A Global Perspective on Inflation and the Covid-19 Recovery

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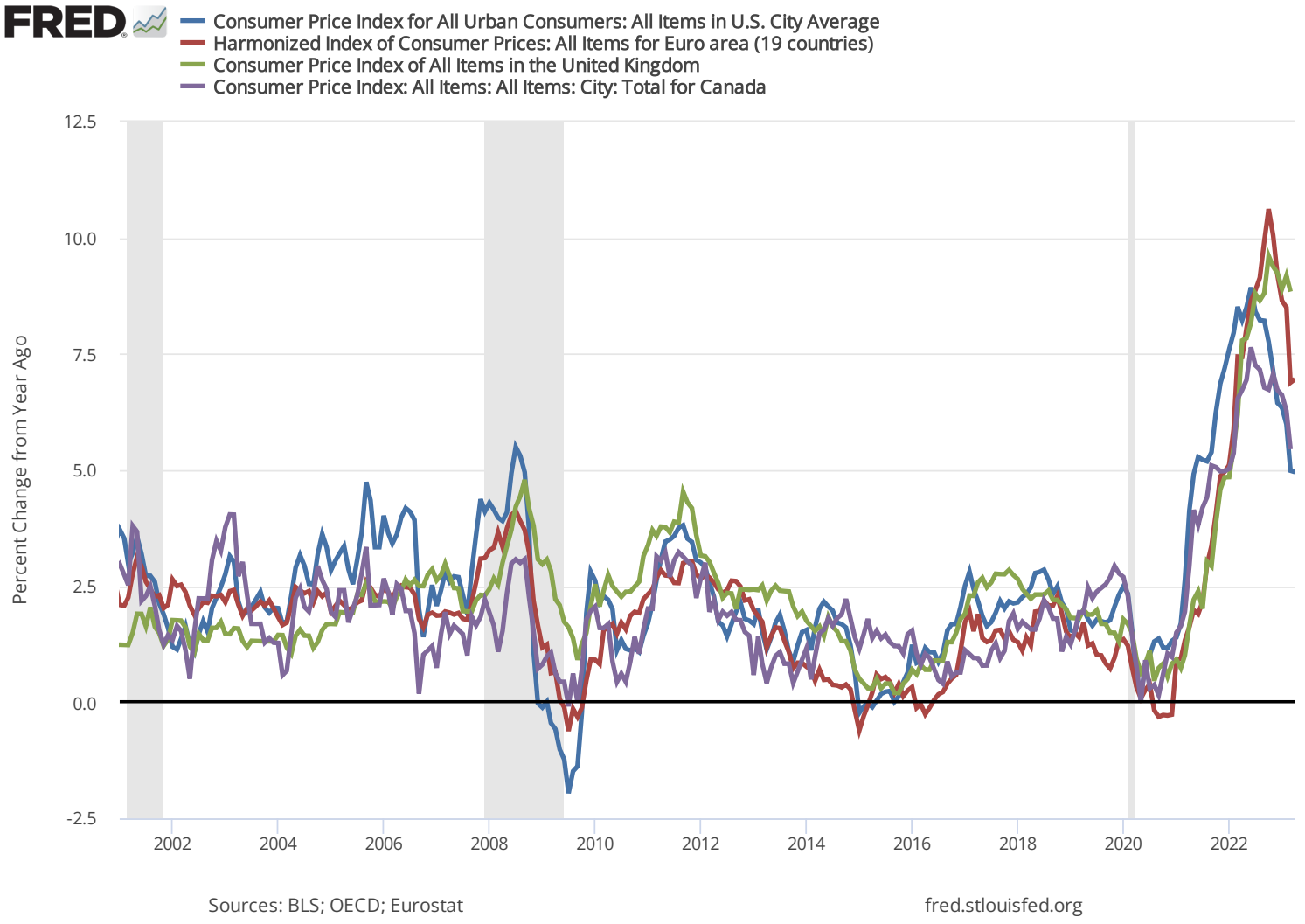
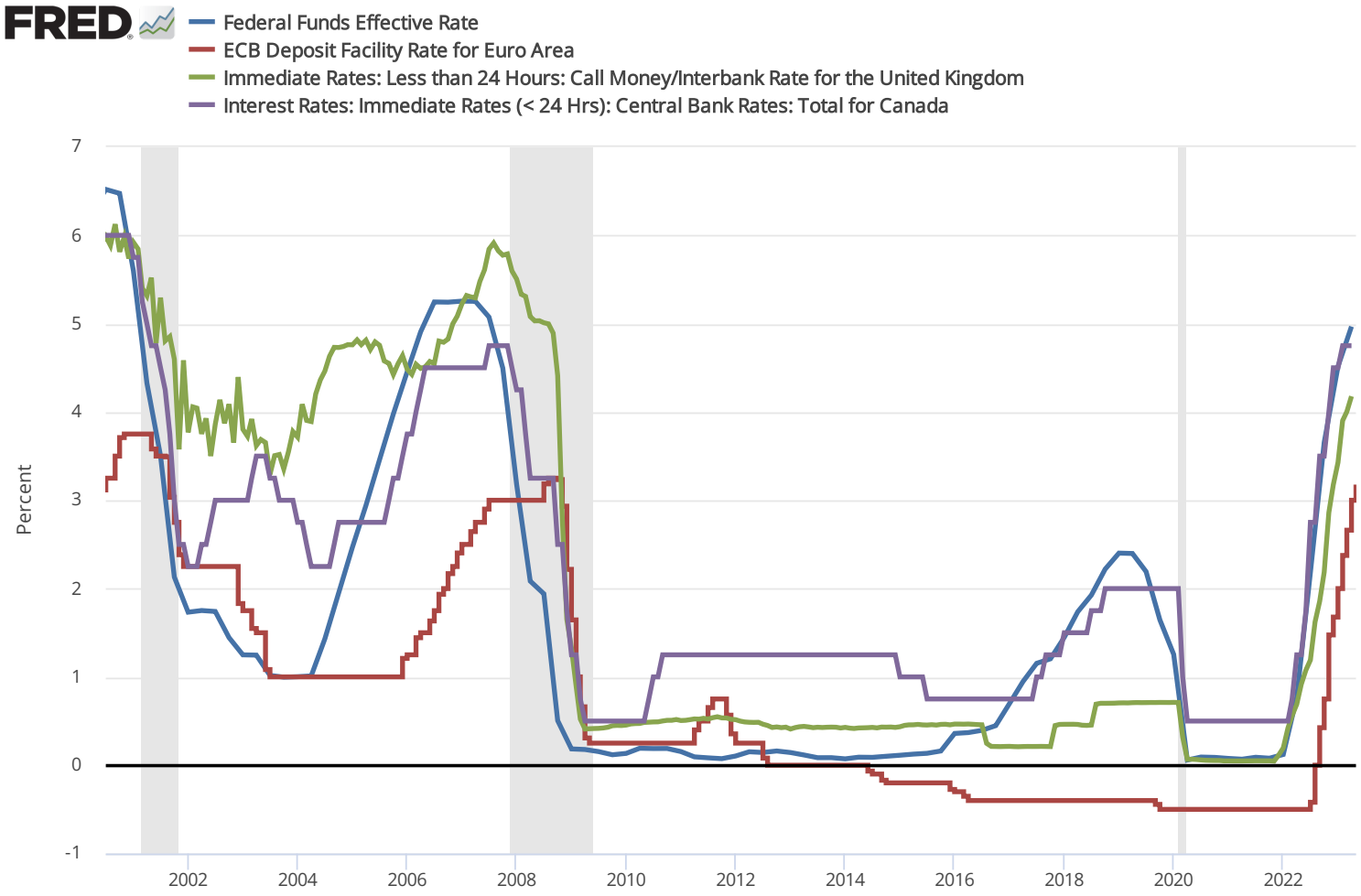
The return of inflation



Synchronized monetary tightening



Why a global approach to macroeconomic policy?

- Global economy is highly interconnected
  - Trade and capital mobility tie countries together
  - Macroeconomic cycles tend to have a global dimension
- Active policy debates touching on international macro
  - How should monetary and fiscal policy be conducted in open economies?
  - Do policy interventions trigger international spillovers?
  - Are there gains from international macroeconomic policy cooperation?

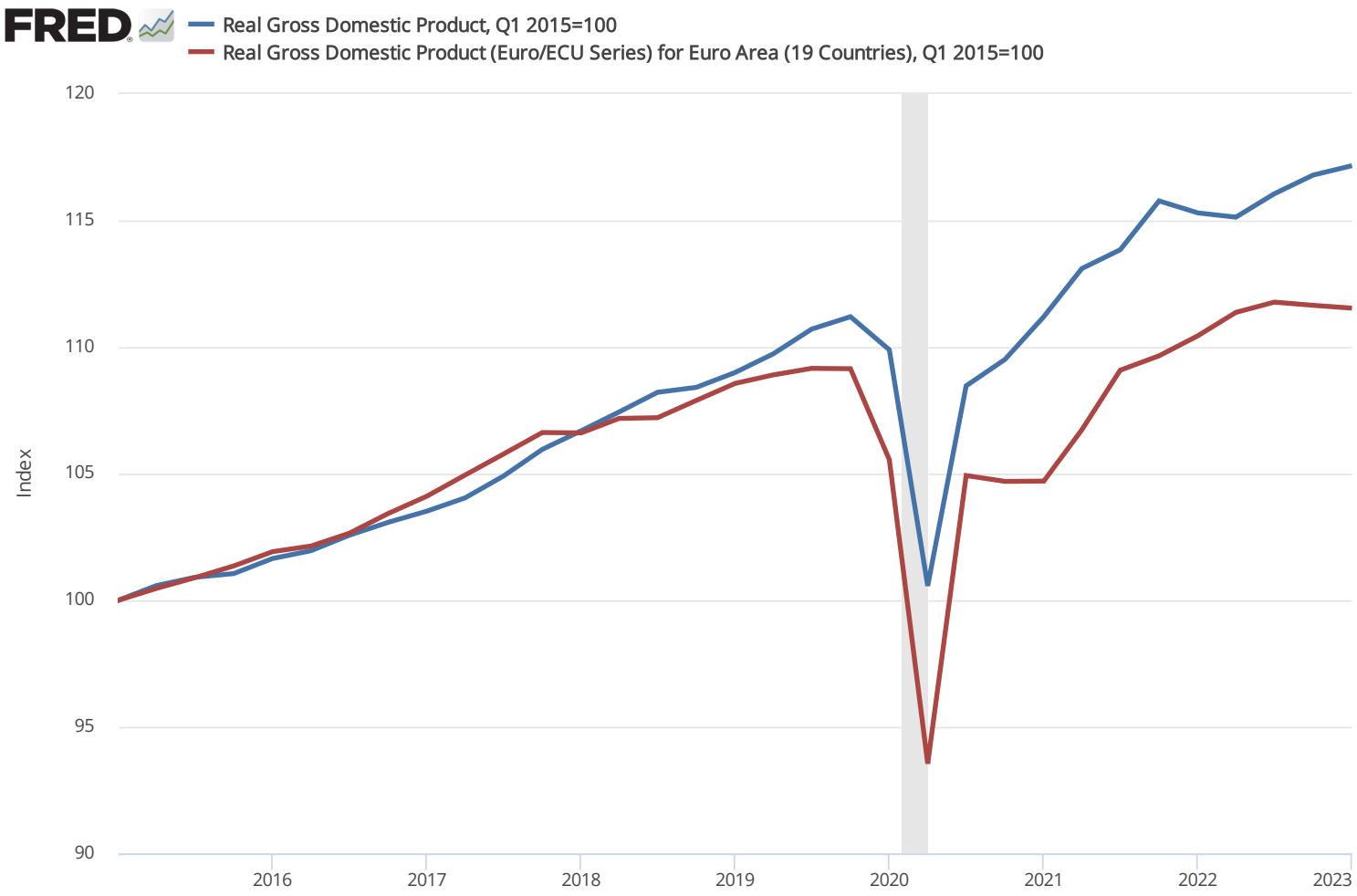
Outline

1. Background facts
2. Theoretical framework
3. Demand imbalances in a closed economy
4. International transmission of inflation
5. International monetary policy cooperation

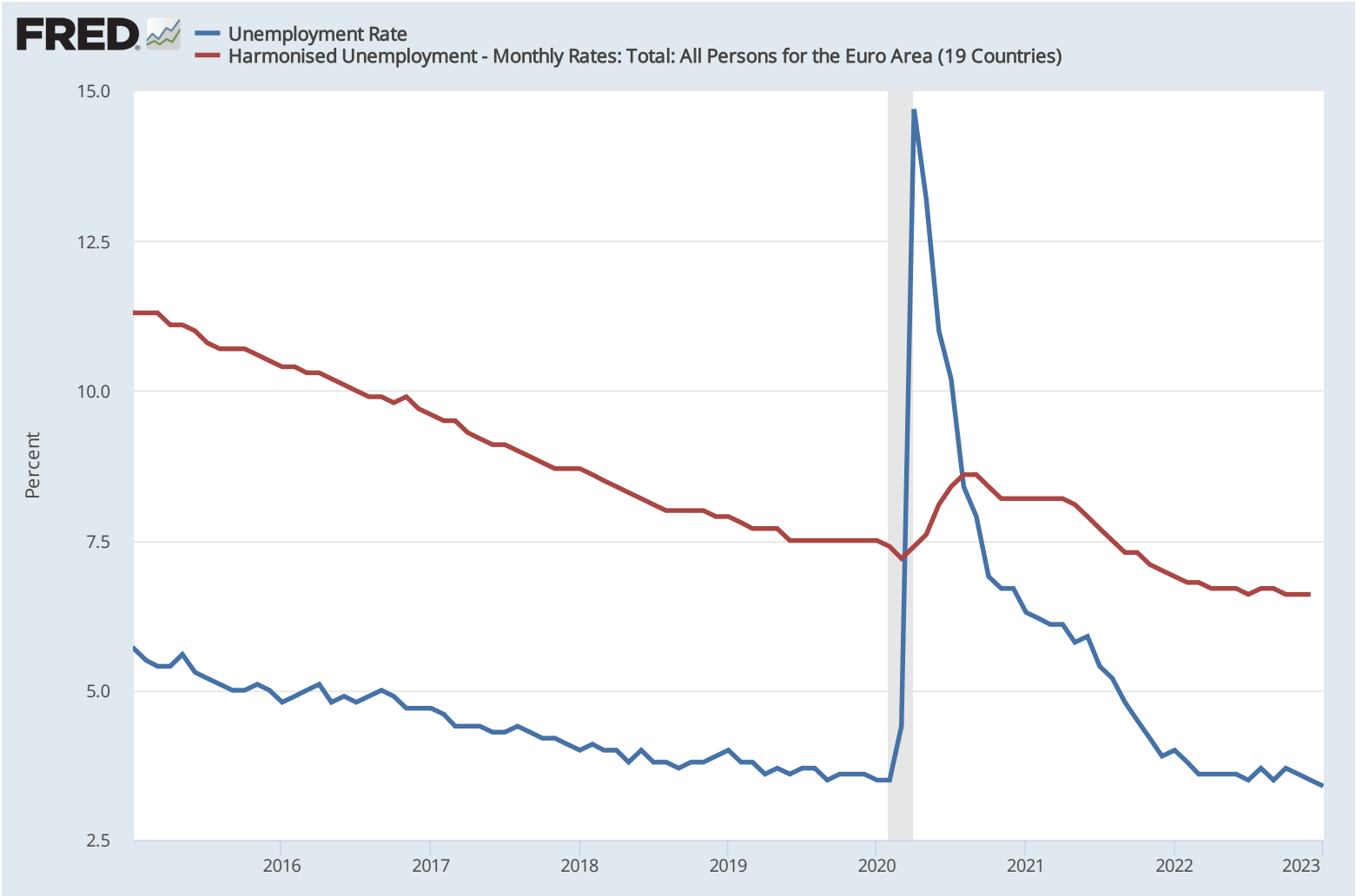
The recovery from the Covid recession

- Covid pandemic triggered a large global recession, followed by
  - Swift recovery in output and employment
  - Sharp rise in inflation

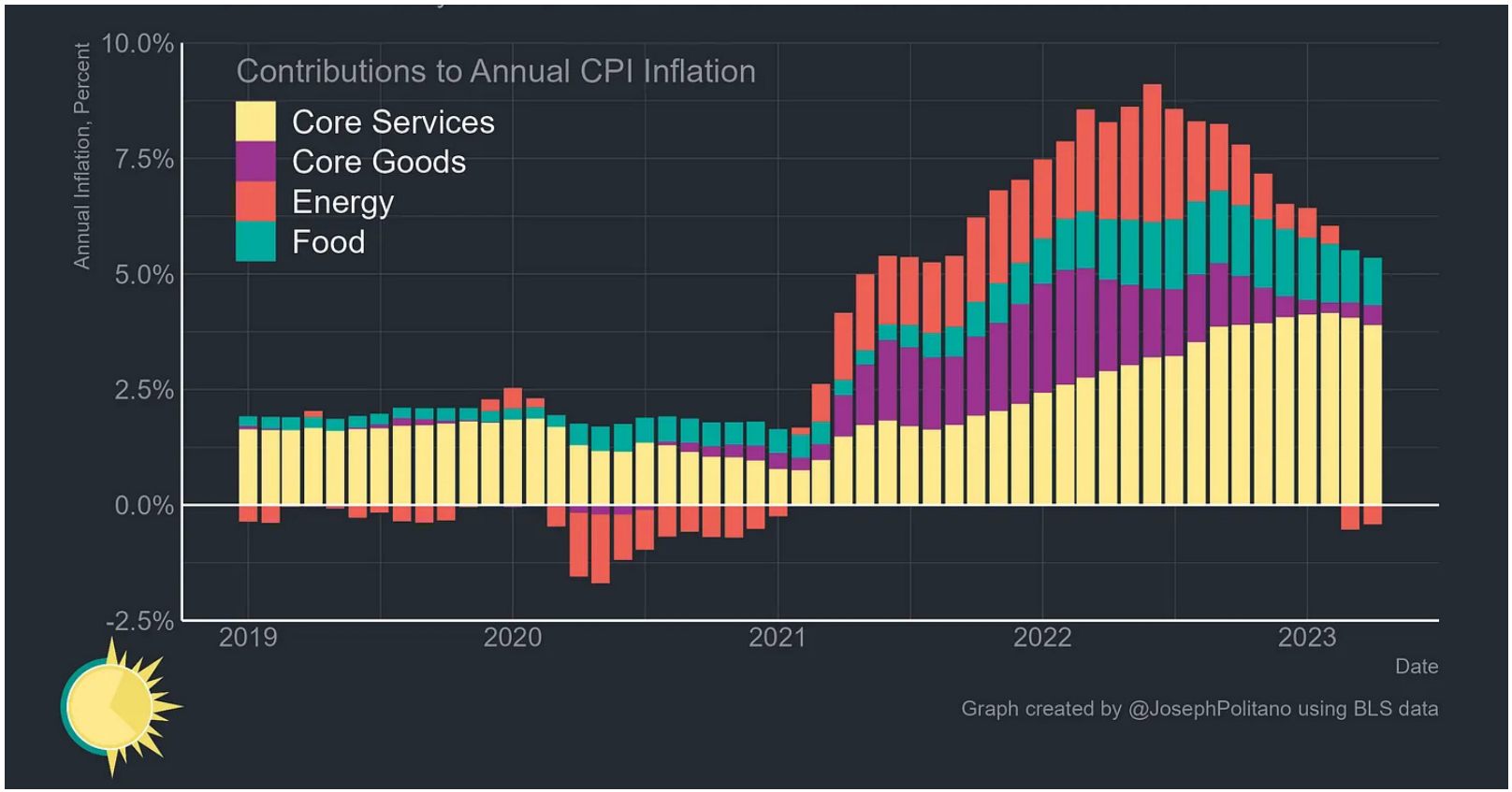
Swift output recovery



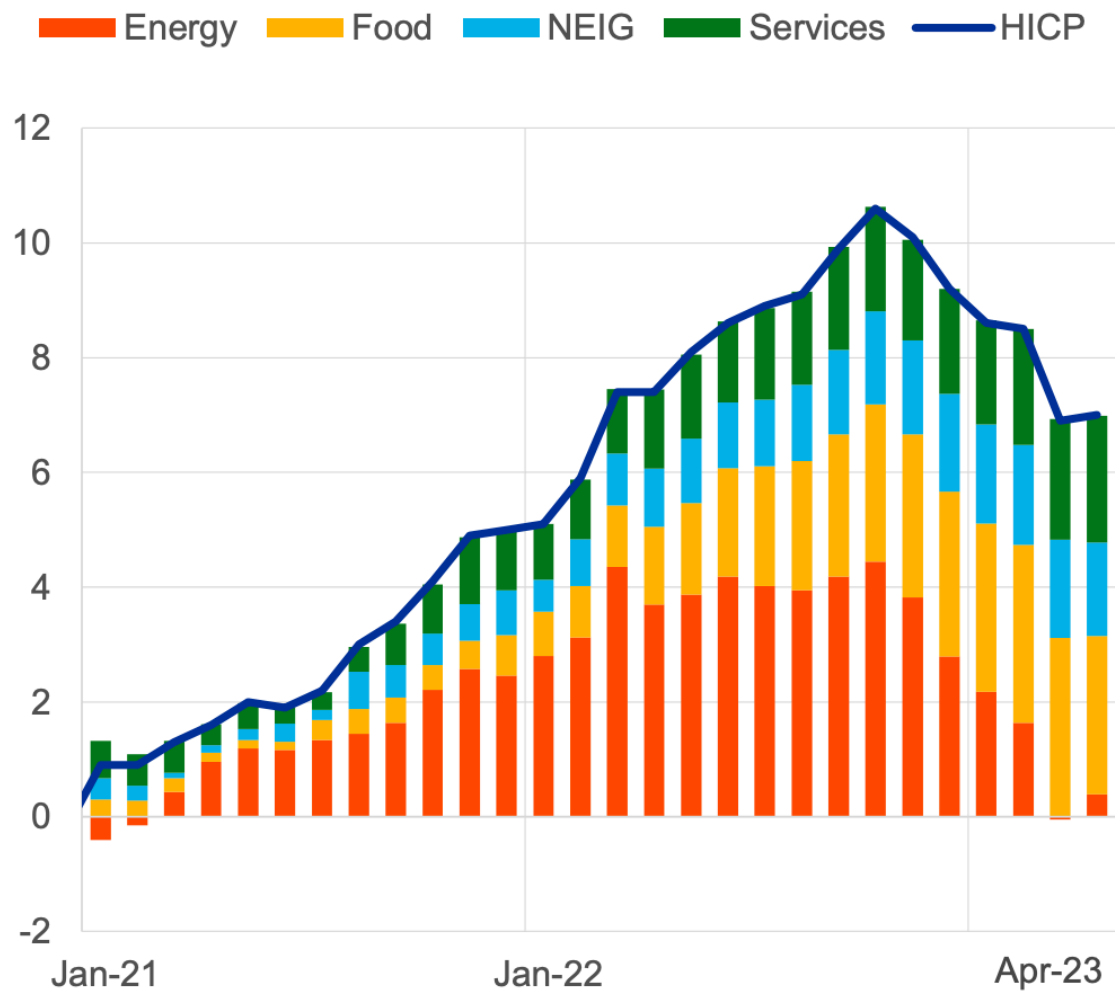
Strong labor market



Contributions to CPI inflation: United States



Contributions to CPI inflation: Euro area

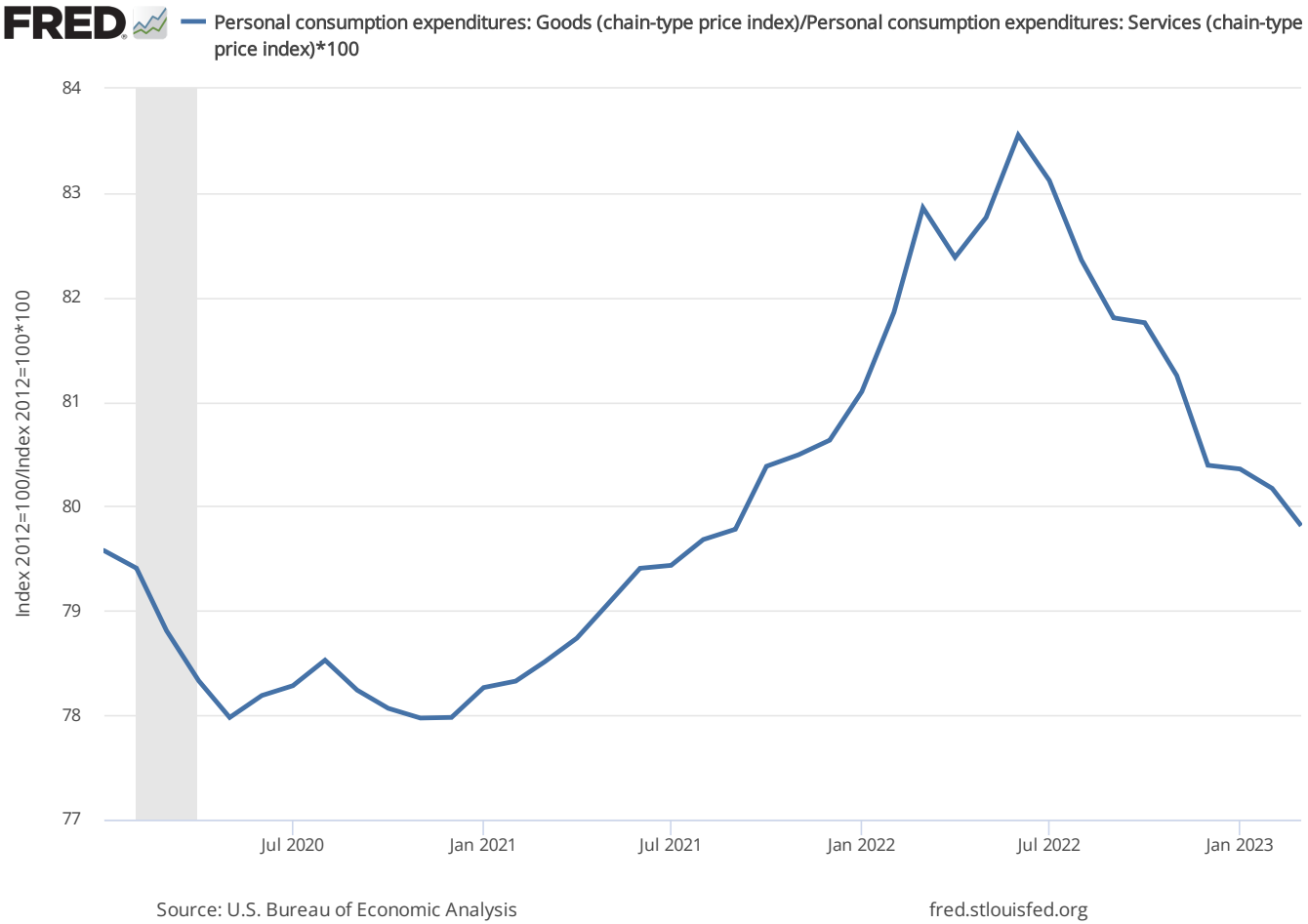


Sources: Eurostat and ECB calculations.
Latest observation: April 2023 (flash).

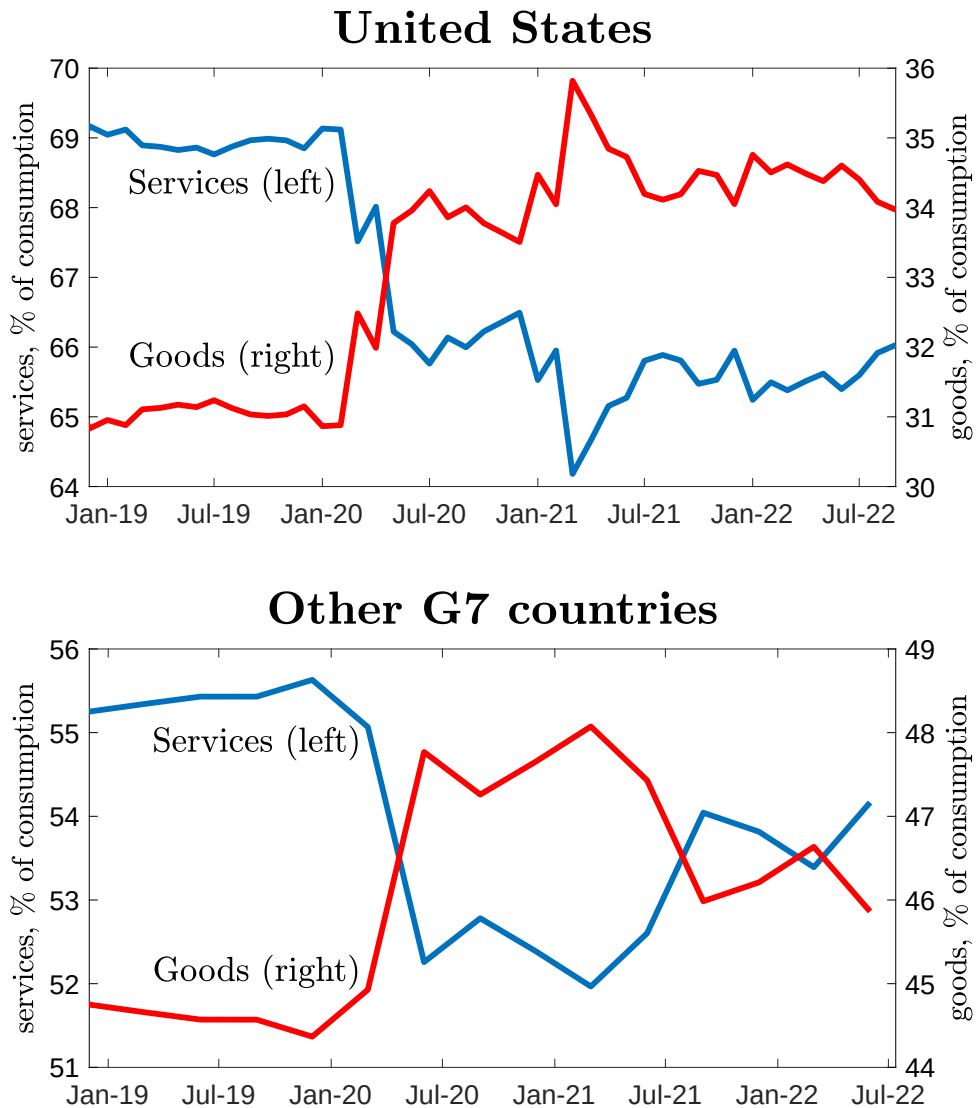
The recovery from the Covid recession

- Covid pandemic triggered a large global recession, followed by
  - Swift recovery in output and employment
  - Sharp rise in inflation
- Factors contributing to global scarcity of tradable goods
  - Unbalanced demand due to pandemic and fiscal stimulus
  - Global supply chains disruptions + high commodity prices

Global scarcity of tradable goods

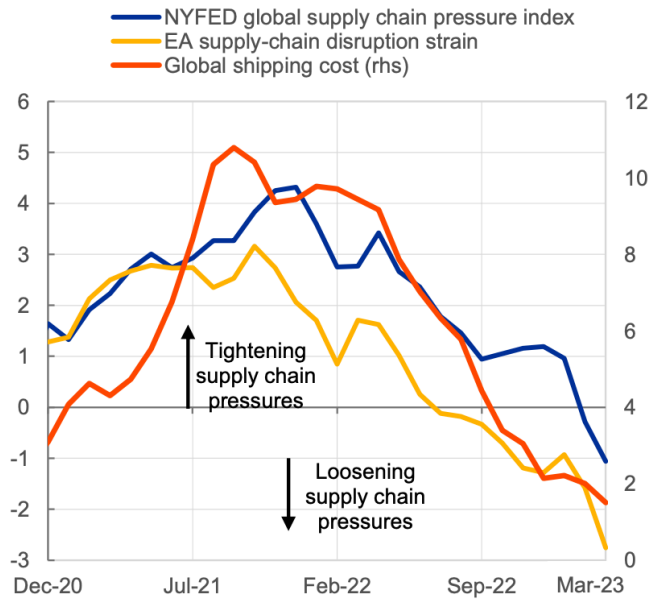


Unbalanced demand



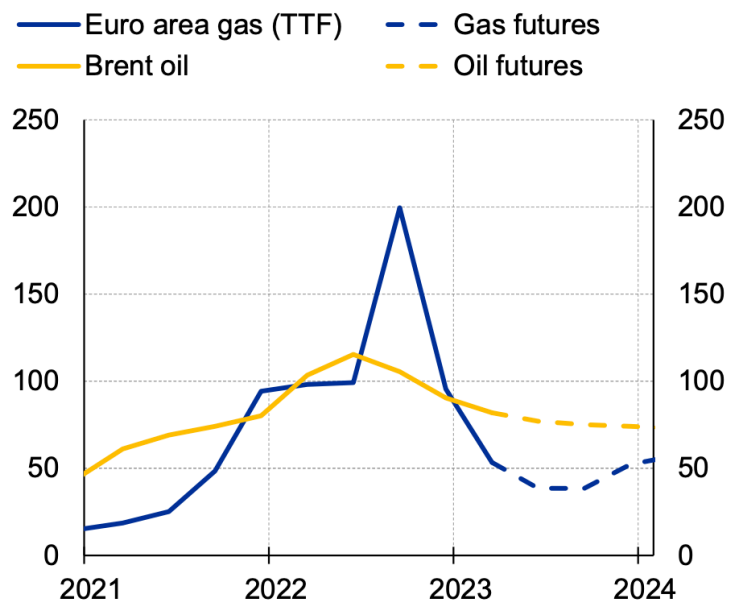
Supply disruptions

Supply bottlenecks
(lhs: standard deviations; rhs: USD per TEU)



Sources: Haver Analytics, Refinitiv and ECB calculations.
Notes: Global shipping cost is Freightos Baltic aggregate across major trade routes. TEU stands for twenty-foot equivalent unit shipping container.
Latest observation: March 2023

Gas and oil prices with futures
(Gas: EUR/MWh, Oil: USD/barrel)



Sources: Refinitiv, Bloomberg and ECB calculations.
Latest observation: 5 May 2023.

Outline

1. Background facts
2. Theoretical framework
3. Demand imbalances in a closed economy
4. International transmission of inflation
5. International monetary policy cooperation
6. Supply disruptions in the T sector

Organizing framework (Fornaro and Romei, 2022)

- Multi-country Keynesian model with multiple sectors
  - Continuum of small open economies ($i \in [0, 1]$)
  - Each country produces a tradable good and a non-tradable one
  - Nominal wages are rigid
- Optimal monetary response to global reallocation shock
  - Temporary rise in consumers' demand for the tradable good, relative to the non-tradable one
- Similar results for shocks that temporarily lower global supply of T good (supply chains disruptions, rise in energy prices)

Households

- Lifetime utility of the representative household in country i

$$\sum_{t=0}^{\infty} \beta^t \left(\log\left(C_{i,t}\right) - \chi\left(\frac{P_{i,t}}{P_{i,t-1}}\right)\right)$$

$$C_{i,t} = \left(\frac{C^T_{i,t}}{\omega_{i,t}}\right)^{\omega_{i,t}} \left(\frac{C^N_{i,t}}{1-\omega_{i,t}}\right)^{1-\omega_{i,t}}$$

- $\chi\left(P_{i,t}/P_{i,t-1}\right)$ is a convex function capturing disutility from deviations of CPI inflation from target (normalized to zero)

- No disutility from working, labor endowment $\bar{L}$

$$P^T_{i,t}C^T_{i,t} + P^N_{i,t}C^N_{i,t} + P^T_{i,t}B_{i,t+1} + B^n_{i,t+1} =$$

$$= \mathrm{W}_{i,t}L_{i,t} + \Pi_{i,t} + P^T_{i,t}R_{i,t-1}B_{i,t} + R^n_{i,t-1}B^n_{i,t}$$

Optimality conditions

- Euler equation

$$C_{i,t}^T = \frac{C_{i,t+1}^T}{\beta R_{i,t}} \frac{\omega_{i,t}}{\omega_{i,t+1}}$$

- No arbitrage between the two bonds

$$R_{i,t} = \frac{R_{i,t}^n P_{i,t}^T}{P_{i,t+1}^T}$$

- Demand for NT goods

$$C_{i,t}^N = \frac{1-\omega_{i,t}}{\omega_{i,t}} \frac{P_{i,t}^T}{P_{i,t}^N} C_{i,t}^T$$

- Consumer price index given by

$$P_{i,t} = \left(P_{i,t}^T\right)^{\omega_{i,t}} \left(P_{i,t}^N\right)^{1-\omega_{i,t}}$$

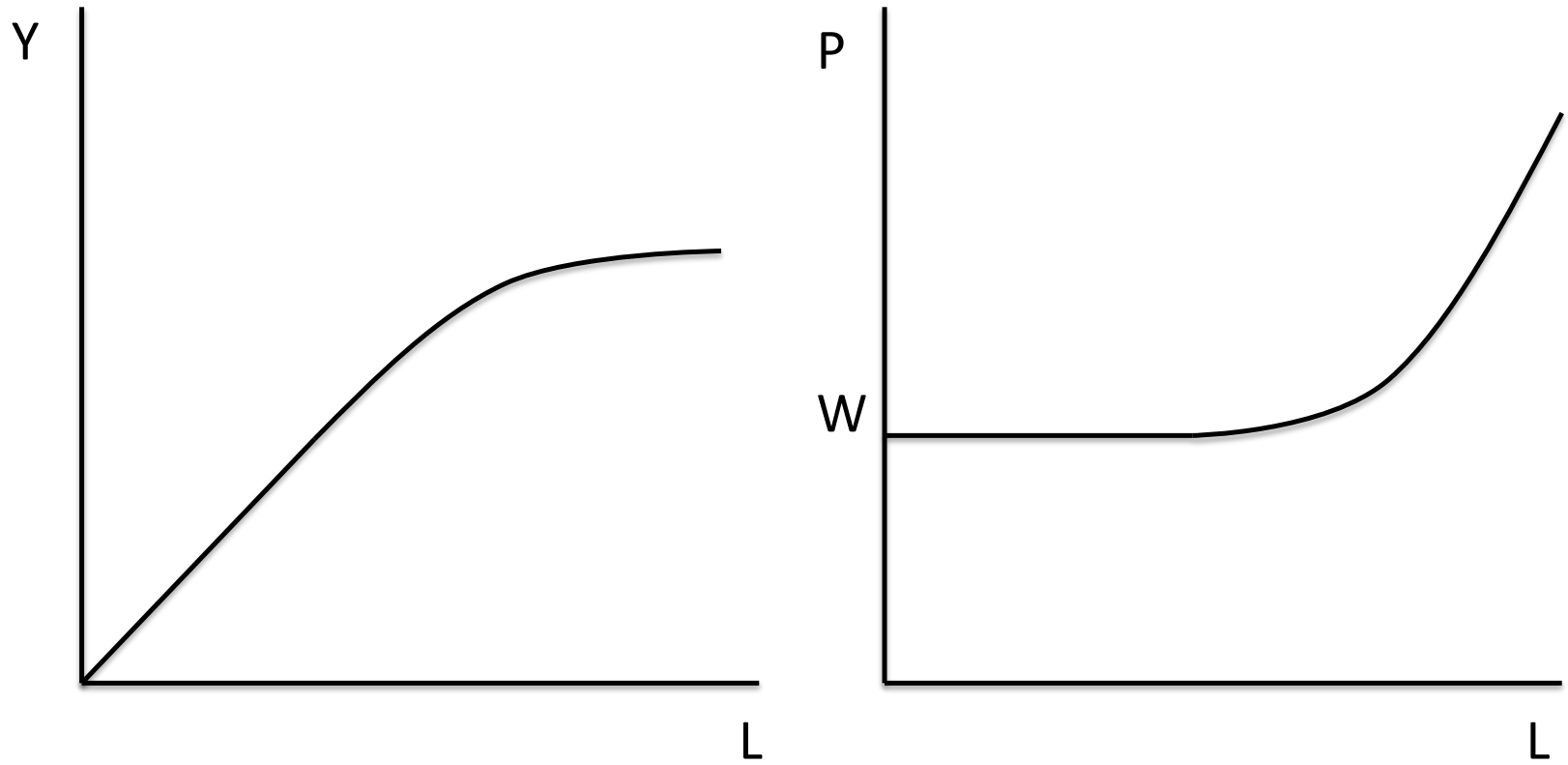
Nominal wage rigidities

- Nominal wage is fixed in the short run

$$W_{i,0} = W_{i,-1} = 1$$

- Involuntary unemployment may arise in the short run
  - $L_{i,0} = \bar{L}$: full employment
  - $L_{i,0} < \bar{L}$: involuntary unemployment
- From period 1 on, wages are fully flexible

Key idea: convex sectoral supply curves



- See empirical evidence by Boehm and Pandalai-Nayar (AER, 2022)

Firms and production

- Short run ($t = 0$): competitive firms, perfect sectoral labor mobility
- Non-tradable sector

$$Y_{i,0}^N = L_{i,0}^N \rightarrow P_{i,0}^N = W_{i,0}$$

- Tradable sector

$$Y_{i,0}^T = \left(L_{i,0}^T\right)^{\alpha} \rightarrow P_{i,0}^T = \frac{W_{i,0}}{\alpha}\left(Y_{i,0}^T\right)^{\frac{1-\alpha}{\alpha}}$$

- Law of one price

$$P_{i,0}^T = \mathcal{E}_{i,0}^j P_{j,0}^T$$

- Long run ($t \geq 1$): constant endowments Y^T and Y^N

Market clearing

- Normalize $B^n_{i,t} = 0$, tradable good market clearing

$$Y^T_{i,t} - C^T_{i,t} = B_{i,t+1} - R_{i,t-1}B_{i,t}$$

  - Financial autarky: $R_{i,t}$ adjusts so that $Y^T_{i,t} = C^T_{i,t}$
  - Free capital mobility: $R_{i,t} = R_t$ adjusts so that $\int_0^1 B_{i,t+1}di = 0$

- NT good market clearing

$$C^N_{i,t} = Y^N_{i,t}$$

- Labor market

$$L_{i,t} = L^T_{i,t} + L^N_{i,t} \leq \bar{L}$$

Monetary policy instruments and targets

- Central banks control the policy rate $R^n_{i,t}$
- However, it is more convenient to think of monetary policy as choosing a target path for $P_{i,t}$
- We can then back out the path of $R^n_{i,t}$ using

$$R^n_{i,t} = \frac{P_{i,t+1}C_{i,t+1}}{\beta P_{i,t}C_{i,t}}$$

- We will thus frame monetary policy in terms of targeting rules

Optimal policy problem

- Non-cooperative optimal monetary policy: each central bank sets a path for $P_{i,t}$ to maximize its citizens' utility

$$\sum_{t=0}^{\infty} \beta^t \left(\omega_{i,t} \log \left(C_{i,t}^T \right) + (1 - \omega_{i,t}) \log \left(C_{i,t}^N \right) - \chi \left(\frac{P_{i,t}}{P_{i,t-1}} \right) \right)$$

- In the long run ($t \geq 1$), optimal monetary policy is simply

$$P_{i,t} = P_{i,t-1}$$

- In the short run central bank sets $P_{i,0}^T$ to maximize domestic utility

A demand reallocation shock

- Temporary reallocation shock
  - Initial steady state $\omega_{i,-1} = \omega$
  - Short run: $\omega_{i,0} > \omega$ for at least some i
  - Long run: $\omega_{i,t} = \omega$ for $t \geq 1$
- Symmetric initial steady state with $B_{i,0} = 0$ and

$$P_{i,-1} = P^T_{i,-1} = P^N_{i,-1} = 1$$

Outline

Optimal policy problem

- Central bank sets $P_{i,0}^T$ to maximize

$$\omega_0 \log Y_{i,0}^T + (1-\omega_0) \log Y_{i,0}^N - \chi\left(P_{i,0}\right)$$

- Subject to

$$Y_{i,0}^T = \left(\alpha P_{i,0}^T\right)^{\frac{\alpha}{1-\alpha}}$$

$$Y_{i,0}^N = \frac{1-\omega_0}{\omega_0} Y_{i,0}^T P_{i,0}^T$$

$$\left(Y_{i,0}^T\right)^{\frac{1}{\alpha}} + Y_{i,0}^N \leq \bar{L}$$

$$P_{i,0} = \left(P_{i,0}^T\right)^{\omega_0}$$

A pseudo Phillips curve

- Private sector behavior gives rise to a pseudo Phillips curve

$$P_{i,0} = \frac{1}{\alpha}\left(\frac{\omega_0 \alpha L_{i,0}}{1-\omega_0(1-\alpha)}\right)^{\omega_0(1-\alpha)} \tag{PC}$$

- Rise in $P_{i,0}^T$ sustains demand and employment in both sectors
  - Labor reallocation: $\uparrow Y_{i,0}^T$, $\uparrow L_{i,0}^T$
  - Expenditure switching: $\uparrow \frac{P_{i,0}^T}{P_{i,0}^N}$ $\uparrow C_{i,0}^N$, $\uparrow L_{i,0}^N$
  - Income effect: $\uparrow Y_{i,0}^T$, $\uparrow C_{i,0}^T$, $\uparrow C_{i,0}^N$, $\uparrow L_{i,0}^N$
- Reallocation shock lowers demand for NT goods and shifts the Phillips curve (cost-push shock)

Back to the optimal policy problem

- To maintain full employment, central bank needs to set

$$P_{i,0} = P_{i,0}^{fe} \equiv \frac{1}{\alpha}\left(\frac{\omega_0 \alpha \bar{L}}{1-\omega_0(1-\alpha)}\right)^{\omega_0(1-\alpha)}$$

- But maintaining full employment may not always be optimal, because the inflation cost may be too high

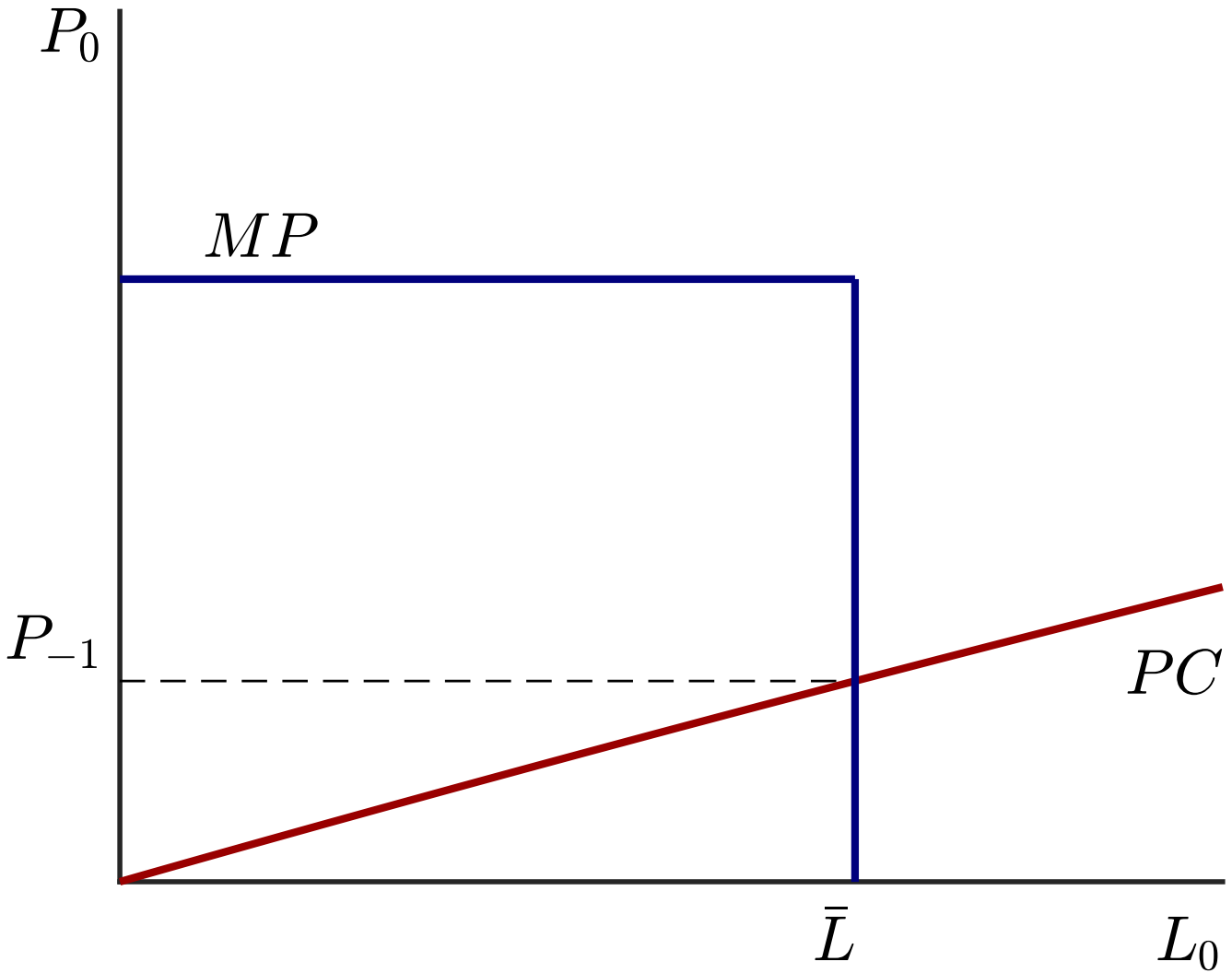
- If so, then optimal to set $P_{i,0} = \bar{P}_{i,0}$ defined implicitly by

$$\chi'\left(\bar{P}_{i,0}\right)\bar{P}_{i,0} = \frac{1}{\omega_0}\left(\frac{\alpha}{1-\alpha} + 1 - \omega_0\right)$$

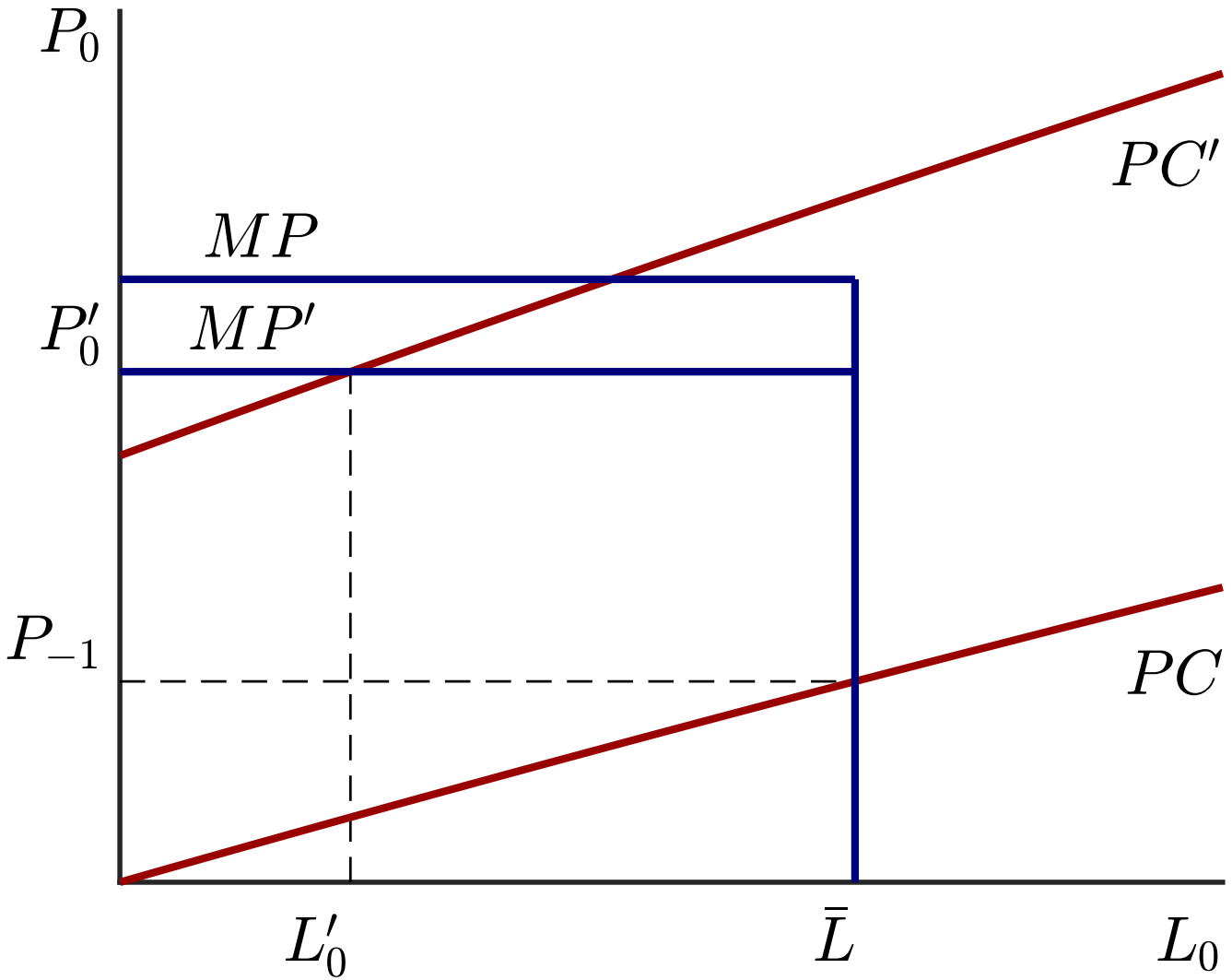
- The short run optimal monetary policy then sets

$$P_{i,0} = \min\left(P_{i,0}^{fe}, \bar{P}_{i,0}\right) \qquad \text{(MP)}$$

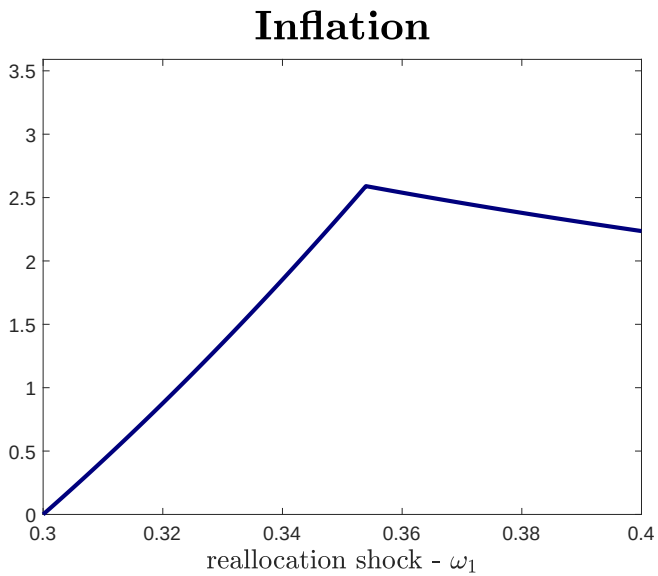
Optimal monetary policy response to reallocation shock

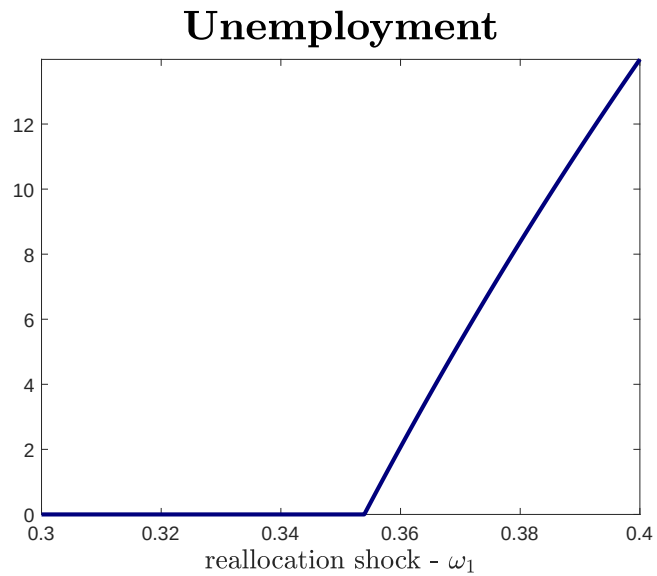


Optimal monetary policy response to reallocation shock



Optimal monetary policy response to reallocation shock



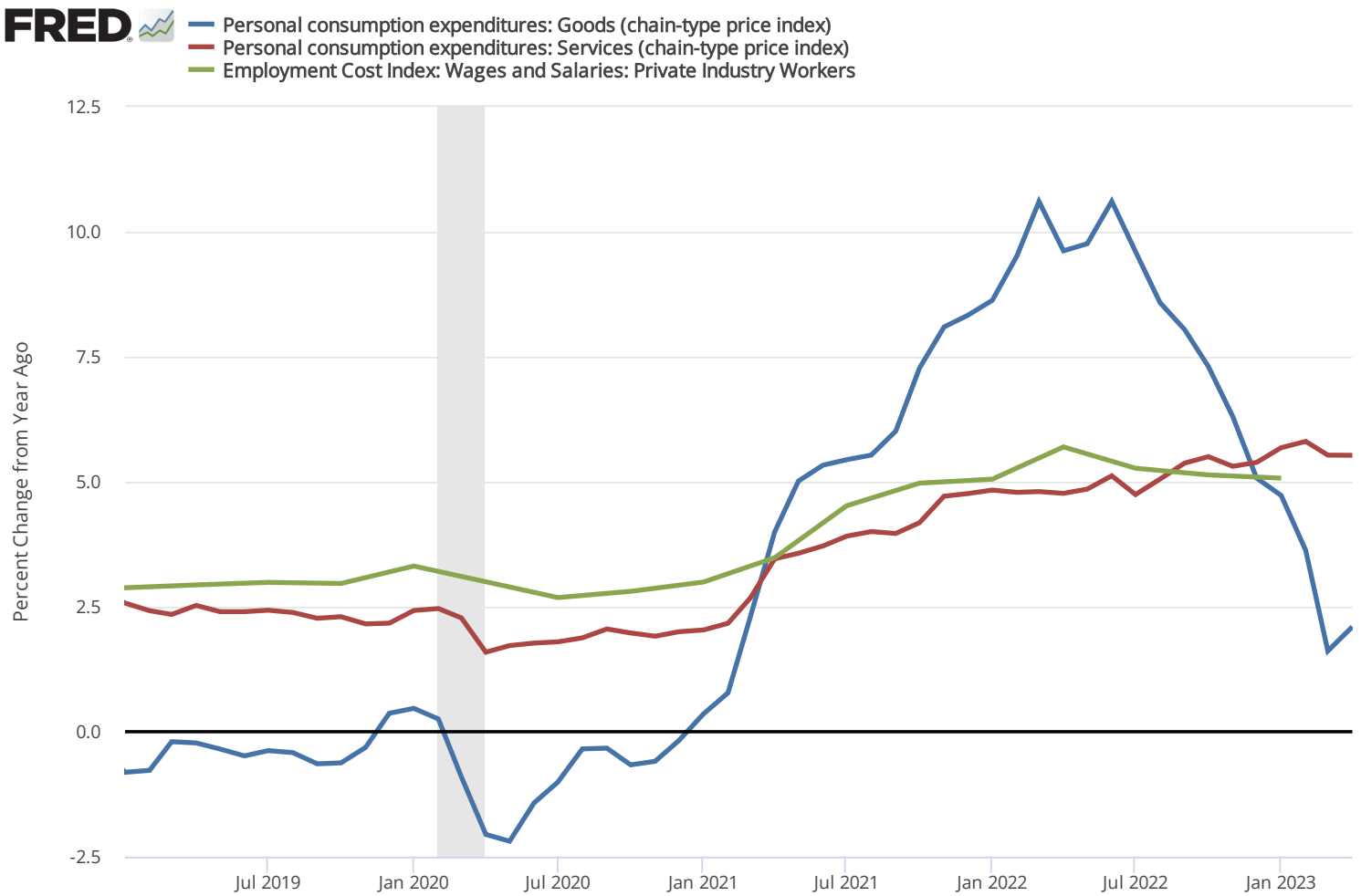


- Inflation is useful to smooth the reallocation process (Olivera, 1964; Tobin, 1972; Guerrieri et al., 2021)

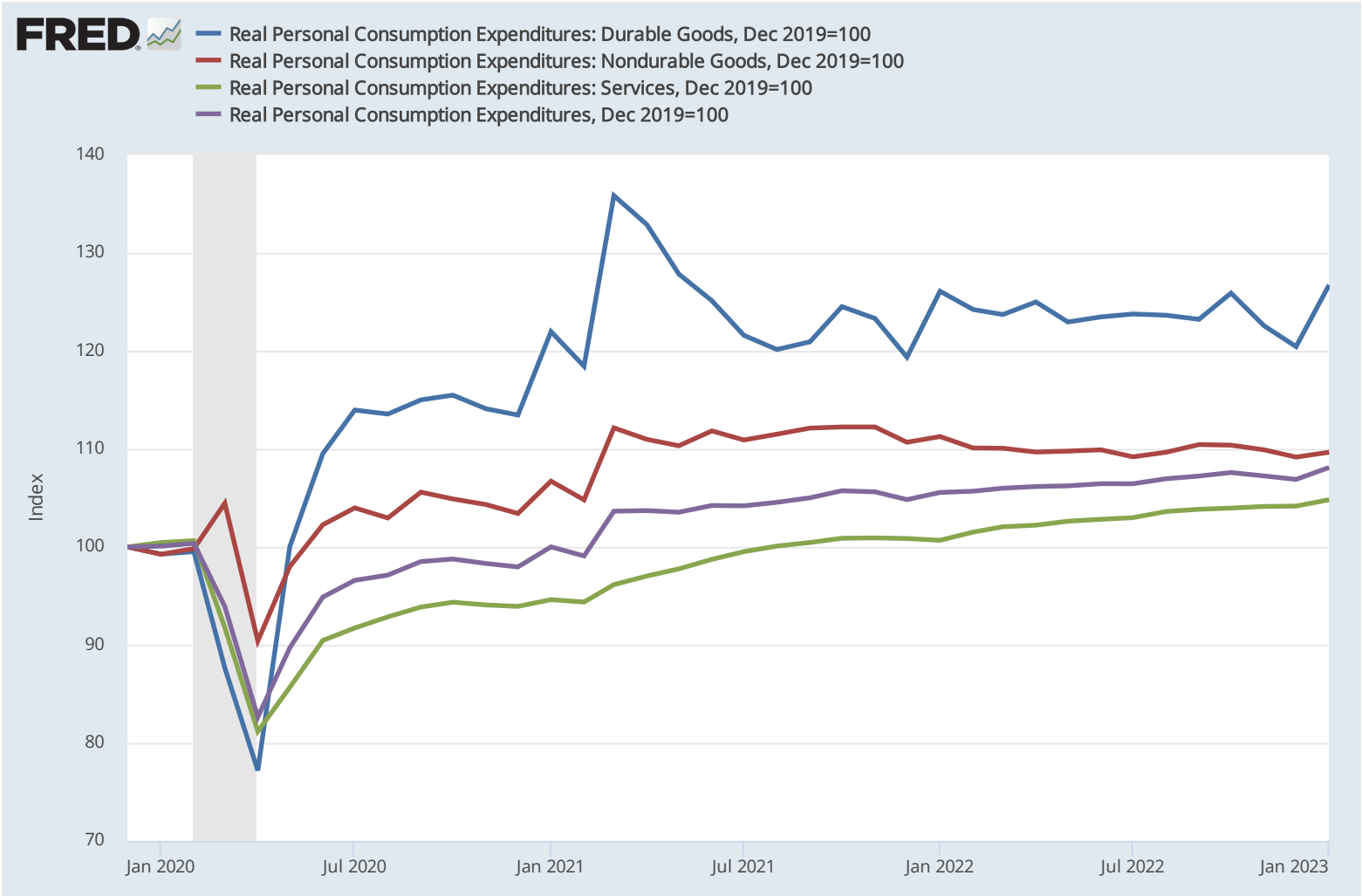
Some implications

- Sectoral asymmetry in inflation and economic activity
  - Rise in P^T/P^N
  - Fall in W/P^T
  - Reallocation of economic activity from NT to T

Higher goods inflation compared to services and wages



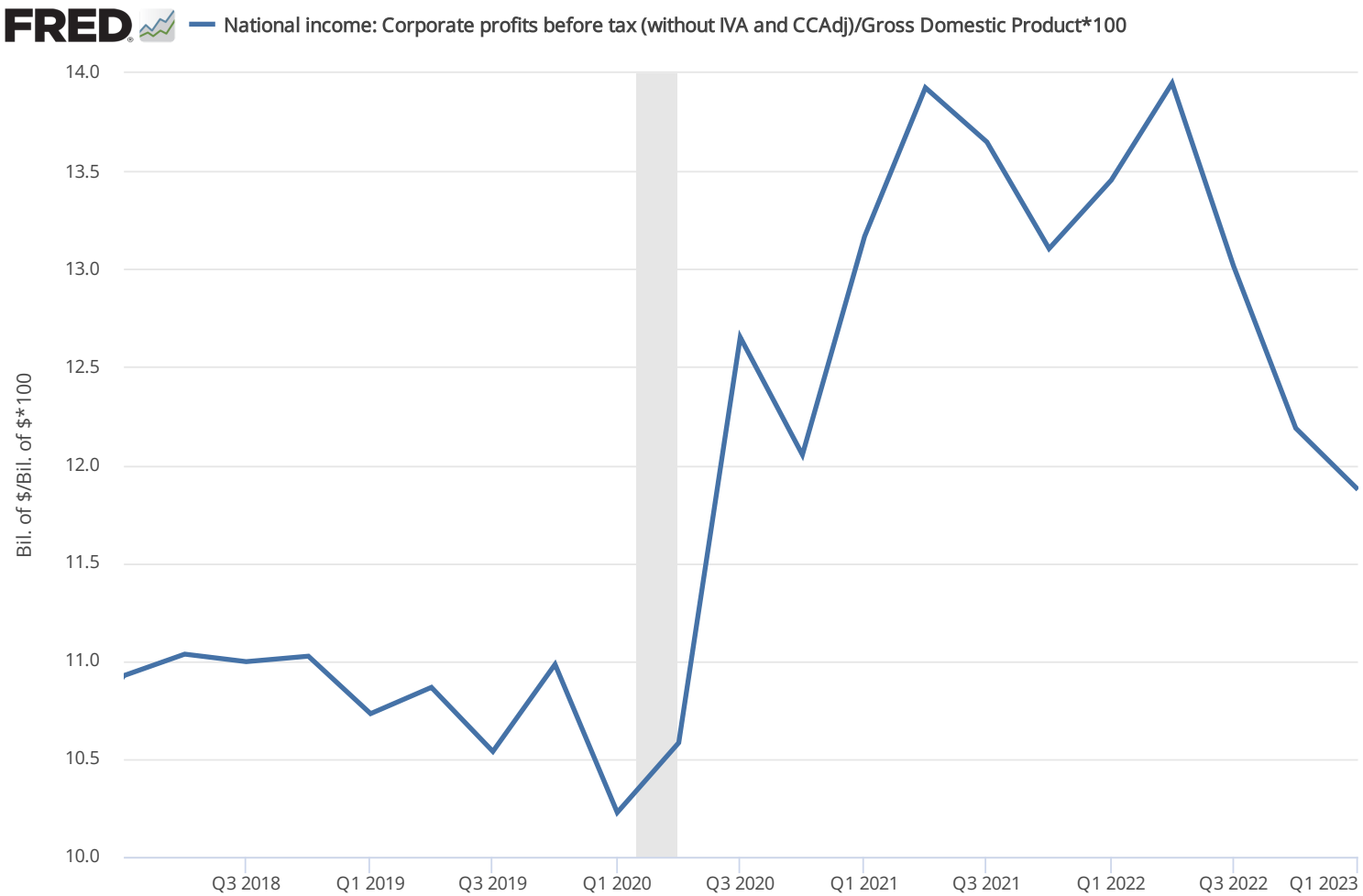
Real consumption: goods vs. services



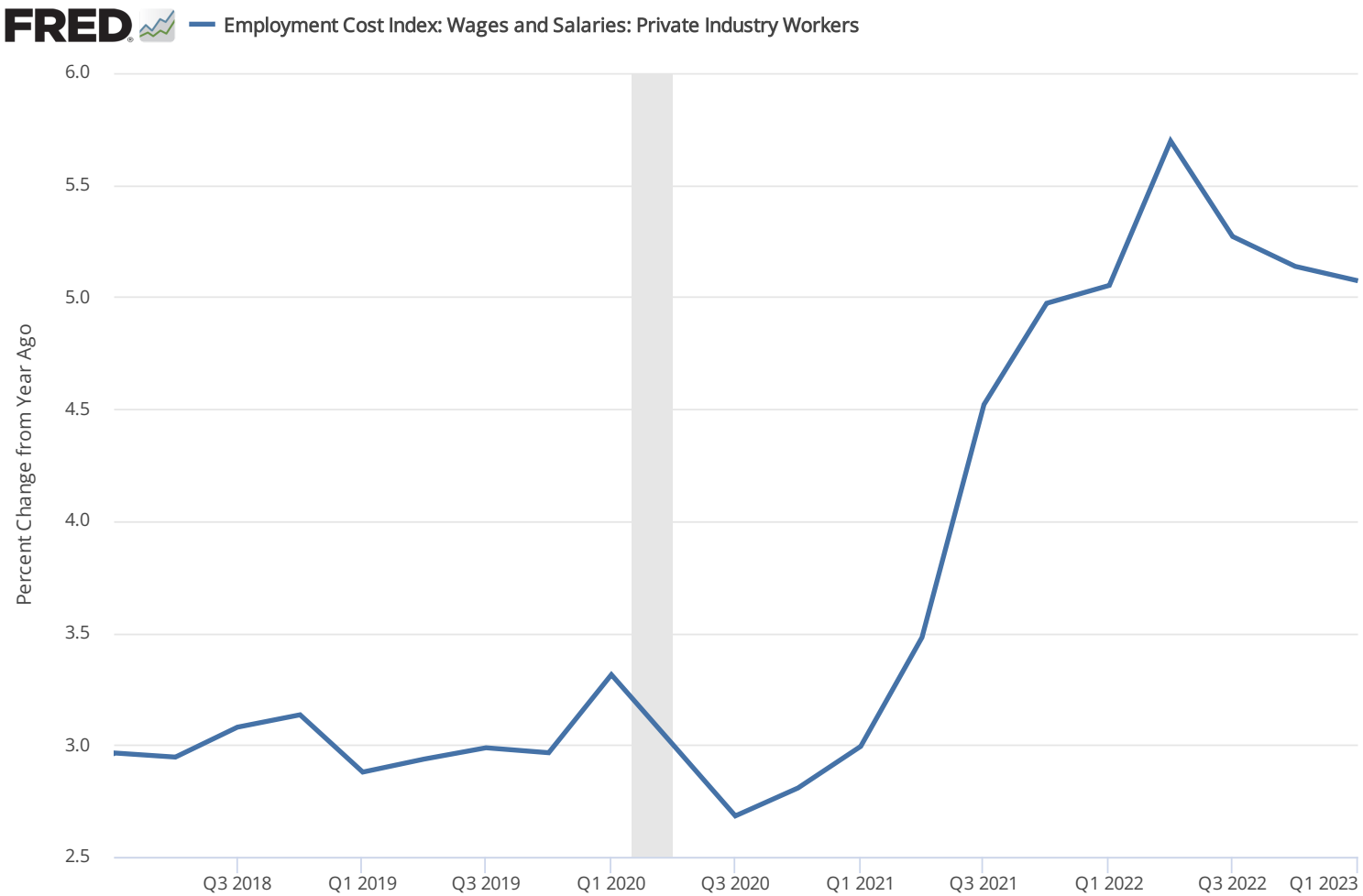
Some implications

- Sectoral asymmetry in inflation and economic activity
  - Rise in P^T/P^N
  - Fall in W/P^T
  - Reallocation of economic activity from NT to T
- Profits vs. wages
  - Initial rise in the profit share
  - Real wages recover as demand normalizes

Profits/GDP


FRED
National income: Corporate profits before tax (without IVA and CCAdj)/Gross Domestic Product*100
Bil. of $/Bil. of $*100
14.0
13.5
13.0
12.5
12.0
11.5
11.0
10.5
10.0
Q3 2018
Q1 2019
Q3 2019
Q1 2020
Q3 2020
Q1 2021
Q3 2021
Q1 2022
Q3 2022
Q1 2023

Nominal wage growth



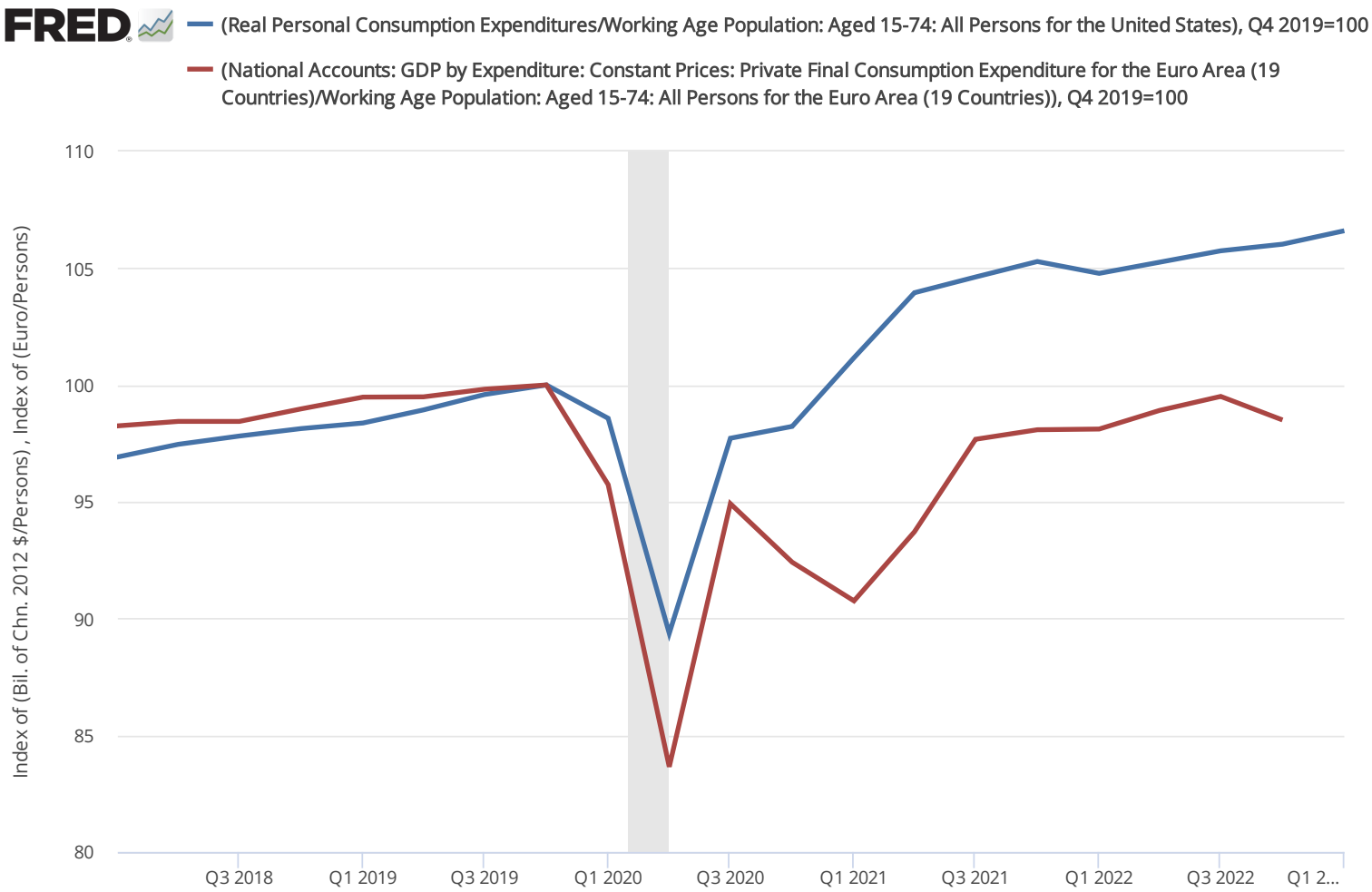
Asymmetric monetary response

- Imagine that the disutility from inflation is higher in the EU compared to US

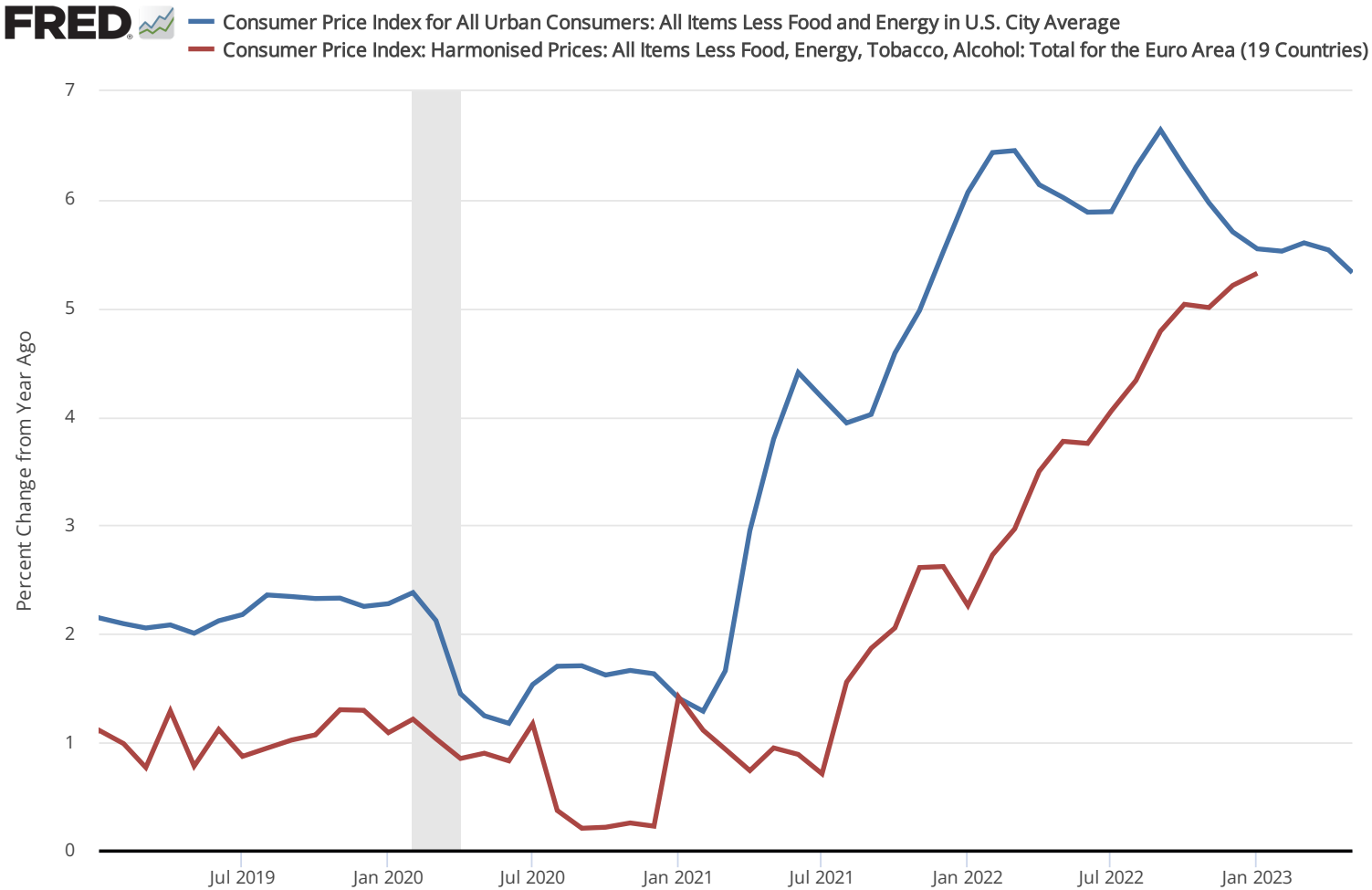
$$\chi'_{eu}(\cdot) > \chi'_{us}(\cdot)$$

- In period 0, US may have higher inflation and employment compared to EU
- In fact, during the first phases of the recovery the US had both faster growth and higher inflation
- Starting from 2022, two factors complicate the picture
  - Fed hawkish pivot ($\uparrow \chi'_{us}(\cdot)$)
  - Energy shock in the EU

Real private consumption: US vs. euro area



Core inflation: US vs. euro area



Outline

What changes under free capital mobility?

- Countries may use the international credit markets to smooth the impact of the reallocation shock on consumption

$$C_{i,0}^T = \frac{\omega_{i,0}(1-\beta)}{\omega_{i,0}(1-\beta)+\omega\beta}\left(Y_{i,0}^T + \frac{R}{R-1}\frac{Y^T}{R_0}\right)$$

- Capital flows affect demand for non-tradables

$$Y_{i,0}^N = \frac{1-\omega_{i,0}}{\omega_{i,0}} C_{i,0}^T P_{i,0}^T$$

- Now a monetary expansion ($\uparrow P_{i,0}^T$) has a smaller impact on domestic demand for NT goods because income effect is weaker

$$\frac{\partial C_{i,0}^T}{\partial Y_{i,0}^T} << 1$$

- The reason is that part of the increase in $Y_{i,0}^T$ due to a monetary expansion is sold to foreign consumers

Capital flows and the Phillips curve

- Capital inflows (& trade deficits) sustain demand for NT goods and improve the trade off between inflation and employment

$$P_{i,0} = \frac{1}{\alpha}\left(\frac{\alpha\omega_{i,0}L_{i,0}}{\alpha\omega_{i,0} + (1-\omega_{i,0})\frac{C^T_{i,0}}{Y^T_{i,0}}}\right)^{\omega_{i,0}(1-\alpha)} \tag{PC}$$

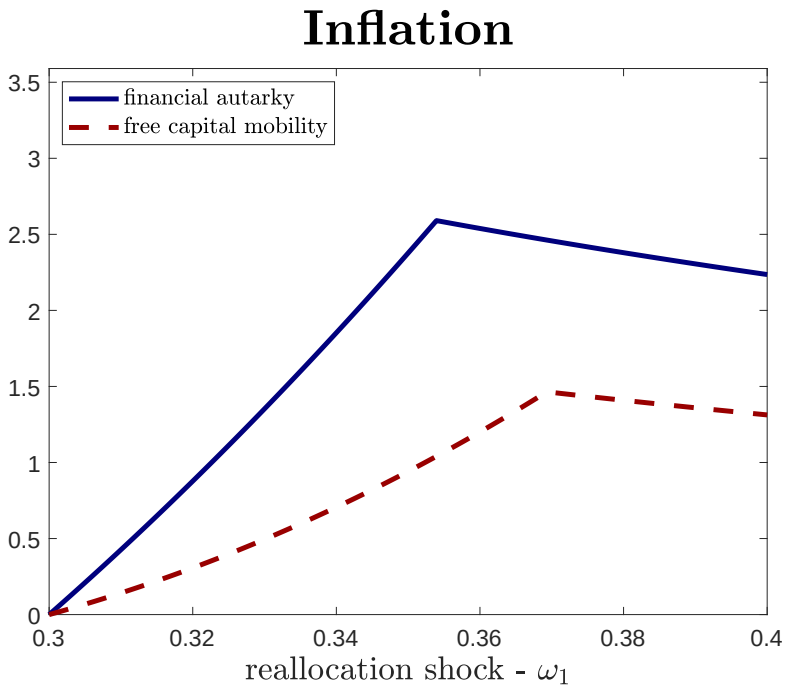
- Capital mobility makes national Phillips curves steeper
  - $\downarrow P_{i,0}$ increases trade deficit $\uparrow C^T_{i,0}/Y^T_{i,0}$ which mitigates $\downarrow L_{i,0}$

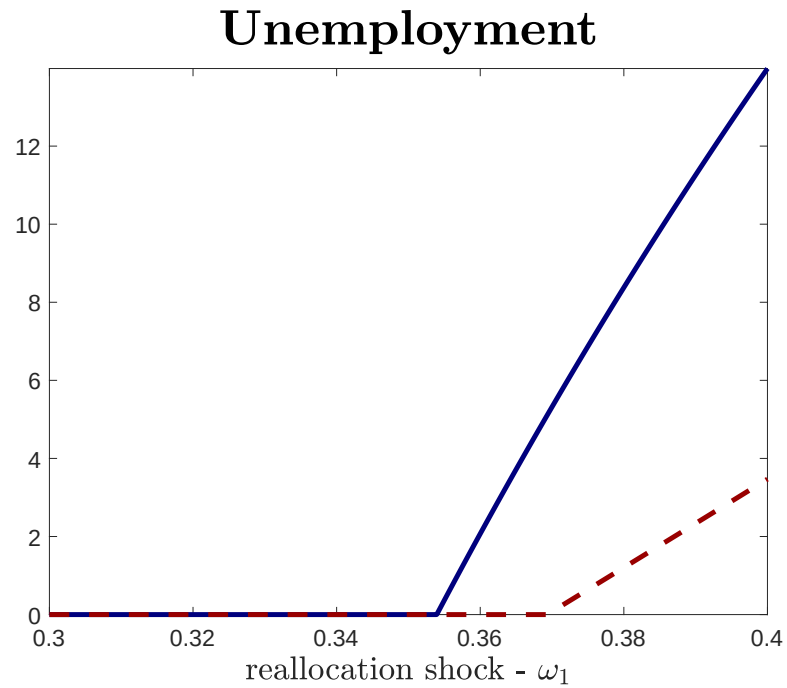
International transmission of a reallocation shock

- Rise in $\omega_{i,0}$ occurring in a single country $\rightarrow$ trade deficit
  - Capital inflows contain rise in inflation and unemployment in country i

$$\downarrow P_{i,0} = \frac{1}{\alpha}\left(\frac{\uparrow L_{i,0}\alpha\omega_{i,0}}{\alpha\omega_{i,0} + (1-\omega_{i,0})\uparrow \frac{C^T_{i,0}}{Y^T_{i,0}}}\right)^{\omega_{i,0}(1-\alpha)} \qquad \text{(PC)}$$

An idiosyncratic reallocation shock





- Trade deficits contain domestic inflation and unemployment

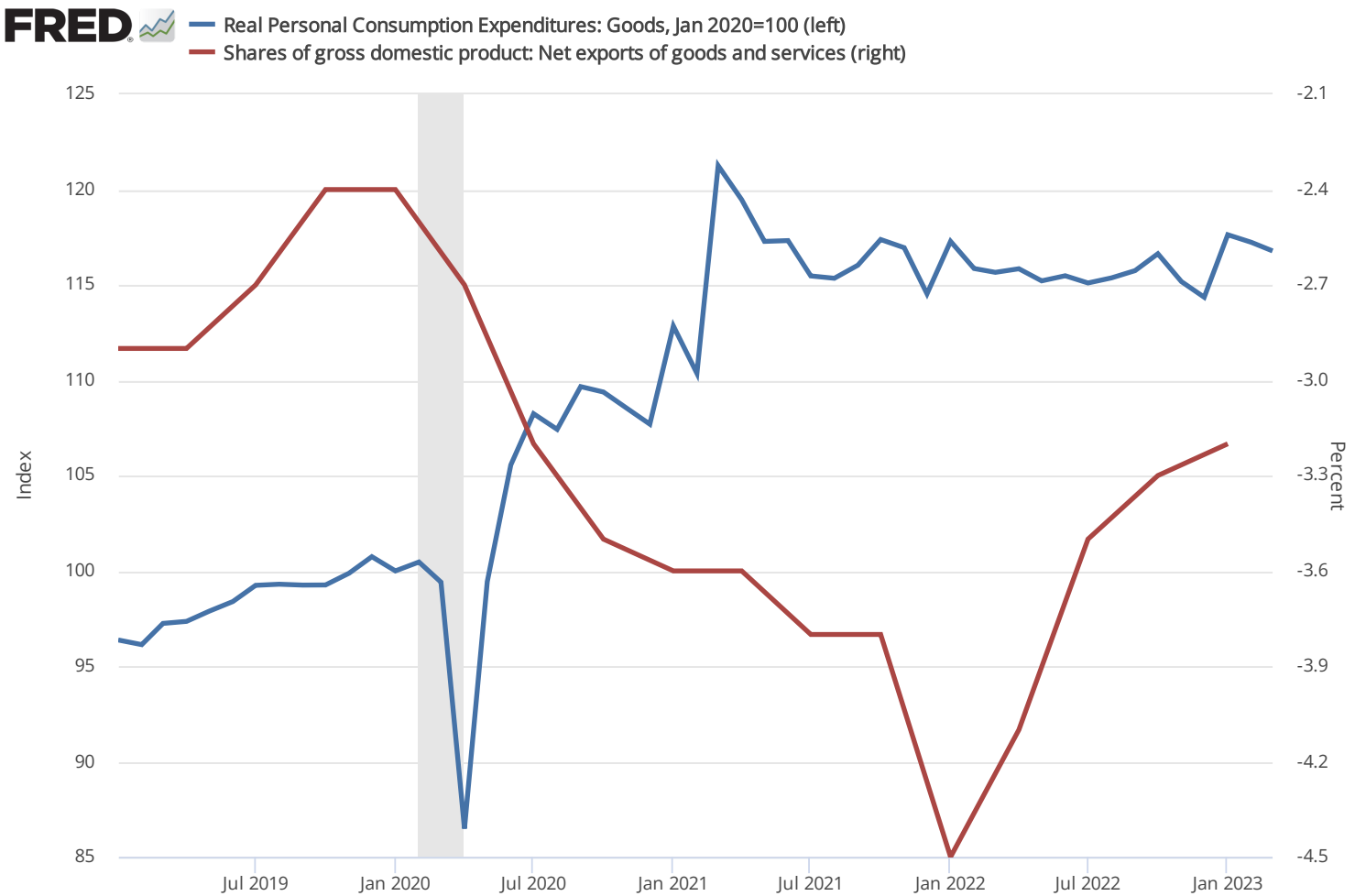
International transmission of a reallocation shock

- Rise in $\omega_{i,0}$ occurring in a single country $\rightarrow$ trade deficit
  - Capital inflows contain rise in inflation and unemployment in country i

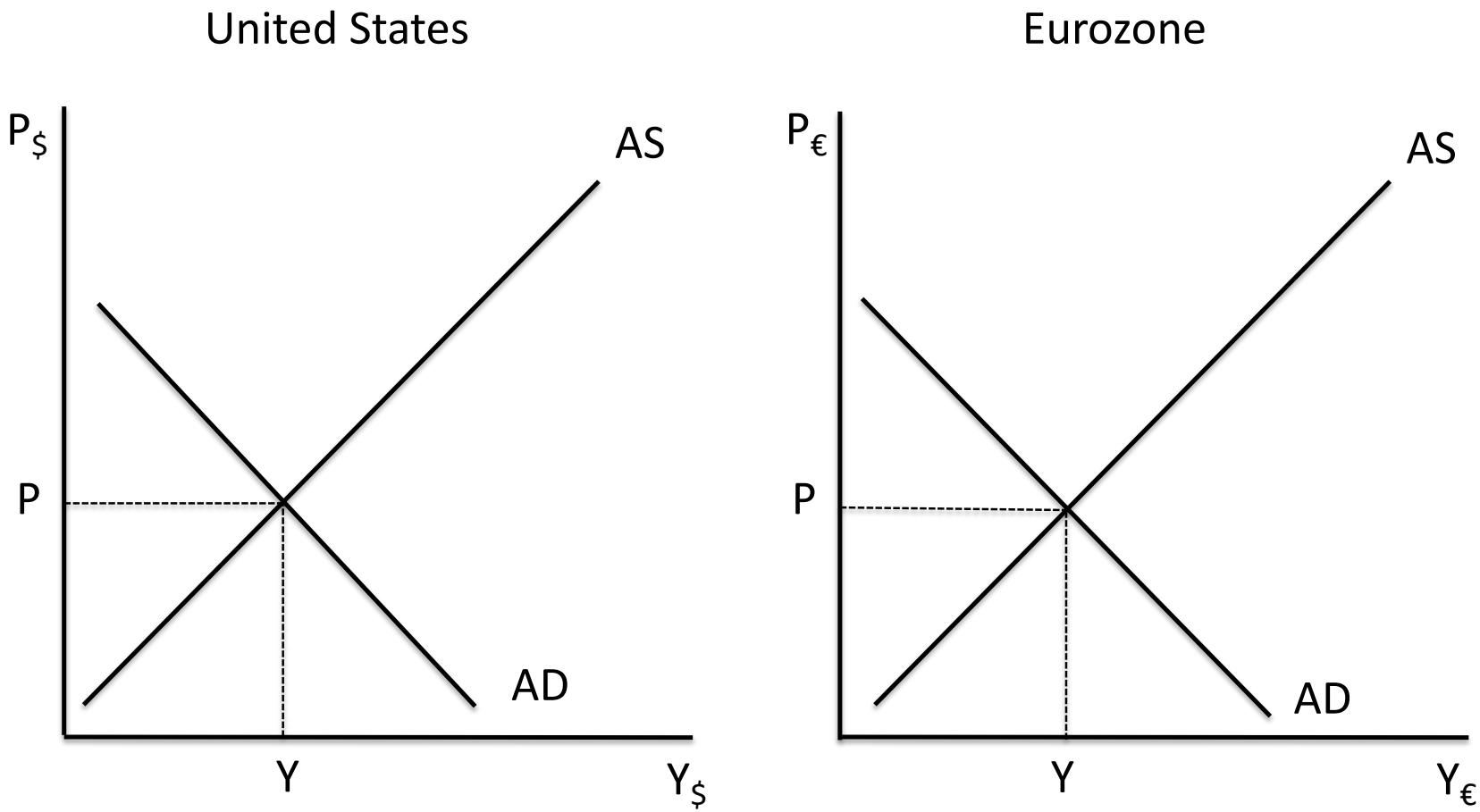
$$\uparrow P_{i,0} = \frac{1}{\alpha}\left(\frac{\downarrow L_{i,0}\alpha\omega_{i,0}}{\alpha\omega_{i,0} + (1-\omega_{i,0})\downarrow \frac{C^T_{i,0}}{Y^T_{i,0}}}\right)^{\omega_{i,0}(1-\alpha)} \qquad \text{(PC)}$$

- But rest of the world suffers capital outflows, as well as higher inflation and unemployment
  - Trade deficits export inflation abroad!

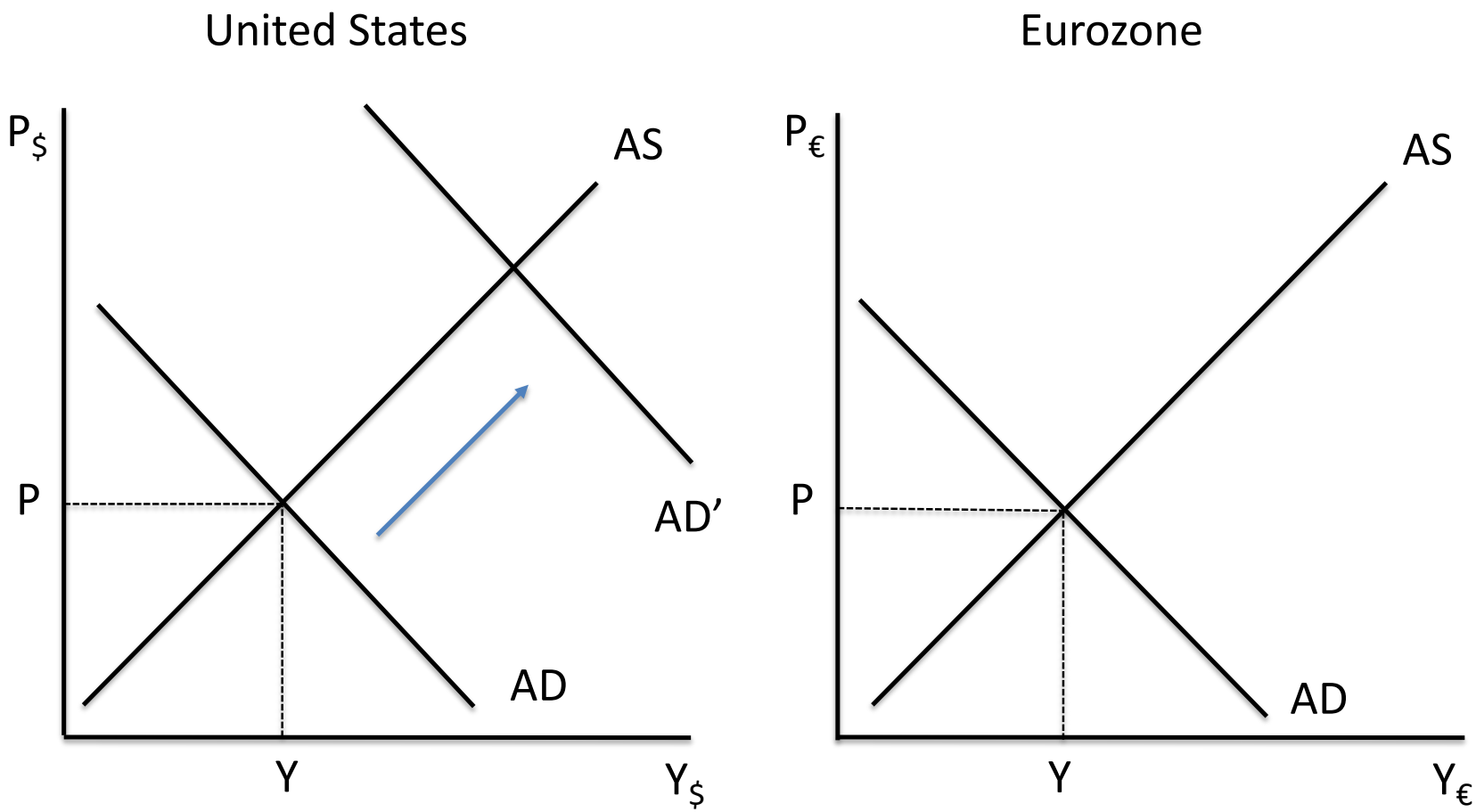
High US goods consumption financed by trade deficits



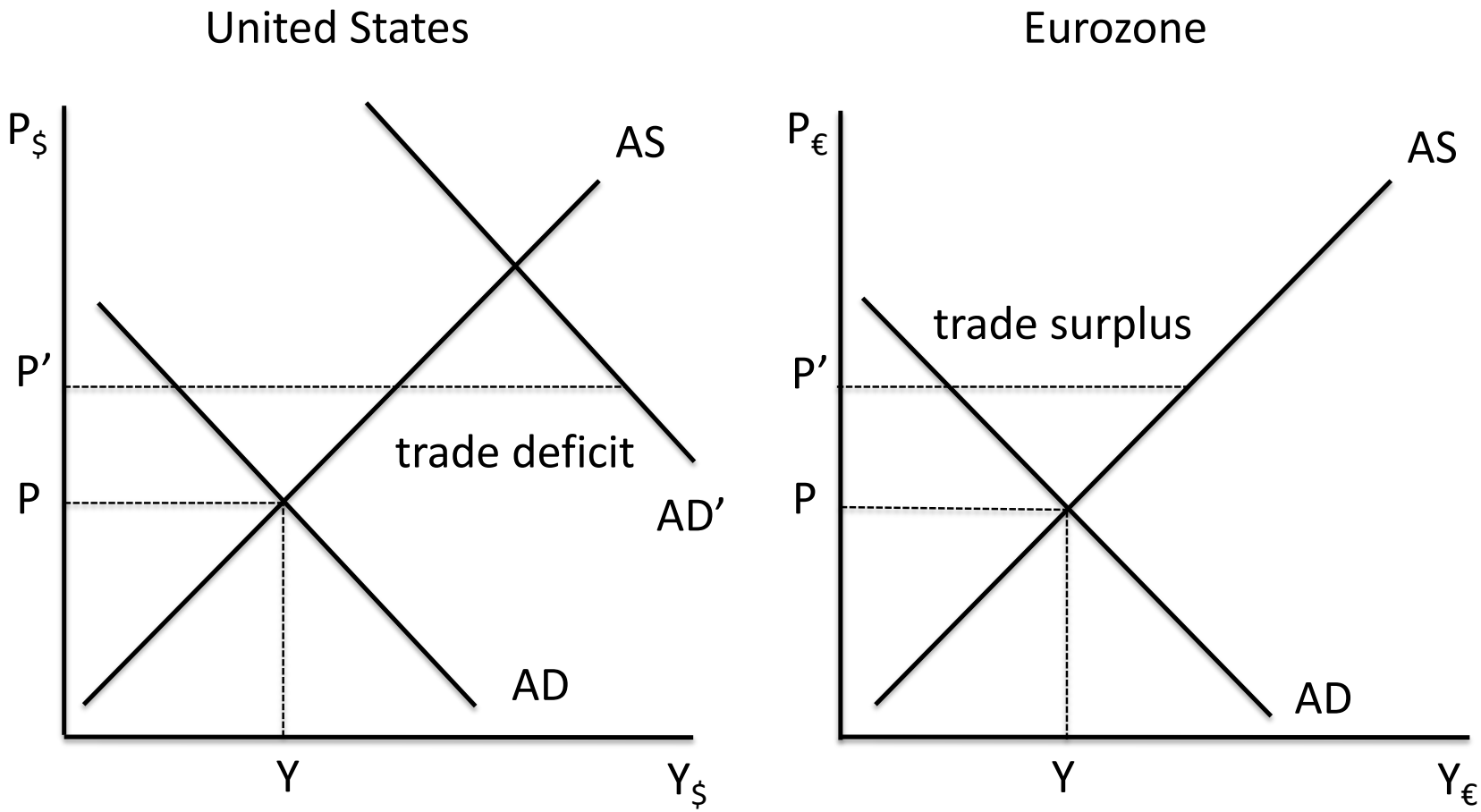
Initial equilibrium



Surge in US demand for goods



Inflation spreads to the euro area



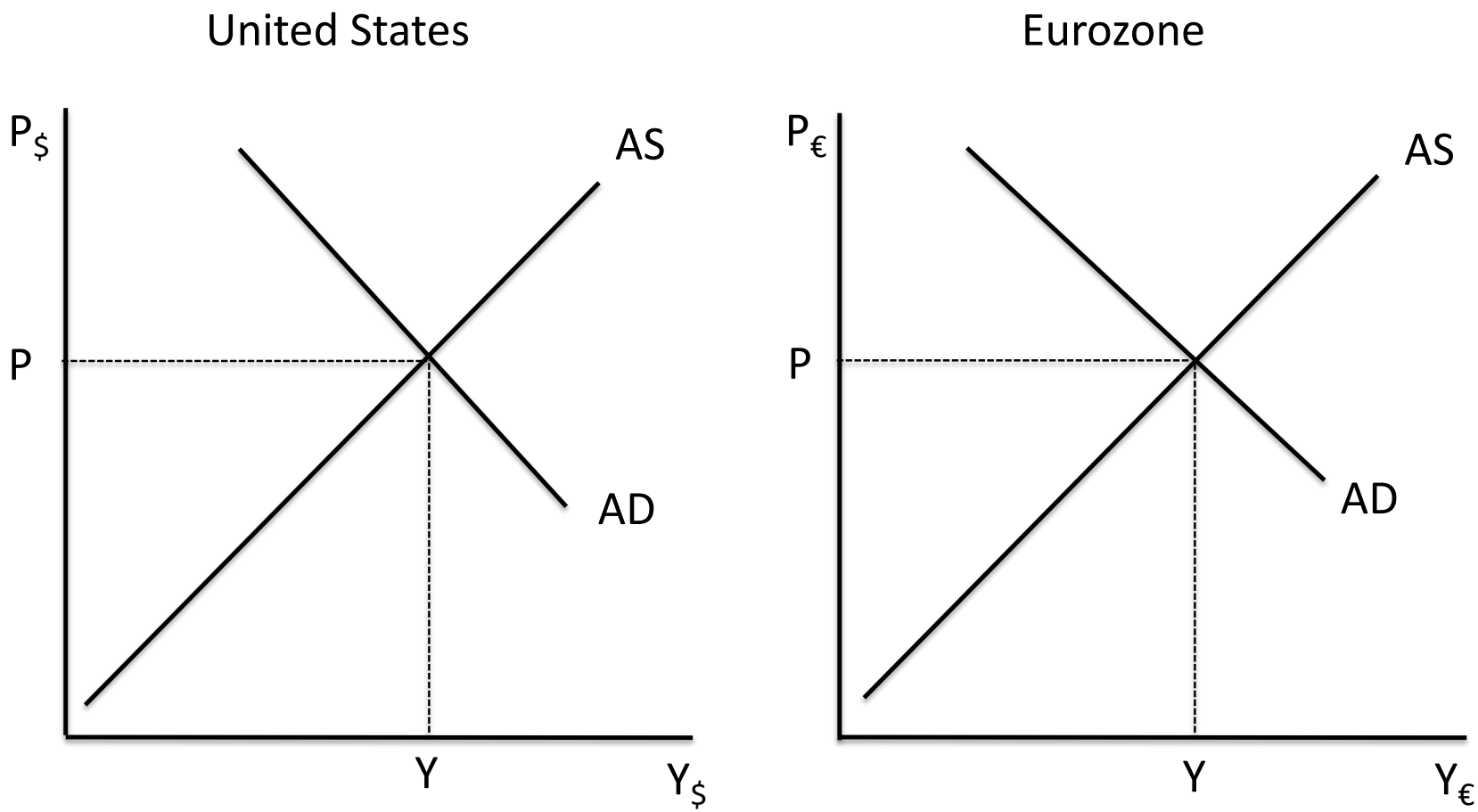
International transmission of a monetary contraction

- Monetary contraction in country i ($\downarrow P_{i,0}$)
  - Higher policy rate attracts capital inflows $\uparrow C^T_{i,0}/Y^T_{i,0}$, currency appreciates

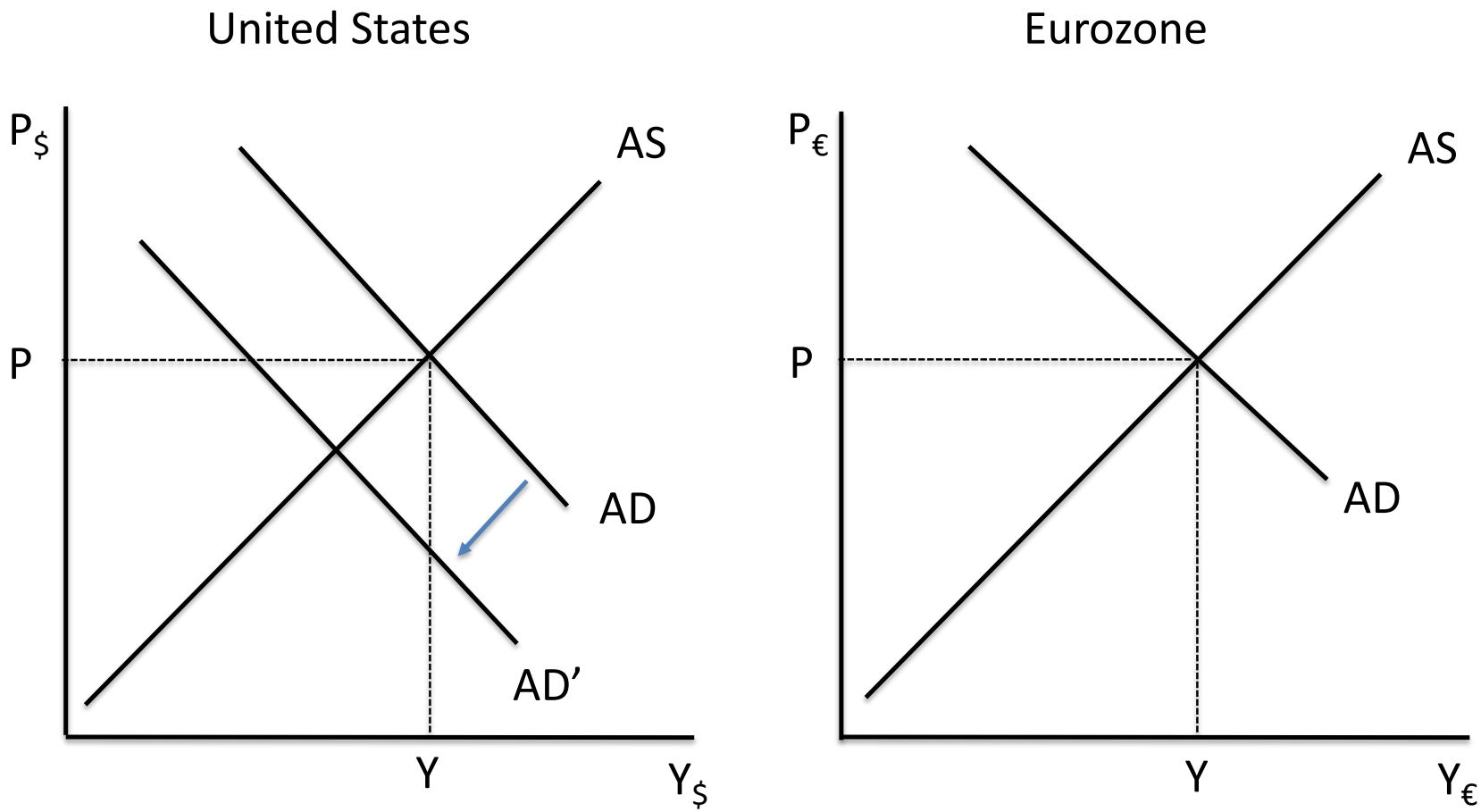
$$P_{i,0} = \frac{1}{\alpha}\left(\frac{\alpha\omega_{i,0}L_{i,0}}{\alpha\omega_{i,0} + (1-\omega_{i,0})\frac{C^T_{i,0}}{Y^T_{i,0}}}\right)^{\omega_{i,0}(1-\alpha)} \tag{PC}$$

- Capital inflows reduce the drop in consumption and output associated with a disinflation
- But rest of the world experiences lower consumption and higher inflation

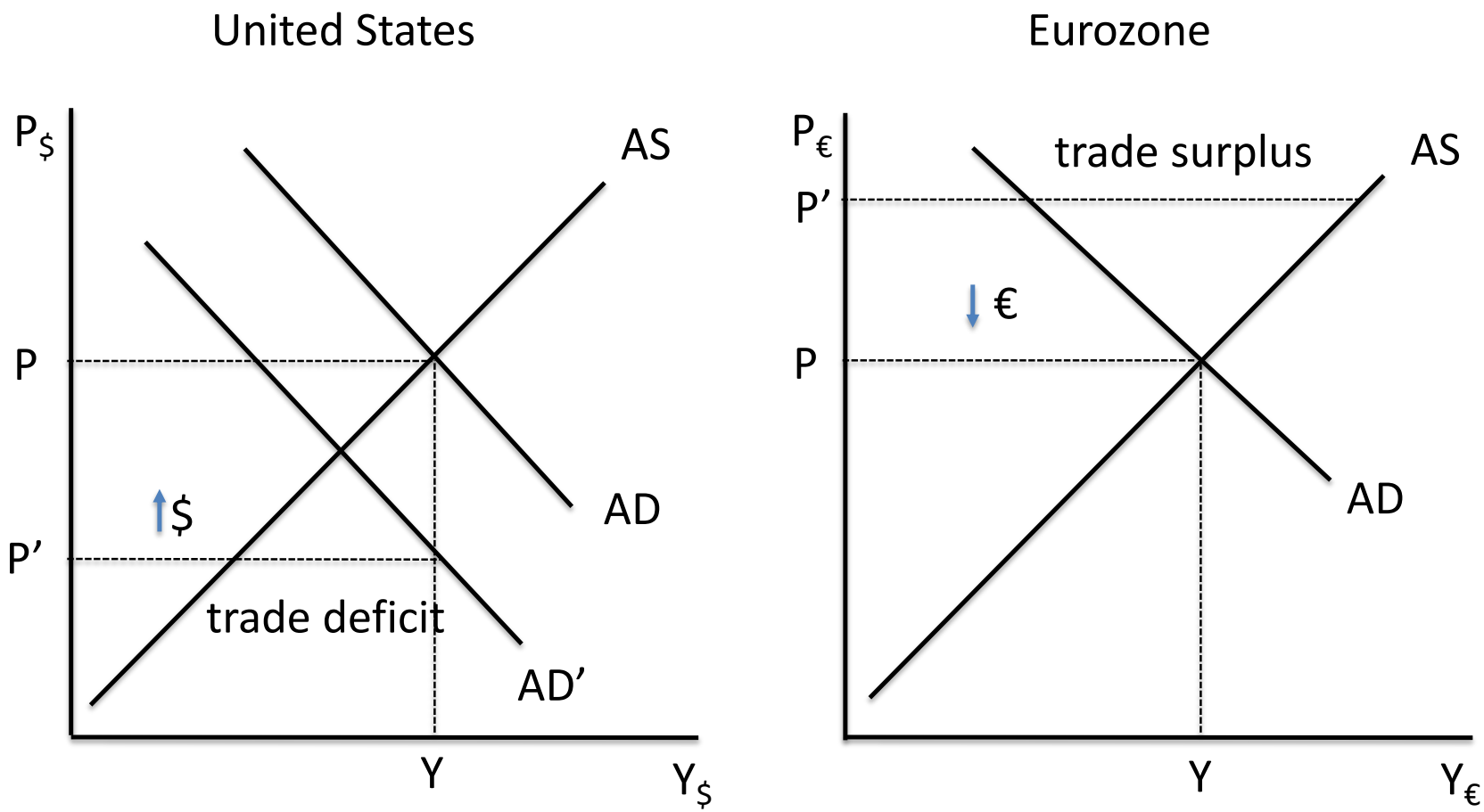
Initial equilibrium



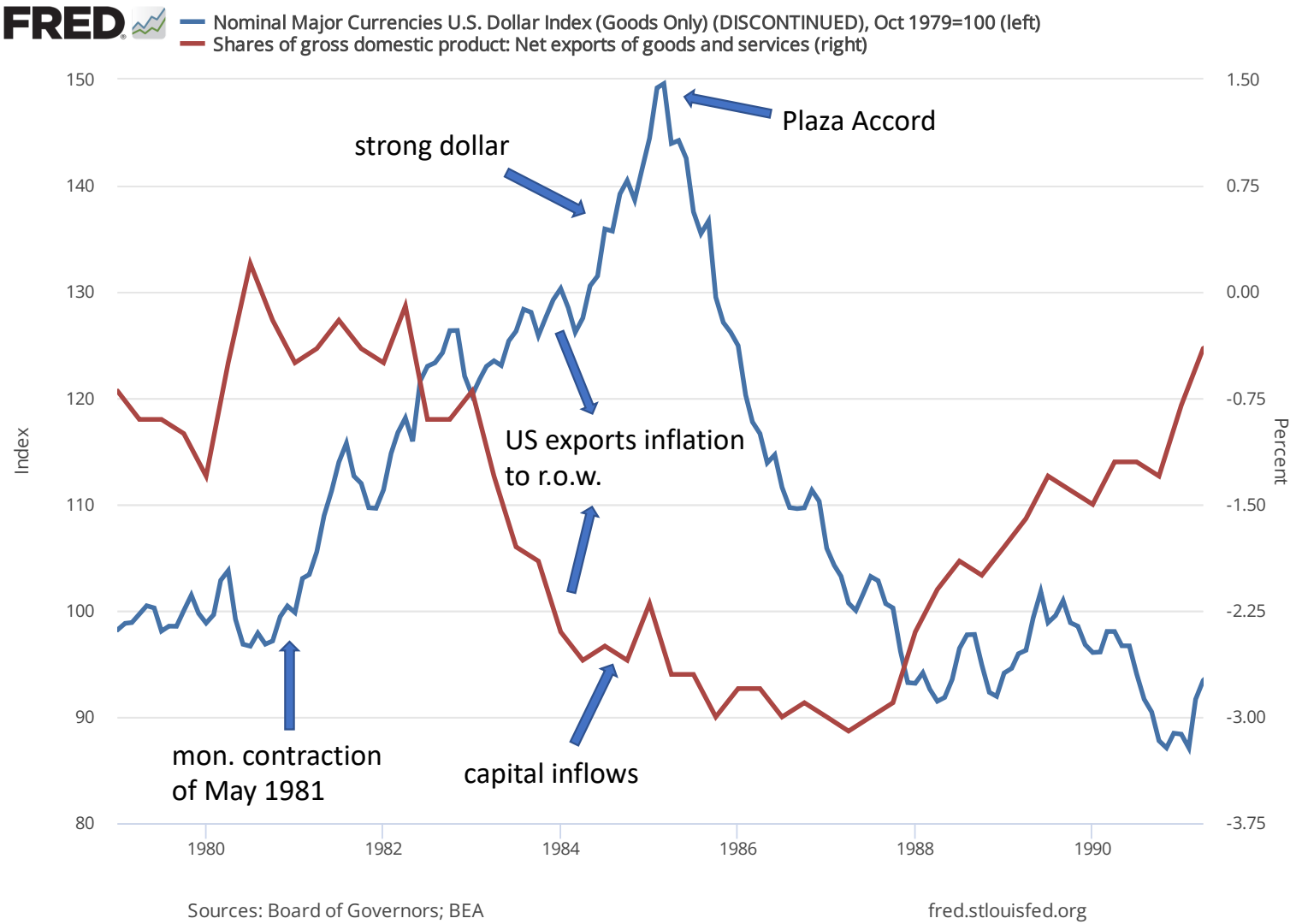
US monetary tightening



Strong dollar exports inflation

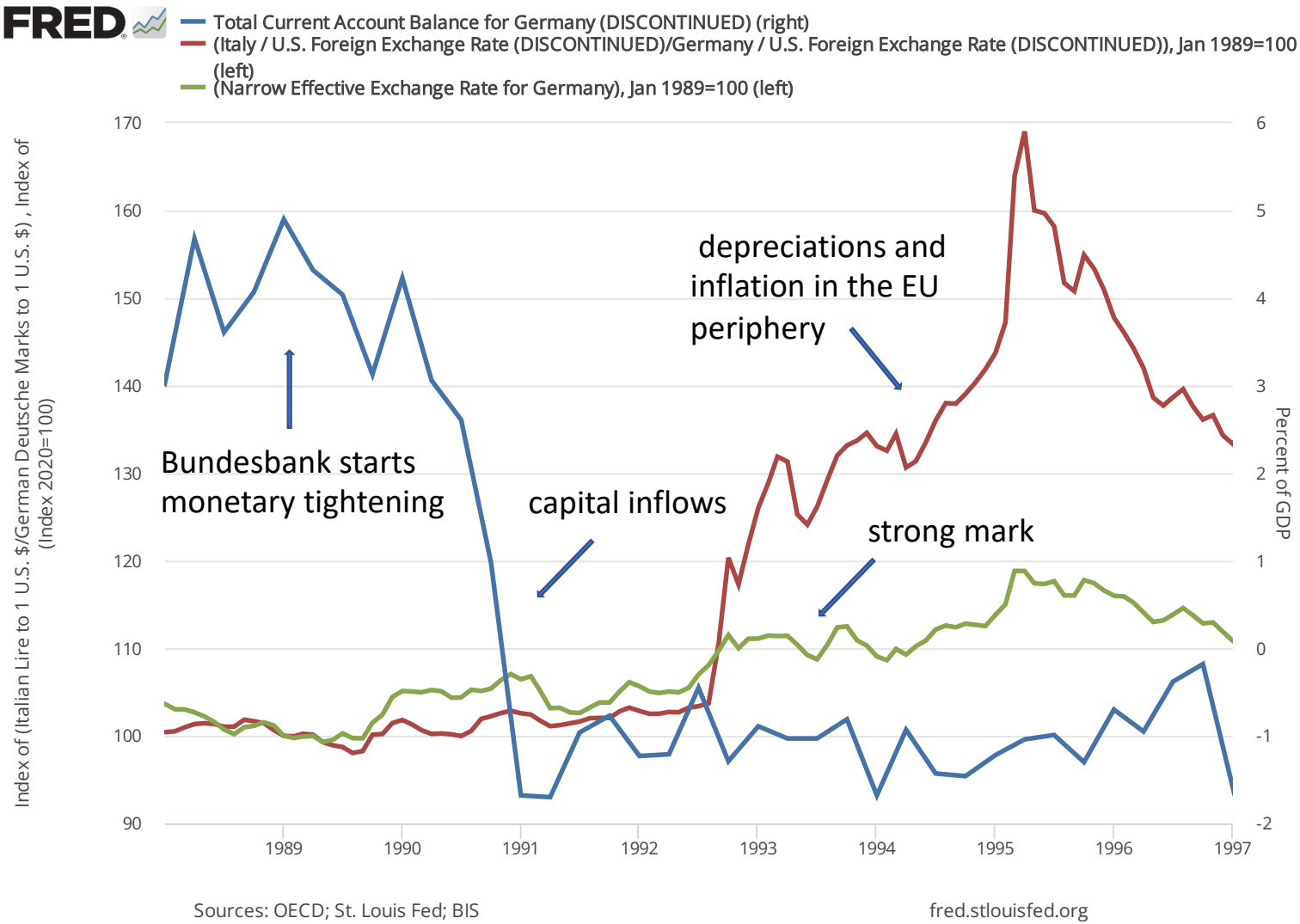


International perspective on Volcker disinflation



See Sachs (1985)

The 1992 EMS crisis



See Buiter, Corsetti and Pesenti (1998)

Outline

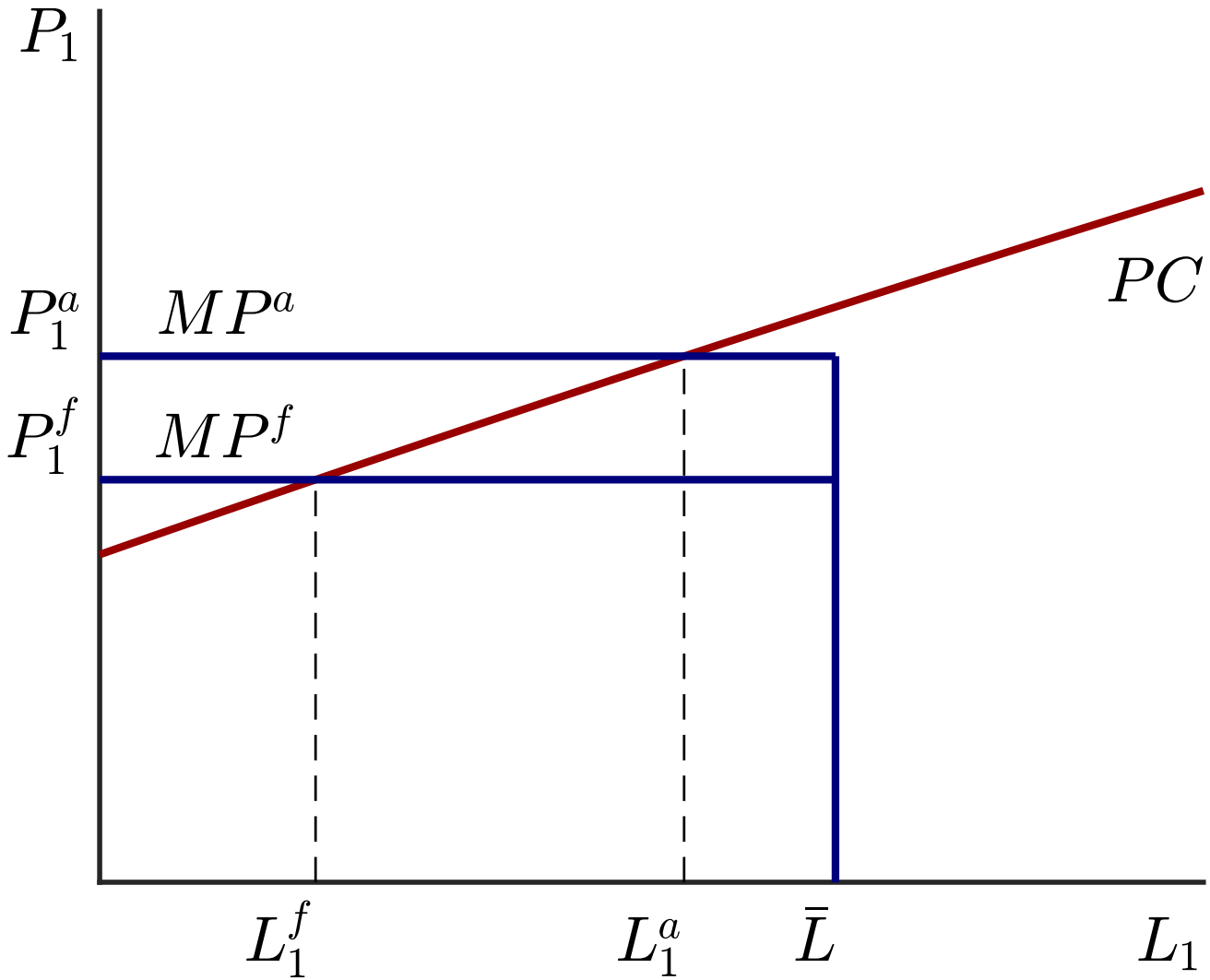
A global reallocation shock

- Now consider a rise in ω_0 occurring in every country
- Everyone tries to borrow on the international credit markets $\rightarrow R_0$ rises until trade balance is restored ($Y_{i,0}^T = C_{i,0}^T$)
- Still, due to free capital mobility, unilateral monetary contractions have a smaller impact on domestic output

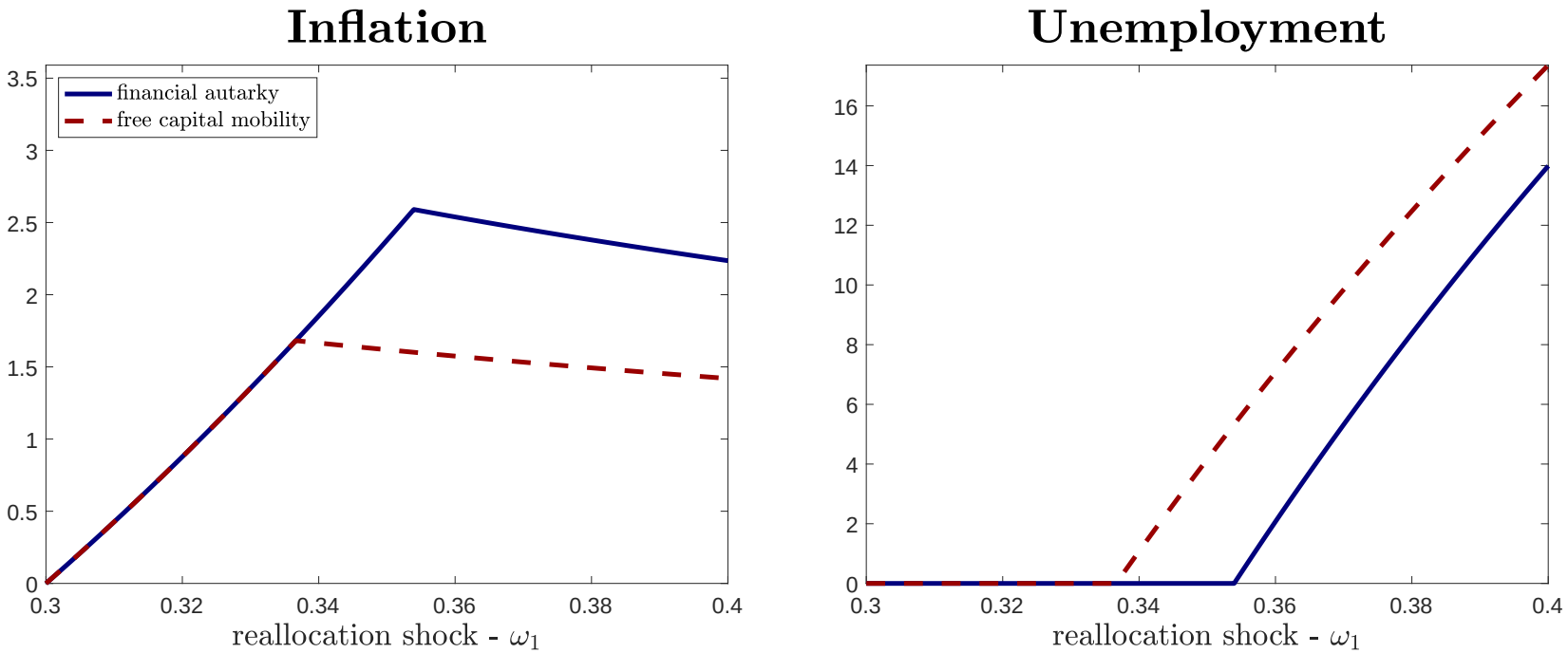
$$\chi'\left(P_{i,0}\right) P_{i,0} = \frac{1}{\omega_0}\left(\frac{\omega_0\left(1-\beta+\omega\beta\right)}{\omega_0(1-\beta)+\omega\beta}\frac{\alpha}{1-\alpha}+1-\omega_0\right)$$

- Compared to closed economies, national monetary authorities tolerate less inflation and more unemployment

A global reallocation shock

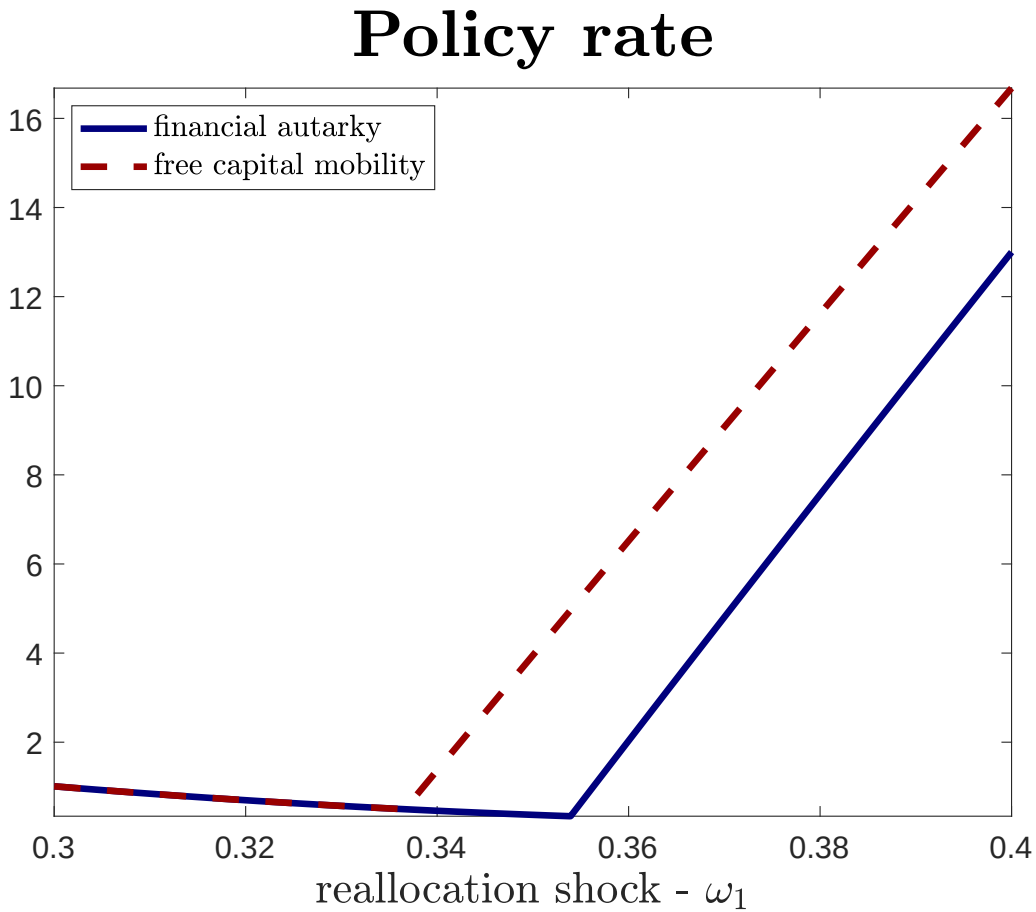


A global reallocation shock



- Tighter monetary policy under free capital mobility, compared to financial autarky

Policy rates during global reallocation shock



Demand imbalances under free capital mobility

- Reallocation shock increases demand for foreign credit
  - Idiosyncratic shock: rise in trade deficit
  - Global shock: rise in world interest rate
- Free capital mobility steepens the country-level Phillips curve, leading to more hawkish monetary policy
  - Idiosyncratic shock: lower inflation and lower unemployment
  - Global shock: lower inflation, but higher unemployment

Gains from cooperation

- With symmetric shock, problem of the global planner is isomorphic to the one of national central banks under financial autarky
- Under free capital mobility, tighter monetary policy and excessive slump compared to global optimum
- Suppose a single country lowers $P_{i,0}^T$ (and appreciates ER)
  - $Y_{i,0}^T$ falls, drop in net exports toward rest of the world
  - Lower demand for NT goods and employment in r.o.w.
  - But benefit from lower inflation fully enjoyed by domestic households
- National central banks do not internalize the negative demand externalities generated by monetary contractions

Reverse currency wars

- Suppose that we start from the global optimum
  - Each country has an incentive to increase its policy rate, appreciate its exchange rate and run a trade deficit
  - But this policy exacerbates the global scarcity of traded goods, and leads to higher inflation and unemployment in the r.o.w.
  - If every country sets policy unilaterally, interest rates and unemployment will be too high from a global perspective
- Competitive appreciations pose a challenge to international cooperation
  - Contrast with the notion of competitive depreciations during periods of weak global demand (1930s, 2010s)
  - But now the issue is scarce global supply of traded goods: echoes of the 1980s and of the Plaza Accord (Frankel, 2022)

Outline

1. Background facts
2. Theoretical framework
3. Demand imbalances in a closed economy
4. International transmission of inflation
5. International monetary policy cooperation
6. Supply disruptions in the T sector

Rise in energy prices

- Steep rise in energy prices
  - How does this affect core inflation and employment?
  - What is the optimal monetary policy response?
- Our perspective: manufacturing much more energy intensive than services

Introducing energy shocks

- T good produced using energy O as an intermediate input

$$Y_{i,0}^T = \left(L_{i,0}^T\right)^{\alpha(1-\alpha_o)} O_{i,0}^{\alpha_o}, \qquad \alpha(1-\alpha_o)+\alpha_o < 1$$

- Energy is sold by r.o.w. at price p_0^o in terms of T good, optimal energy use implies

$$p_0^o O_t = \alpha_o Y_{i,0}^T \rightarrow Y_{i,0}^T = \left(L_{i,0}^T\right)^{\alpha} \left(\frac{\alpha_o}{p_0^o}\right)^{\frac{\alpha_o}{1-\alpha_o}}$$

- Rise in energy price acts like a negative productivity shock in the T sector (supply chains disruptions have a similar effect)

Energy price and the Phillips curve

- Following the steps outlined above, Phillips curve can be written as

$$P_{i,0}^T = \frac{1}{\alpha(1-\alpha_o)} \left(\frac{p_0^o}{\alpha_o}\right)^{\frac{\alpha_o}{1-\alpha_o}} \left[\frac{\alpha\omega L_{i,0}}{\alpha\omega + \frac{1-\omega}{1-\alpha_o}\frac{C_{i,0}^T}{Y_{i,0}^T}}\right]^{1-\alpha} \tag{PC}$$

- Energy shocks shift the Phillips curve
  - Higher energy price requires a lower real wage to maintain the same level of employment
  - Since nominal wage cannot adjust, price inflation is needed to bring real wage down (Bruno and Sachs, 1979, Blanchard and Gali, 2007)

Optimal monetary policy response to energy shock

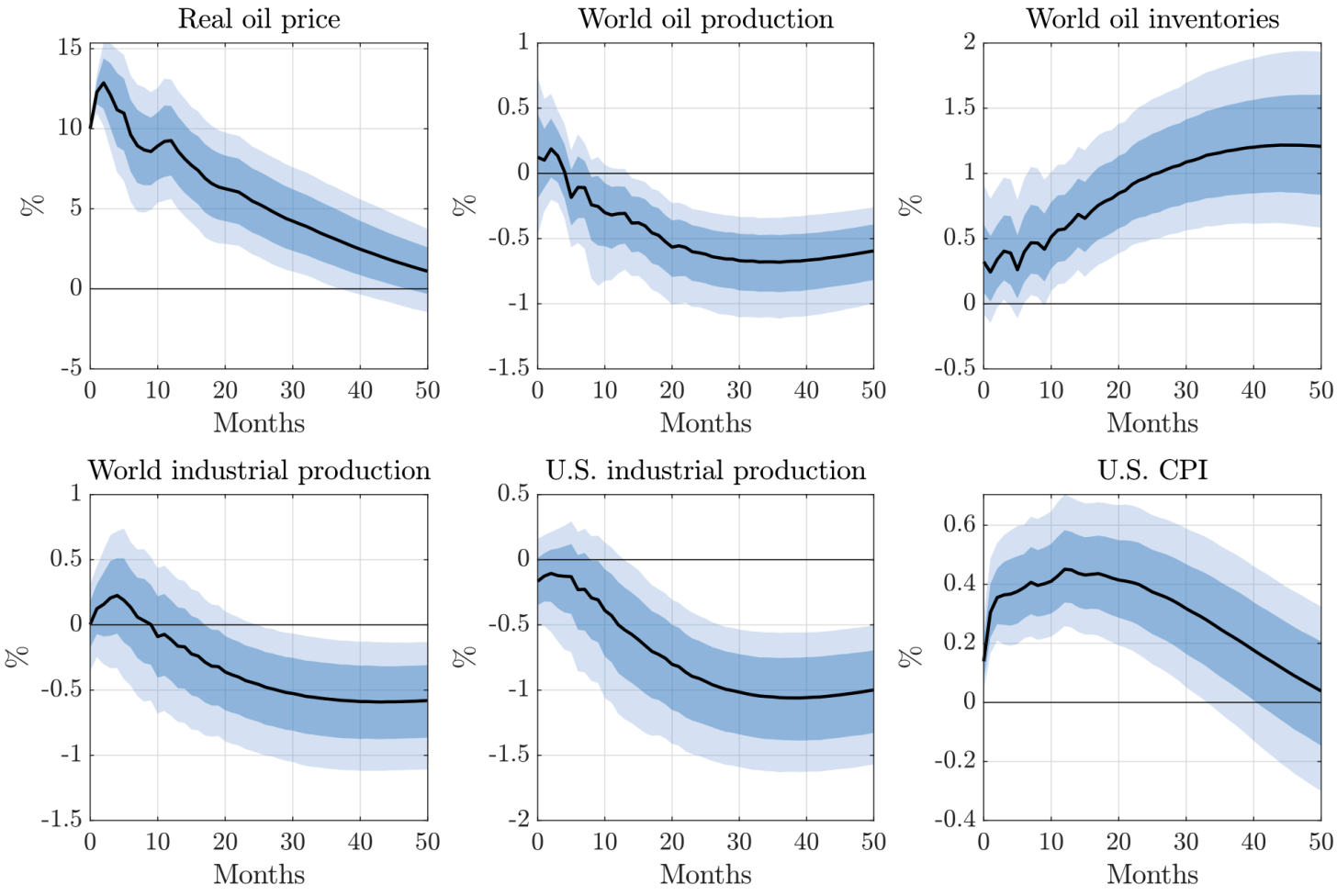
- Problem similar to the case of a reallocation shock: optimal monetary policy imposes a ceiling on inflation

$$\chi'\left(P_{i,0}\right) P_{i,0} = \frac{1}{\omega}\left(\frac{\alpha}{1-\alpha} + 1 - \omega\right)$$

- Rise in energy prices leads to
  - Higher inflation
  - Unemployment, if the shock is sufficiently large
- Hike in energy prices acts as a cost push shock, worsening the trade off between employment and inflation faced by the central bank

Optimal monetary policy response to energy shock

- Energy shock lowers demand for labor by T sector
- Rise in $P^T_{i,0}$ sustains demand and employment in both sectors
  - Competitiveness effect: $\downarrow W_{i,0}/P^T_{i,0}$, $\uparrow Y^T_{i,0}$, $\uparrow L^T_{i,0}$
  - Expenditure switching: $\uparrow \frac{P^T_{i,0}}{P^N_{i,0}}$ $\uparrow C^N_{i,0}$, $\uparrow L^N_{i,0}$
  - Income effect: $\uparrow Y^T_{i,0}$, $\uparrow C^T_{i,0}$, $\uparrow C^N_{i,0}$, $\uparrow L^N_{i,0}$
- Optimal policy trades off the inflation cost against the employment benefits
  - Manufacturing sector contracts
  - Service sector may expand or contract



First stage regression: F: 22.67, robust F: 10.55, R^2: 4.22%, Adjusted R^2: 4.04%

Figure 3: Impulse responses to an oil supply news shock

Source: Kanzig (2021)

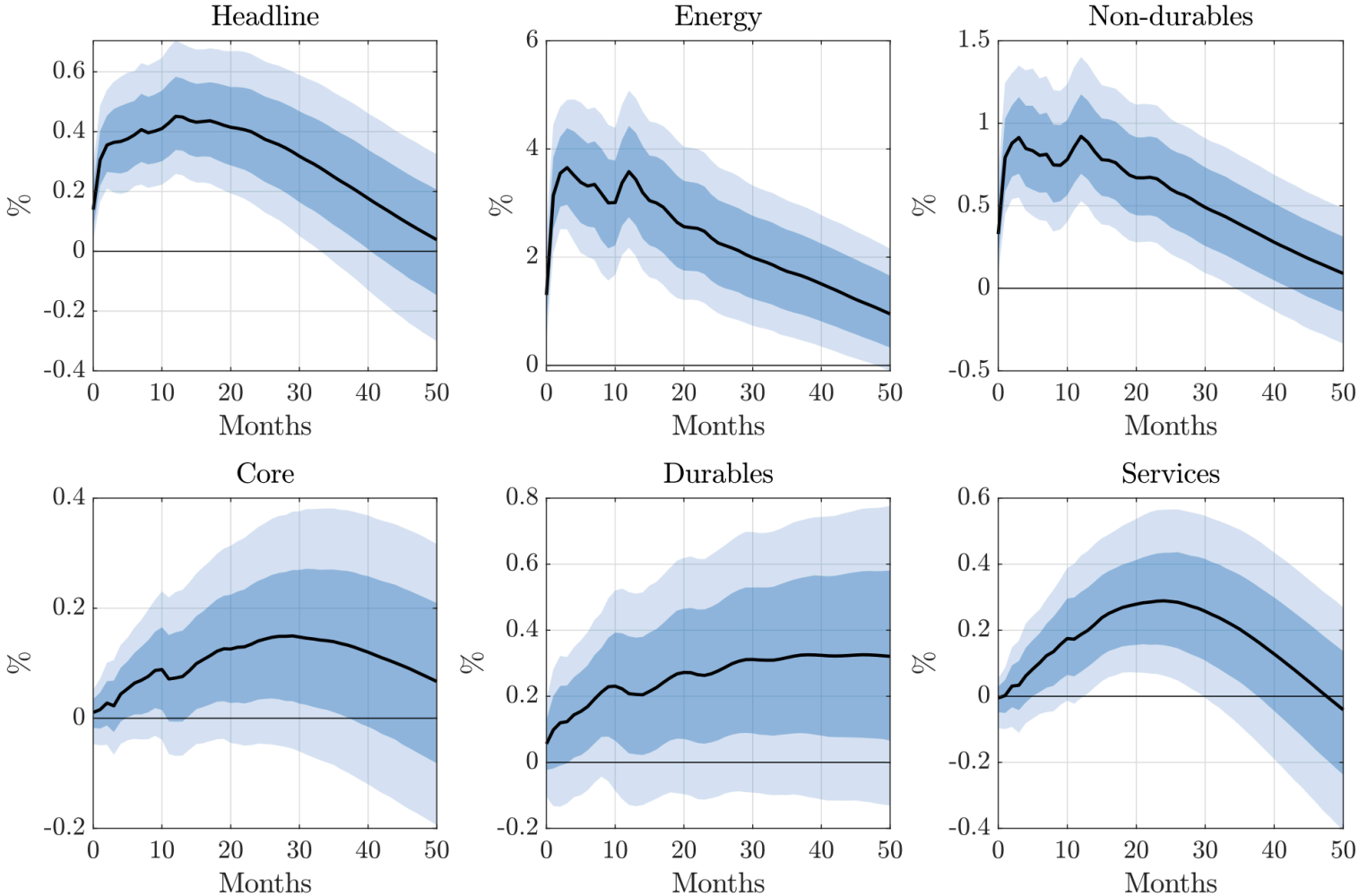
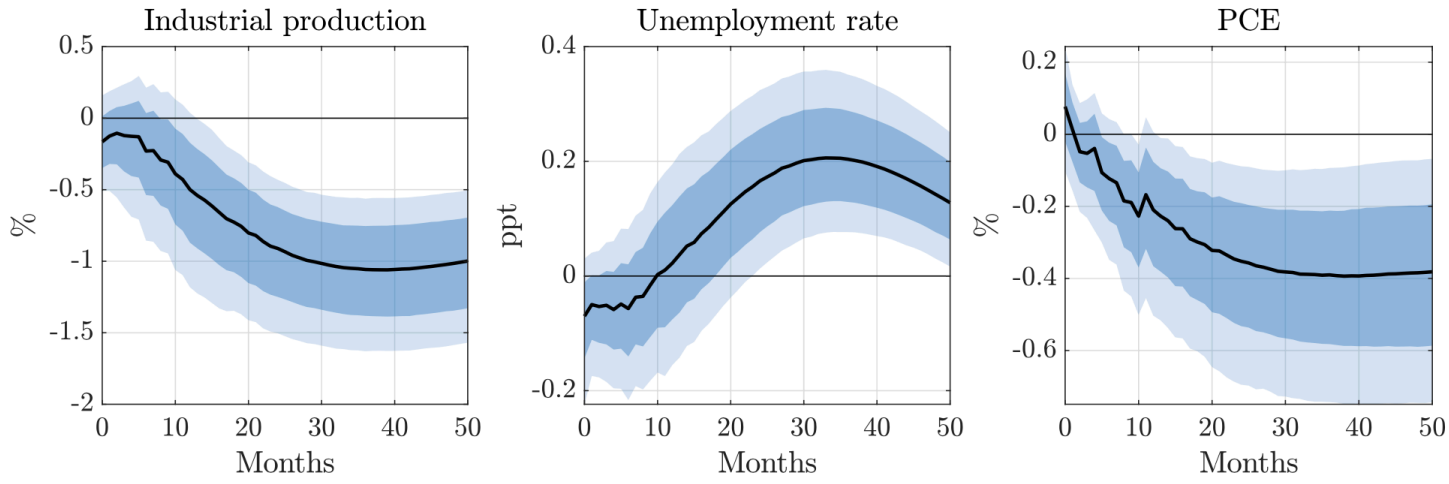


Figure 8: Consumer prices

Source: Kanzig (2021)



Panel B: Quarterly indicators

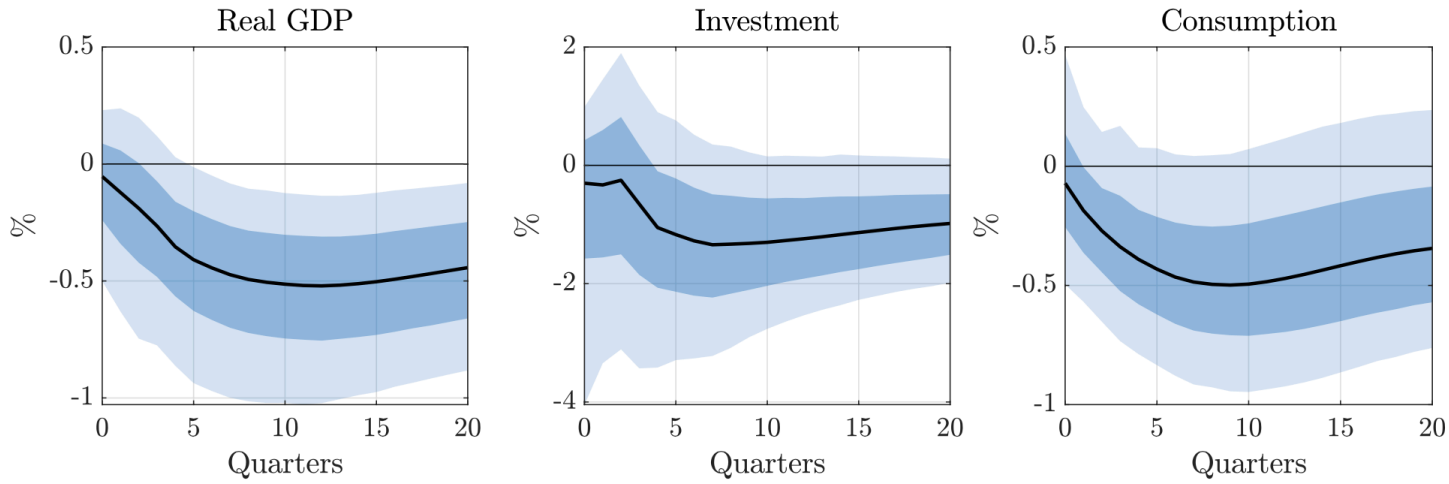


Figure 9: Economic activity

Source: Kanzig (2021)

Capital flows and energy shocks

- Under free capital mobility, $C_{i,1}^T$ determined by

$$C_{i,0}^T = (1-\beta)\left((1-\alpha_o)Y_{i,0}^T + \frac{R}{R-1}\frac{Y^T}{R_0}\right)$$

- Suppose rise in p_0^o affects a single country
  - Drop in $Y_{i,0}^T$, inflation, ER depreciation
  - Rise in trade balance deficit
  - Trade balance deficit helps contain inflation
- If the shock is global, rise in world interest rate (and oil consumers borrow from oil producers)

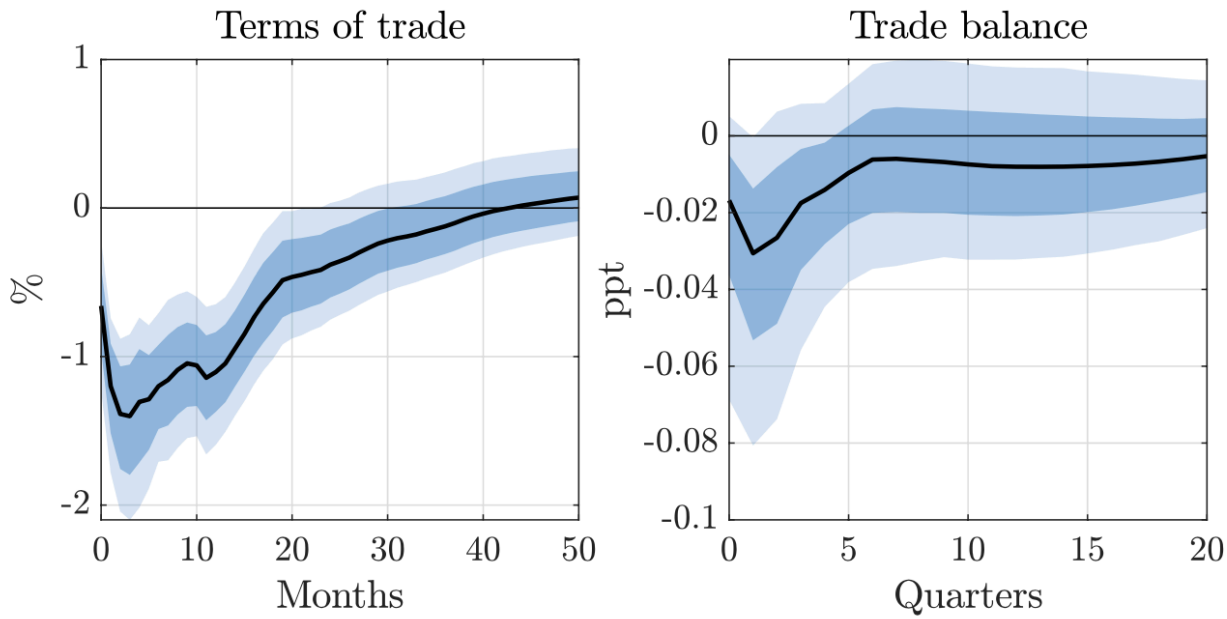


Figure 12: Trade

Source: Kanzig (2021)

International spillovers and gains from coordination

- Rise in energy prices generate the same inflation and demand spillovers seen for the reallocation shock
- Countries may engage in competitive appreciations and reverse currency wars
- After 1979 oil price shock US embarked in a disinflation process characterized by
  - Tight monetary policy and expansionary fiscal policy
  - Trade deficits and strong dollar
- Sachs (1985): trade deficits and strong dollar reduced inflation in the US, but exported it abroad
- See Auclert et al. (2023) for a complementary perspective

Summing up

- Global scarcity of tradable goods
  - Unbalanced demand caused by pandemic and fiscal transfers
  - Supply chains disruptions and high commodity prices
- Rise in inflation part of the optimal policy response
- Capital inflows and ER appreciation contain domestic inflation, but export inflation abroad
- Competitive appreciations may lead to excessively tight monetary policy and global slump

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