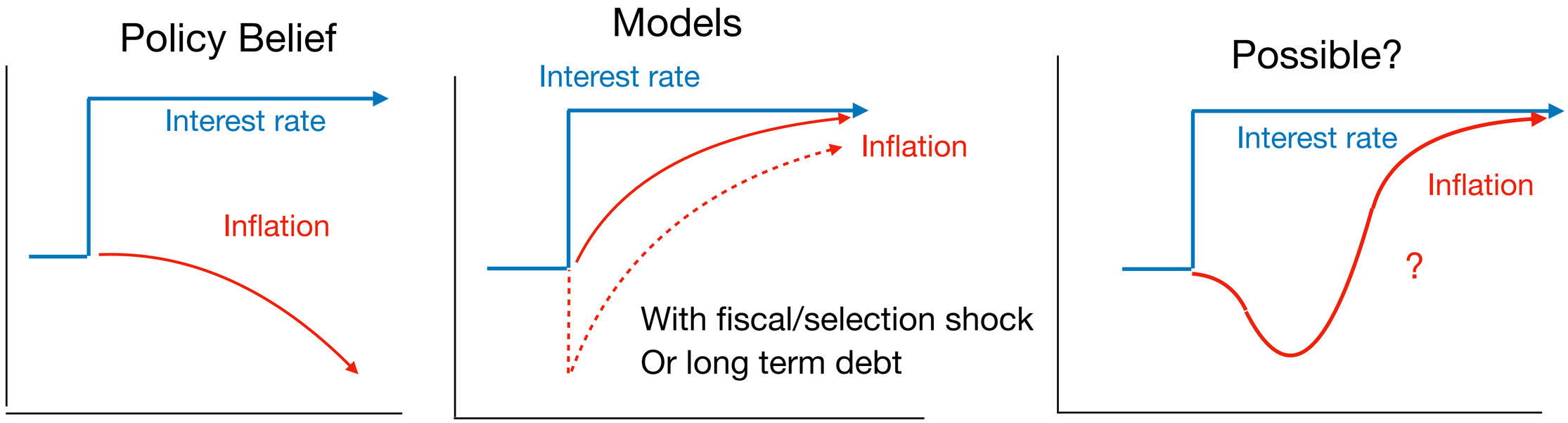
But:

- Limited application.
- Not high rates - lower AD - lower inflation.
- Not Lucas holy water on monetarist/ISLM intuition!
- Still jump down then rise

Research agenda: Do better!

$$x_t = E_t x_{t+1} - 0.5(i_t - E_t \pi_{t+1})$$
$$\pi_t = E_t \pi_{t+1} + 0.5 x_t$$
$$i_t = i_{t-1} + \varepsilon_{i,t}$$
$$\rho v_{t+1} = v_t + r^n_{t+1} - \pi_{t+1} - \tilde{s}_{t+1}$$
$$E_t r^n_{t+1} = i_t$$
$$r^n_{t+1} = 0.9 q_{t+1} - q_t$$

Challenge 2: Future inflation?



- Even with fiscal shock or long term debt, how to lower *future* inflation, not jump down then rise?
- No "long and variable lags."
- "Wrong sign" is deep in standard model. (Stable!)
  - Higher real rate lowers consumption relative to *future* consumption = *higher* consumption growth. Tell central banks! $x_t = E_t x_{t+1} - \sigma(i_t - E_t \pi_{t+1})$, $r = \delta + \gamma g$.
  - Output = inflation relative to *future* inflation. Higher output = inflation *falls*. $\pi_t = \beta E_t \pi_{t+1} + \kappa x_t$.
- Can we modify IS, Phillips to produce something like beliefs in a simple transparent model?

Small step: A generalized Lucas Phillips curve

- Inflation "anchor" in Phillips curve? Adaptive: Lagged inflation. NK: Future inflation. Lucas: past expectation of today's inflation.
- Lucas: "No persistence."

$$\kappa x_t = p_t - E_{t-1} p_t$$

- Generalized Lucas, different firms learn at different rates

$$\kappa x_t = p_t - \int_{j=0}^{\infty} \alpha_j E_{t-j} p_t dj \, .$$

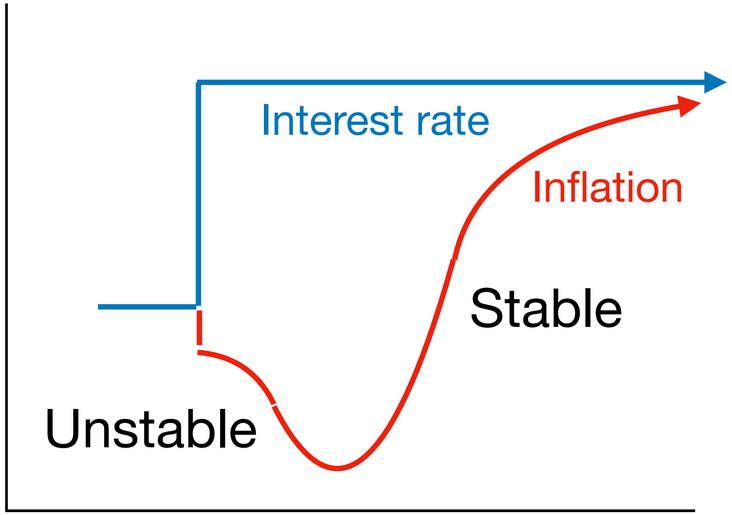
(Similar to Mankiw-Reis) In place of

$$\pi_t = \beta E_t \pi_{t+1} + \kappa x_t$$

- Combine with standard IS, higher rates lower output.
- Produces inflation that is initially unstable, then stable.

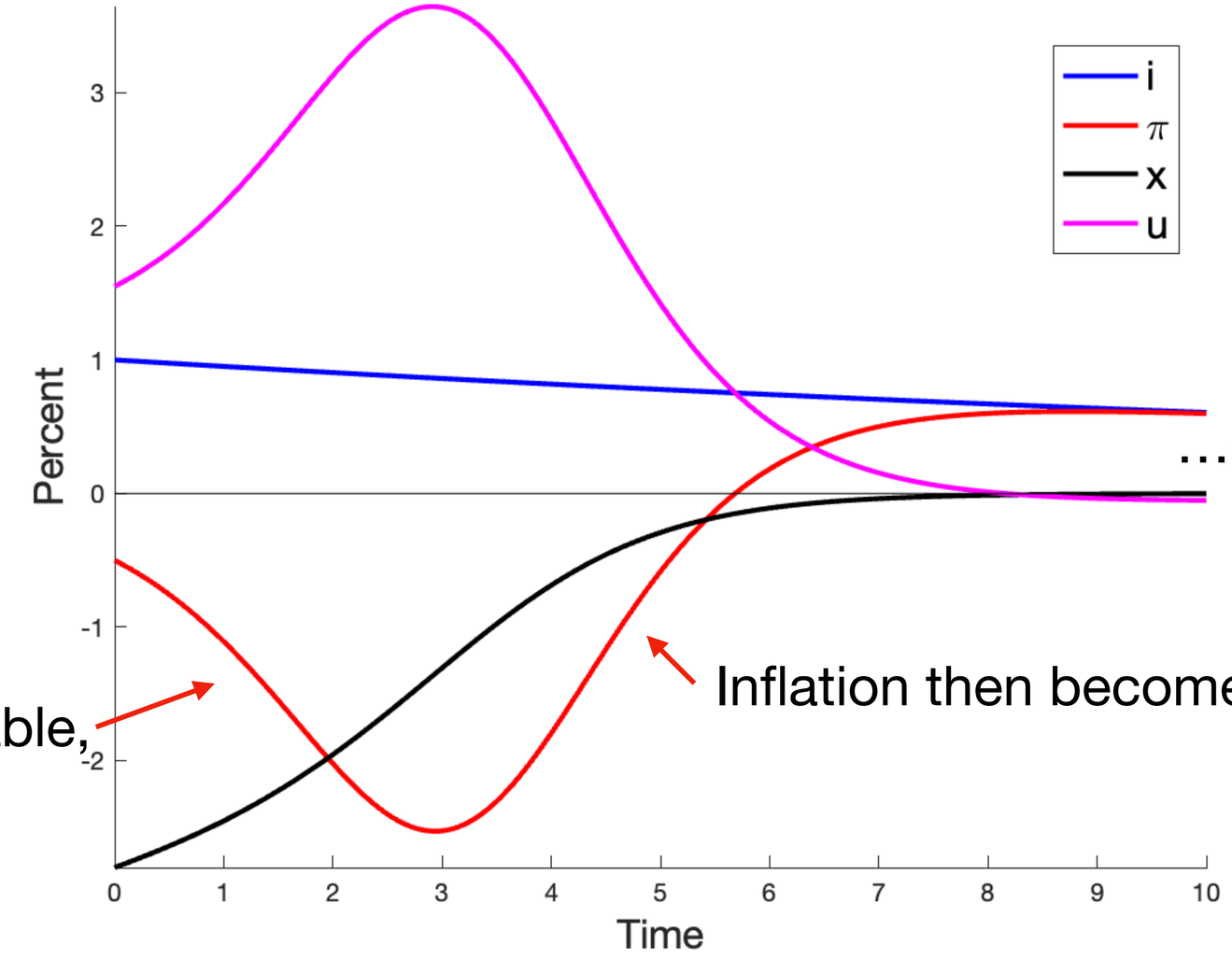
$$\frac{d\pi}{dt} = \gamma(t)\pi_t + \delta(t) i_t;$$

$\gamma(t) > 0$ for small t, $\gamma(t) < 0$ for large t.



A generalized Lucas Phillips curve

+long-term debt, standard IS, no surplus change



…and long-run neutral

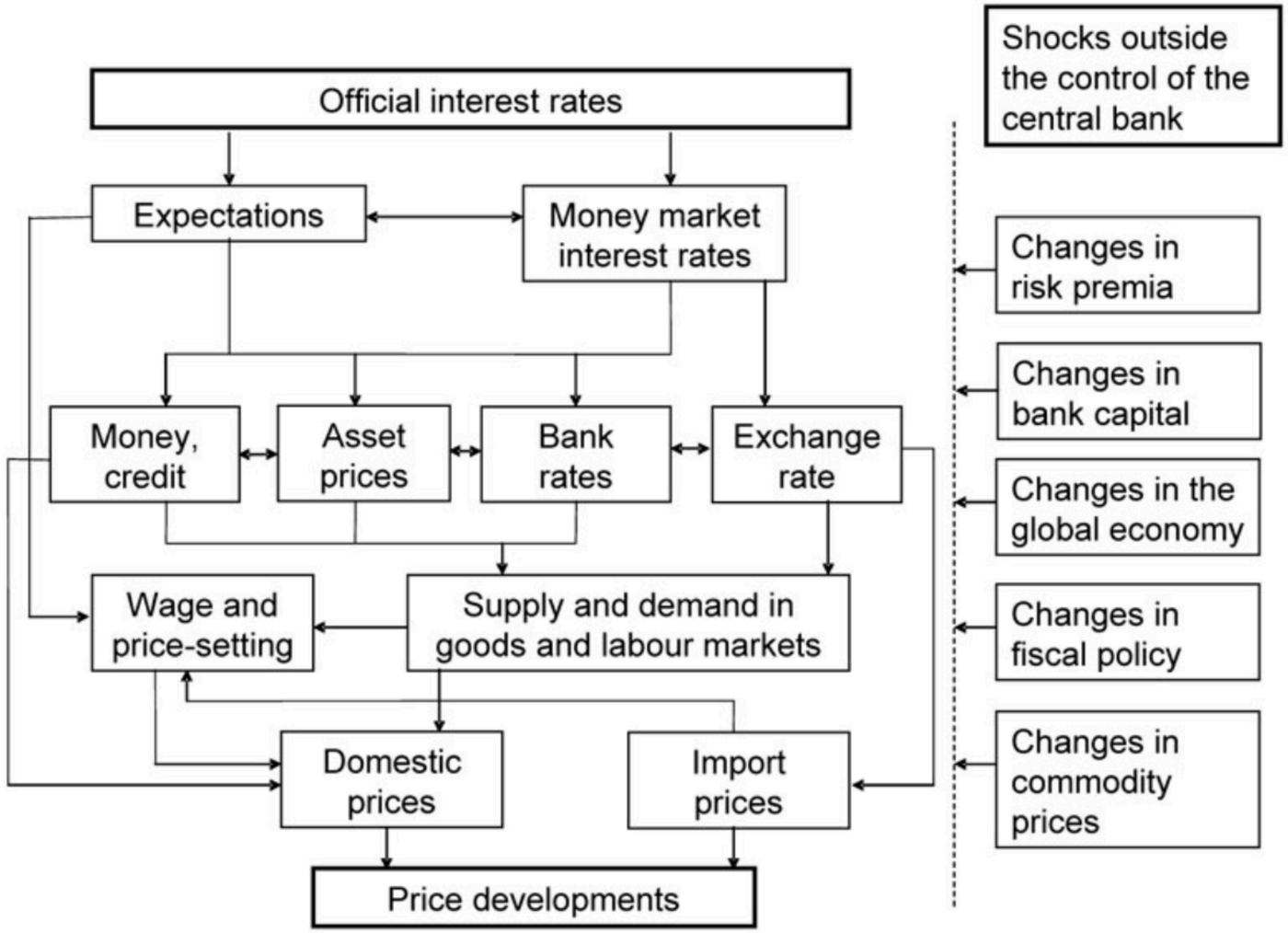
Inflation then becomes stable…

Inflation is initially unstable, amplifies small jump

- Nice picture, but nothing at all like the standard ISLM mechanism!
- A long way to go for basic textbook model of monetary policybut getting there!

What we definitely do not know or control (ECB)

The chart below provides a schematic illustration of the main transmission channels of monetary policy decisions.

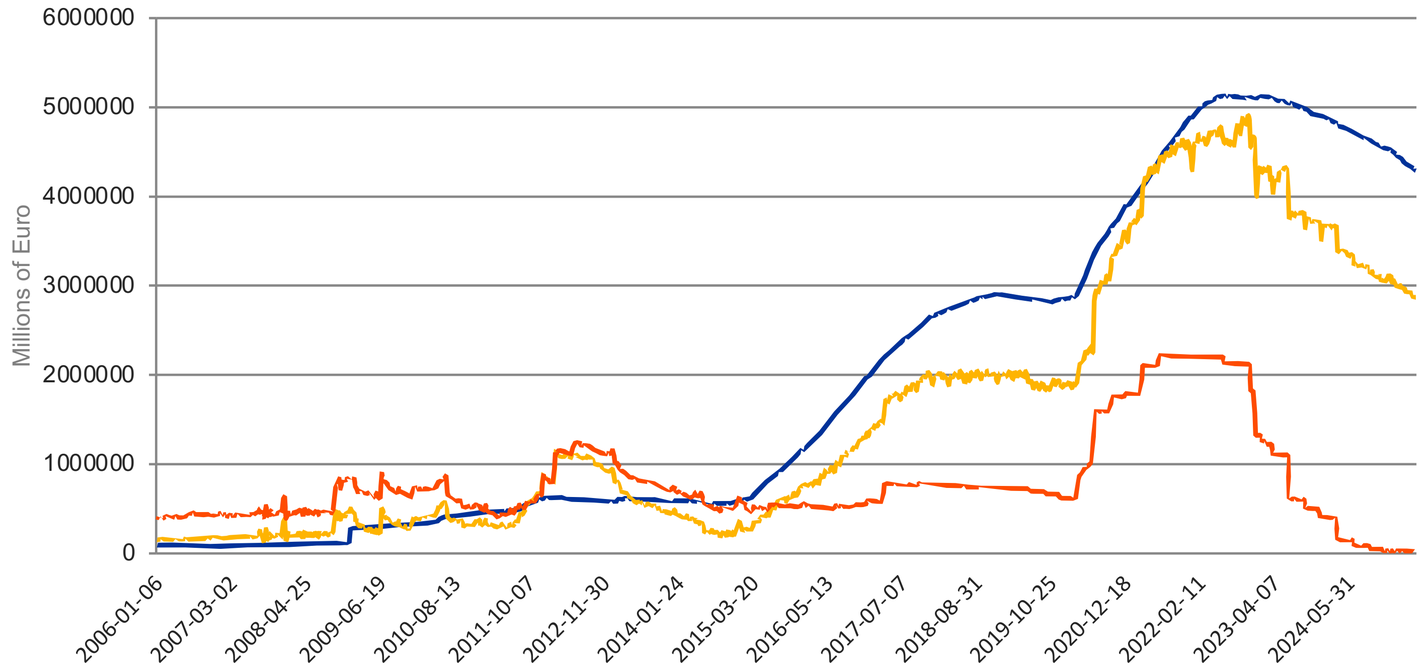


Source: https://www.ecb.europa.eu/mopo/intro/transmission/html/index.en.html

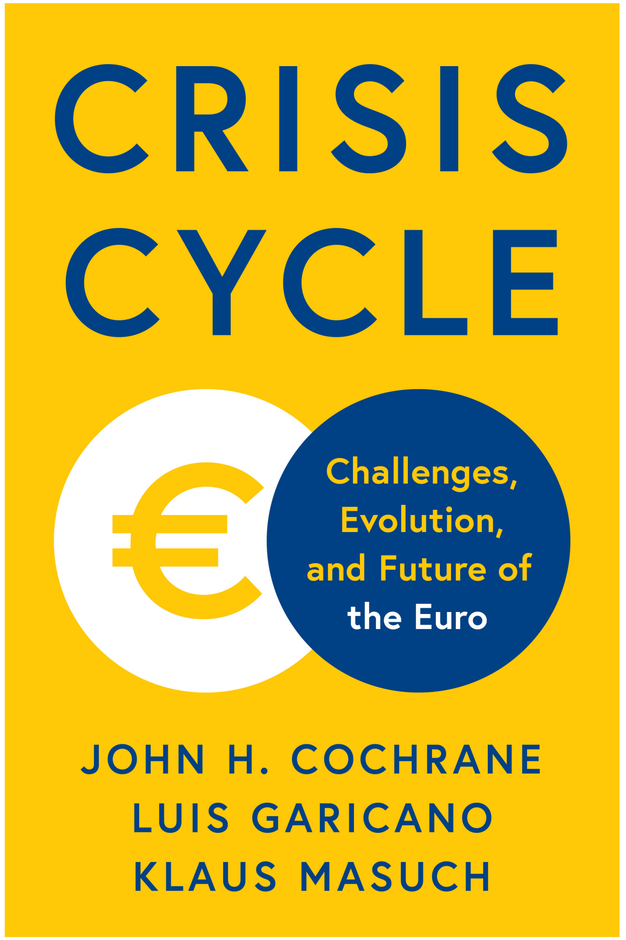
Eurosystem – consolidated balance sheet (Jan. 2006 – June 2024)

- **Bond holdings** (Securities of euro area residents denominated in euro)
- **Bank deposits / reserves** (**Liabilities to euro area credit institutions related to MPOs** denominated in euro)
- **ECB loans to banks** (**Lending to euro area credit institutions related to MPOs** denominated in euro)

Euro Millions
Eurosystem, Euro area, Weekly data



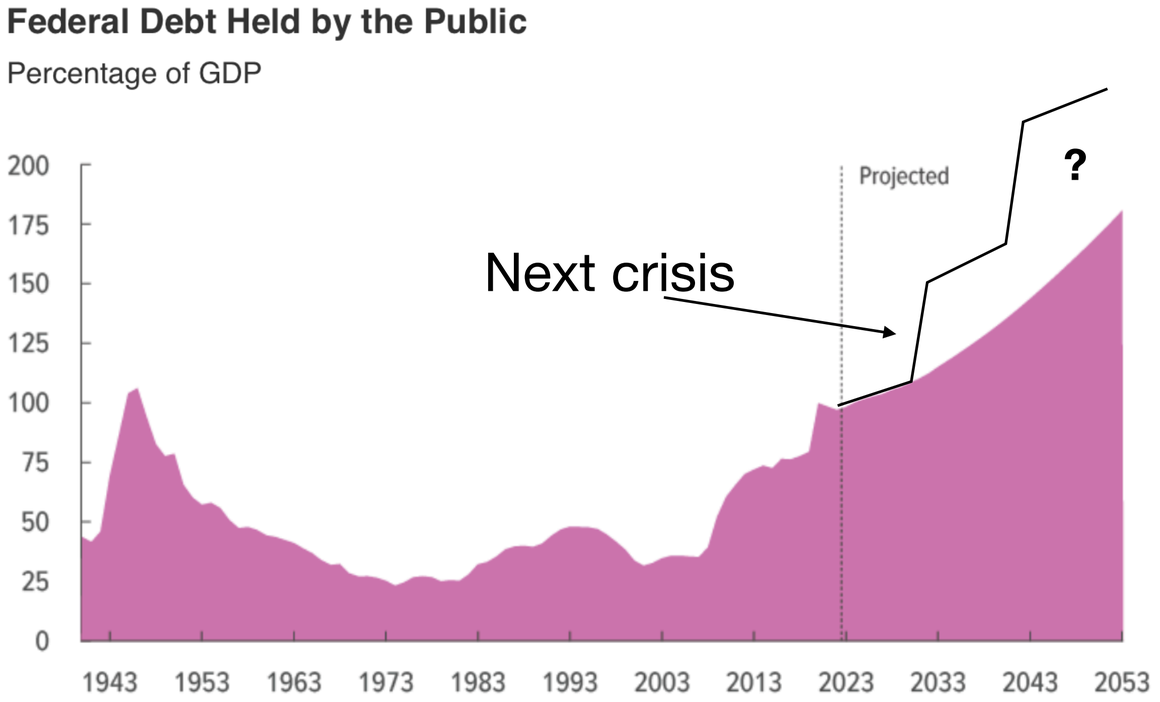
Source: ECB

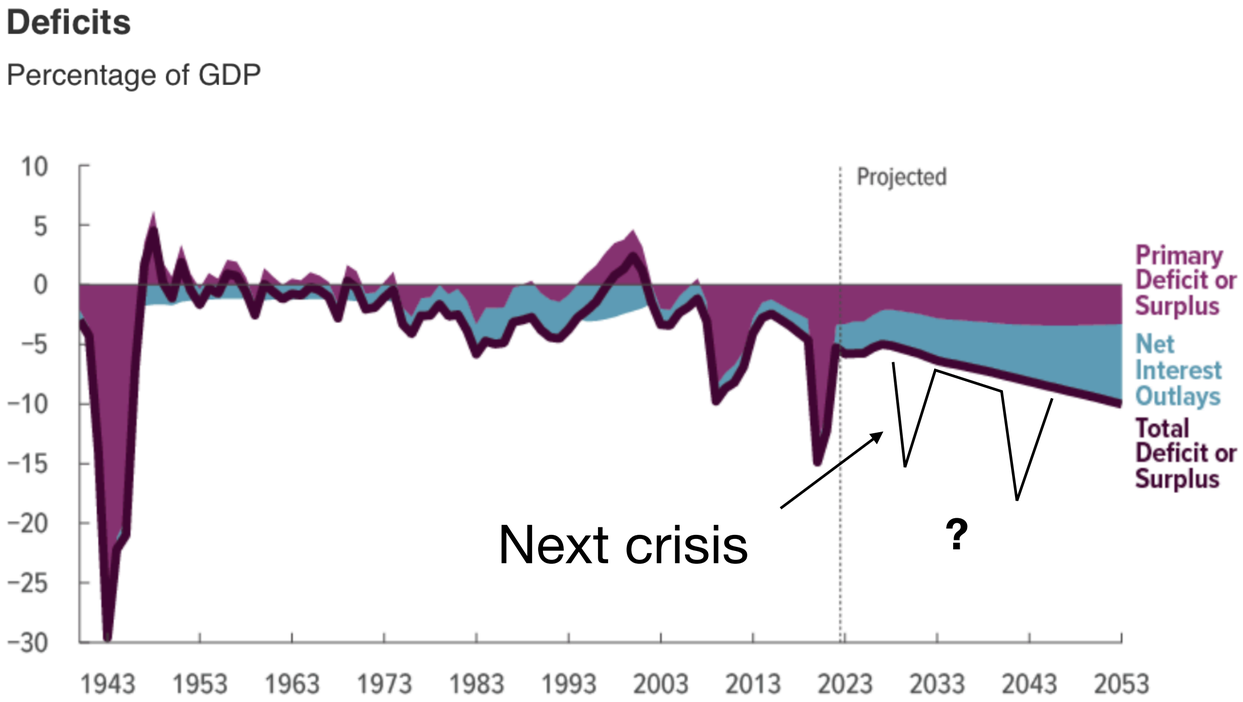


- Currency union with out fiscal, political union is possible
- In the end, countries must default like companies
- “Free rider” problem. Very good initial structure (with a few missing bits)
- Crisis expedients
- Moral hazard
- Reforms

The Future

- How will central banks handle global sovereign debt crisis?
- Fight inflation? *In all current models, central banks cannot durably lower inflation by higher interest rates unless fiscal policy tightens to pay interest costs and bondholder windfall.*
- Borrow in next crisis?
- Best solution? Growth!





Where we are

- With FTPL, we finally have a complete, simple, economic theory of inflation under interest rate targets consistent with current institutions (fiat money, interest rate targets, no money supply control, central banks do not destabilize to select equilibria.)
- Like MV=PY, inflation is *determinate*, long-run *stable* and *neutral*. Builds on sensible flex price model, which illustrates long run properties.
- Marrying FTPL to NK IS, Phillips, & rational expectations gives reasonable dynamics.
- Simple explanation of 2021-2022 and many other episodes (not shown).
- Survives immense recent experiments, QE vs. Covid; ZLB.
- Solves magic forward guidance and many other puzzles (not shown).
- Overturns many classic doctrines (which we see in real life).
  - Passive money, real bills are ok.
  - Inside money does not matter.
  - Interest rate peg can be ok (with good fiscal policy).
  - Market interest on ample reserves is ok.
  - A higher peg with no fiscal change will eventually raise inflation.

Where we need to go

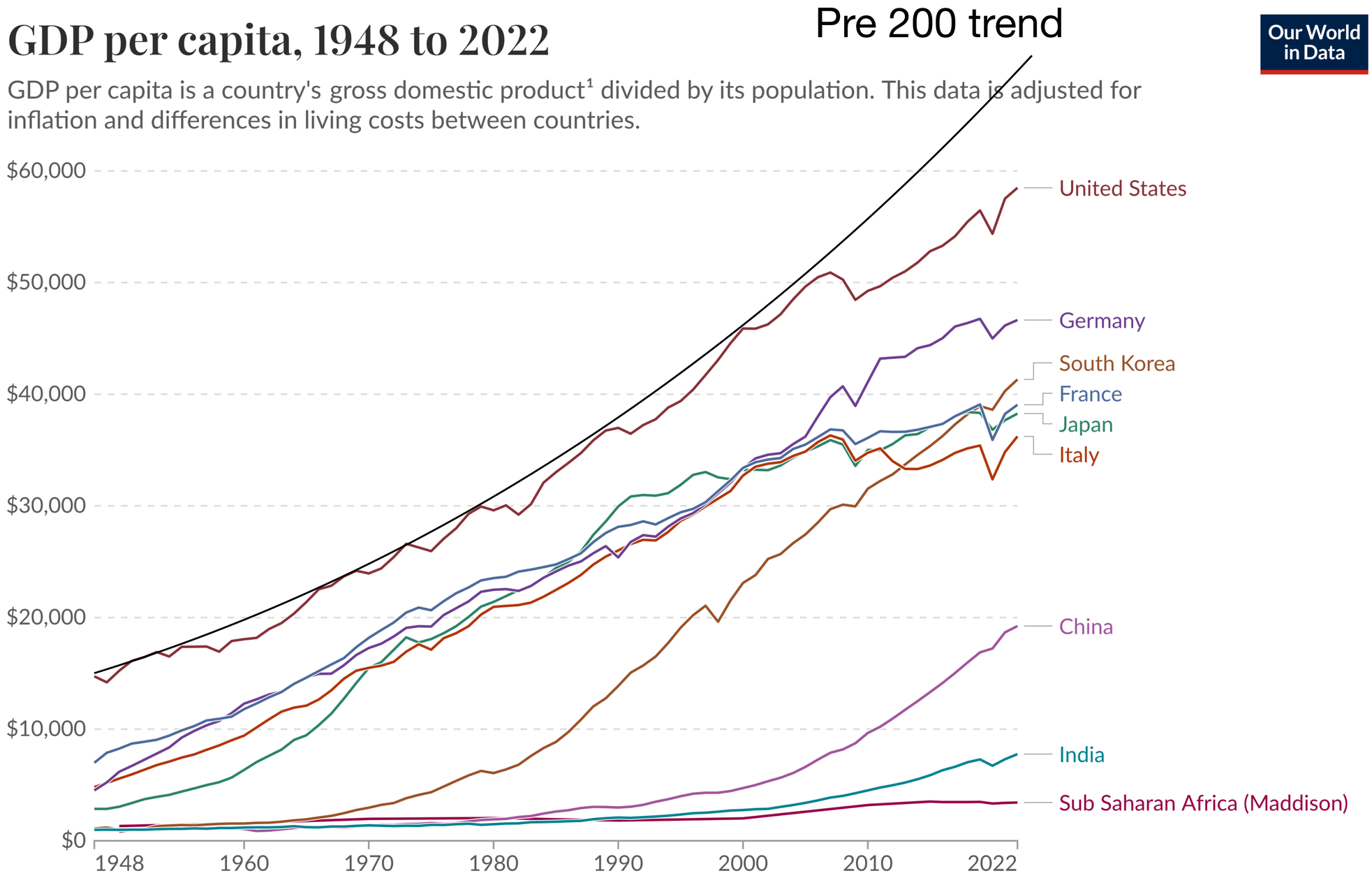
- Interest rate effect challenge:
  - Can higher rates without fiscal policy lower inflation? How?
  - Can higher rates with or without fiscal policy lower future inflation?
- Progress: Long term debt, generalized Lucas Phillips curve.
- Agenda: Better rest of model; IS, price&wage stickiness; expectations, information.
- Neither NK nor FTPL+NK give *anything like* policy-maker mechanisms (high rates, low AD, Phillips inflation). Can they be right on facts, wrong on mechanism? Wrong on facts?

- FTPL: much to do.
  - Better central bank structure? Hold indexed debt? Ideal ECB?
  - Corporate finance of debt. Issue more indexed, foreign, long debt? Issue floating directly?
  - Better policy rules, alternatives to nominal rate? Target indexed/non-indexed spread?
  - Central banks do not fully control inflation. Policy is always coordinated.
  - Fiscal rules for price stability? Debt rules!
  - Separate currency backing from government finance?

The End

GDP per capita, 1948 to 2022

GDP per capita is a country's gross domestic product[1] divided by its population. This data is adjusted for inflation and differences in living costs between countries.



Data source: Bolt and van Zanden – Maddison Project Database 2023

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Note: This data is expressed in international-$[2] at 2011 prices.

GDP per capita

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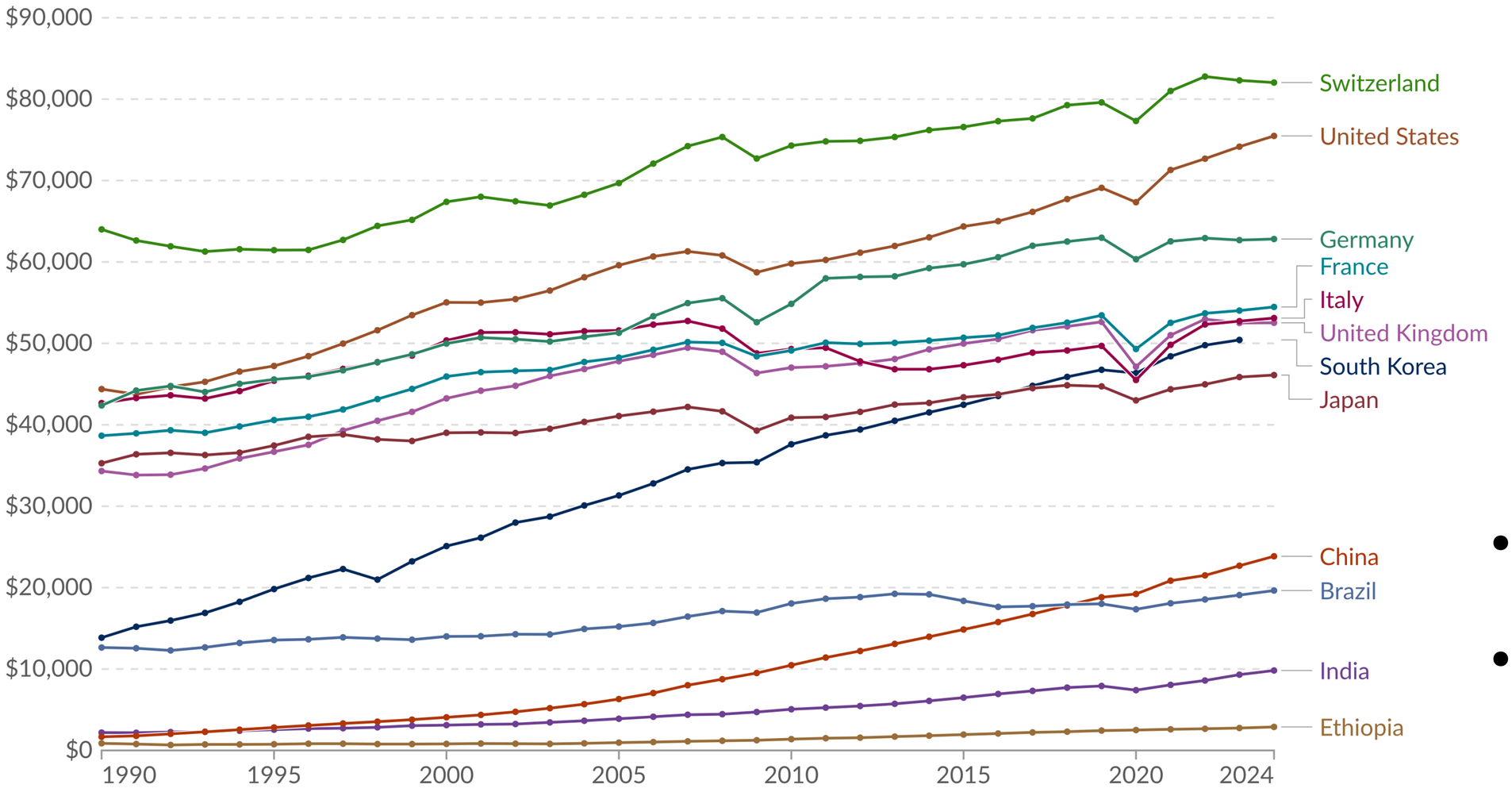

Our World in Data

2024
n international-$ in 2021 prices

Switzerland	$82,026
United States	$75,492
Germany	$62,830
France	$54,465
Italy	$53,115
United Kingdom	$52,518
Japan	$46,097
China	$23,846
Brazil	$19,648
India	$9,817
Ethiopia	$2,884

- Why is euro growth stagnant?
- Why did EU, EMU not lead to burst of growth! (>CH!)

Data source: Eurostat, OECD, IMF, and World Bank (2025)

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Note: This data is expressed in international-$[2] at 2021 prices.