The Scars of Supply Shocks

Luca Fornaro & Martin Wolf

Inflation: Drivers and Dynamics 2022
FRB of Cleveland's Center for Inflation Research and the ECB
September, 2022

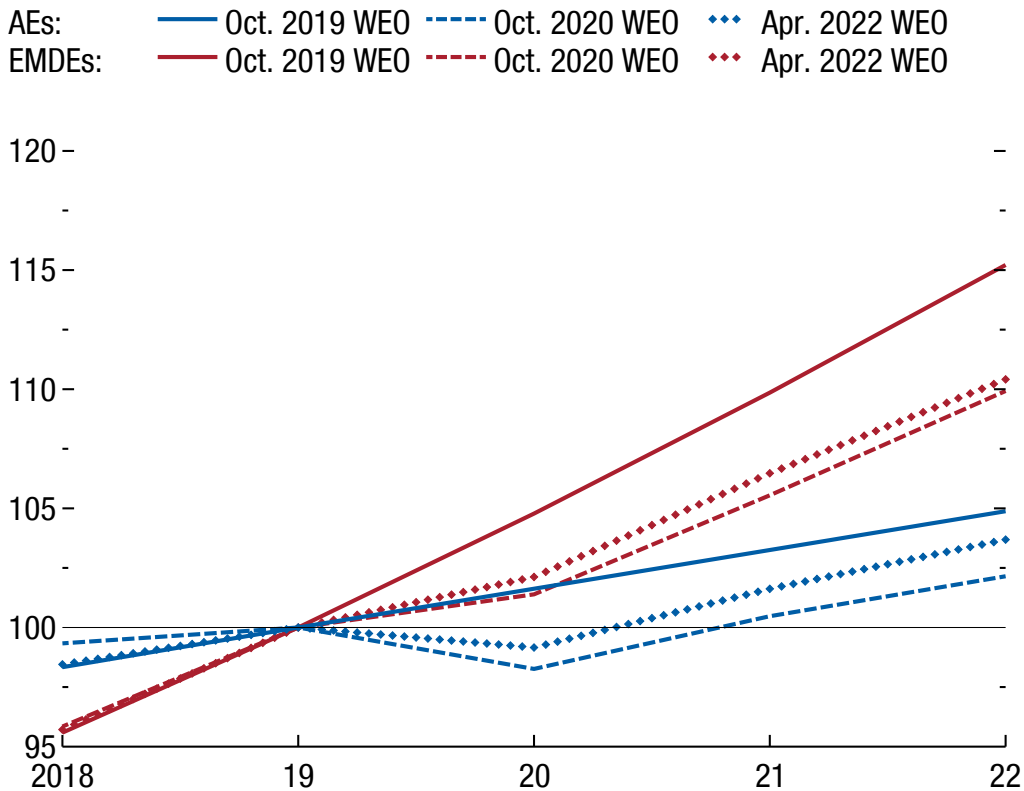
Motivation

Supply disruptions have plagued the global economy

1. Covid disrupted global supply chains and forced factories to shut down
2. Energy and food price shocks due to Russia's invasion of Ukraine

Many observers expect deep scarring effects, by inducing persistent drops in potential output below its pre-crisis trend (IMF, 2022)

Potential GDP (Index: 2019 = 100)



Source: IMF, World Economic Outlook, April 2022

This paper

Revisit the economics of supply disruptions through Keynesian growth model with *scarring effects*

- Nominal wage rigidity
- Firms invest in innovation to appropriate future monopoly rents

Main results

1. Scarring leads to negative wealth effect, depressing aggregate demand
2. Scarring implies additional inflation which pops up with a delay

Implications for monetary policy

Structure of the talk

1. Introduction
2. Model
3. Scarring and aggregate demand
4. Implications for inflation
5. Conclusion

2. Model.

Households

Representative household with utility

$$\sum_{t=0}^{\infty} \beta^t \log(C_t).$$

Households have access to a bond paying interest rate i_t, implies Euler equation

$$\frac{1}{P_t C_t} = \beta(1 + i_t) \frac{1}{P_{t+1} C_{t+1}}.$$

Desired labor supply is $\bar{L}$. $L_t < \bar{L}$ possible due to wage rigidities, described below

Firms

Final output is produced from labor L_t and intermediate goods $x_{j,t}$ with quality $A_{j,t}$

$$Y_t = (Z_t L_t)^{1-\alpha} \int_0^1 A_{j,t}^{1-\alpha} x_{j,t}^{\alpha} dj,$$

where the supply shock is denoted Z_t

Monopolistic competition in production of inputs j implies equilibrium profits

$$(P_{j,t} - P_t) x_{j,t} = P_t \varpi A_{j,t} Z_t L_t,$$

where $\varpi > 0$ is a parameter

- Profits increase in quality $A_{j,t}$
- Profits increase in market size $Z_t L_t$

Innovation

A firm j investing one unit of the final good sees its productivity evolve as (*vertical innovation*)

$$A_{j,t+1} = A_{j,t} + \chi I_{j,t}.$$

Maximize NPV of monopoly rents implies

$$\frac{1}{\chi} = \frac{\beta C_t}{C_{t+1}} \left(\varpi Z_{t+1} L_{t+1} + \frac{\eta}{\chi} \right),$$

where η is probability of losing monopoly rent in the future

Monetary policy and nominal rigidity

As in Werning (2015) and Mian et al. (2021), treat monetary policy as choosing the real interest rate directly, $r_t = (1 + i_t)(P_t / P_{t+1}) - 1$

- Implies we can study real side of the economy without making nominal rigidity explicit (see Section 3)
- Nominal rigidity merely pins down inflation dynamics, discussed in Section 4

Summary of equilibrium in 3 equations

Denote $c_t \equiv C_t / A_t$ and $g_t \equiv A_t / A_{t-1}$. *Aggregate demand* is

$$c_t = \frac{g_{t+1} c_{t+1}}{\beta(1 + r_t)}. \tag{AD}$$

The *growth equation*

$$g_{t+1} = \frac{\beta c_t}{c_{t+1}} (\chi \varpi Z_{t+1} L_{t+1} + \eta). \tag{GG}$$

The *resource constraint*

$$\Psi Z_t L_t = c_t + \frac{g_{t+1} - 1}{\chi}, \tag{RR}$$

where $\Psi > 0$ is a parameter.

Equ: path for $\{c_t, g_{t+1} > 1, L_t \leq \bar{L}\}$ s.t. (AD), (GG) and (RR) hold, given supply shock $\{Z_t\}$ and monetary policy $\{r_t\}$.

3. Scarring and aggregate demand.

Overview

In this section we establish that scarring effects depress aggregate (consumption) demand

- Scarring means future potential output is lost
- By a negative wealth effect, consumption demand falls

Study supply disruptions of the form

$$\log(Z_t) = \rho \log(Z_{t-1}), \tag{1}$$

with initial condition $Z_0 < 1$

The natural interest rate

Summary statistic of the balance aggregate supply/demand

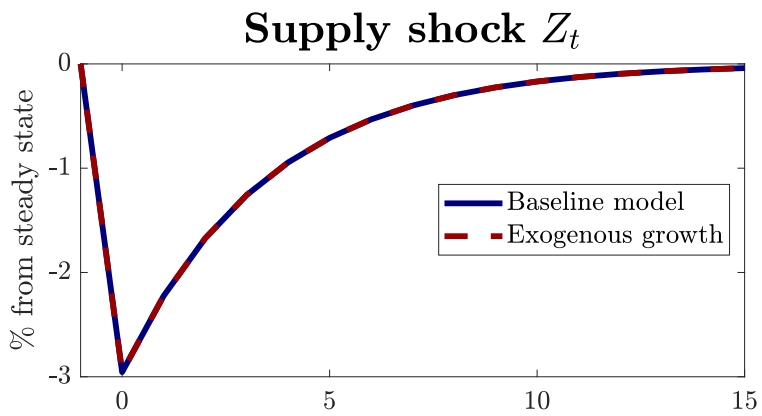
Assume investment-in-innovation share of GDP is small, $\Psi Z_t L_t \approx c_t$. From (AD), the natural rate is given by

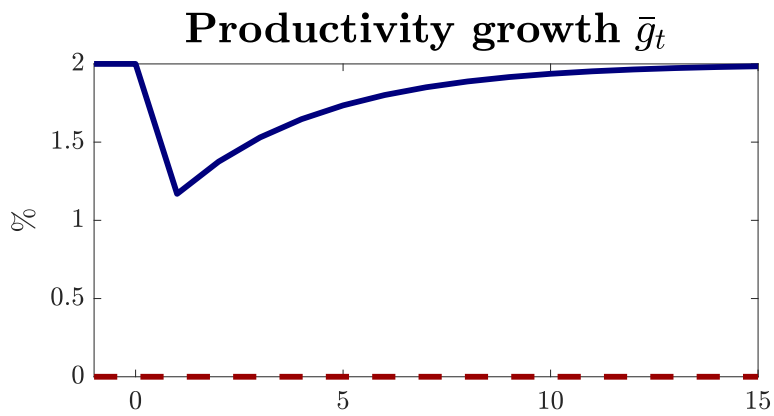
$$1 + \bar{r}_t = \frac{\bar{g}_{t+1}\bar{c}_{t+1}}{\beta \bar{c}_t} = \frac{\bar{g}_{t+1}\Psi Z_{t+1}\bar{L}}{\beta \Psi Z_t \bar{L}} = \frac{\bar{g}_{t+1} Z_0^{\rho^t(\rho-1)}}{\beta}.$$

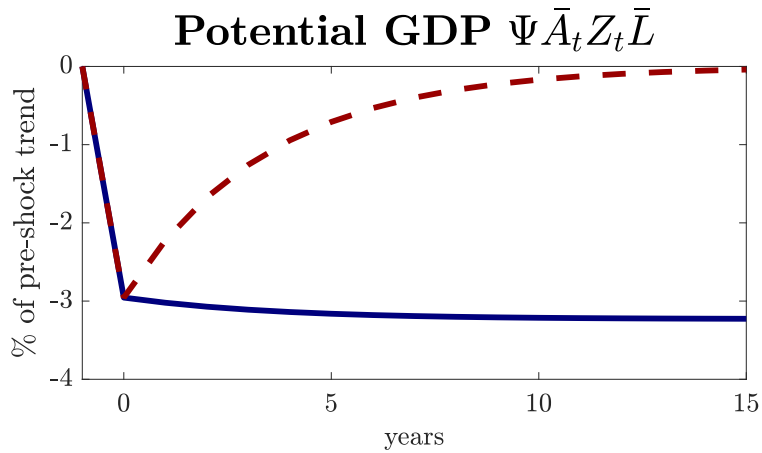
- $Z_0 \downarrow$ implies $\bar{r}_t \uparrow$, i.e. supply falls by more than demand
- Endogenous response of $\bar{g}_{t+1} \downarrow$ (*scarring*) implies $\bar{r}_t \downarrow$

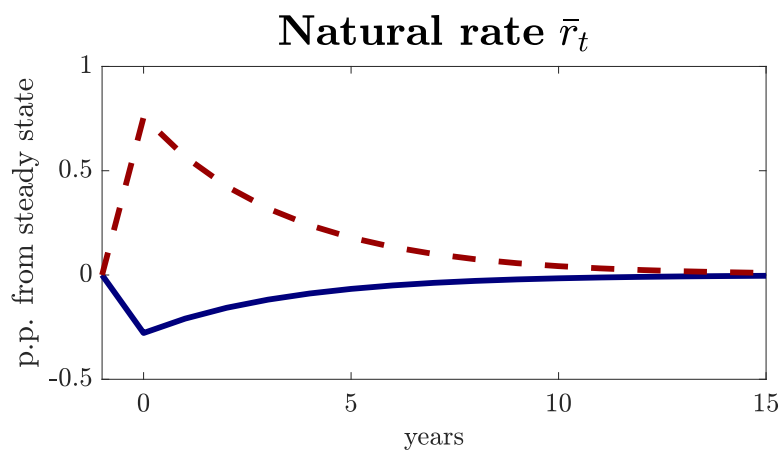
$\Longrightarrow$ Scarring depresses aggregate demand, implying $\bar{r}_t$ rises by less or may even decline

The scars of supply shocks









The supply-demand doom loop

Weak aggregate demand can reinforce scarring effects, triggering a *supply-demand doom loop*

To see this, assume that

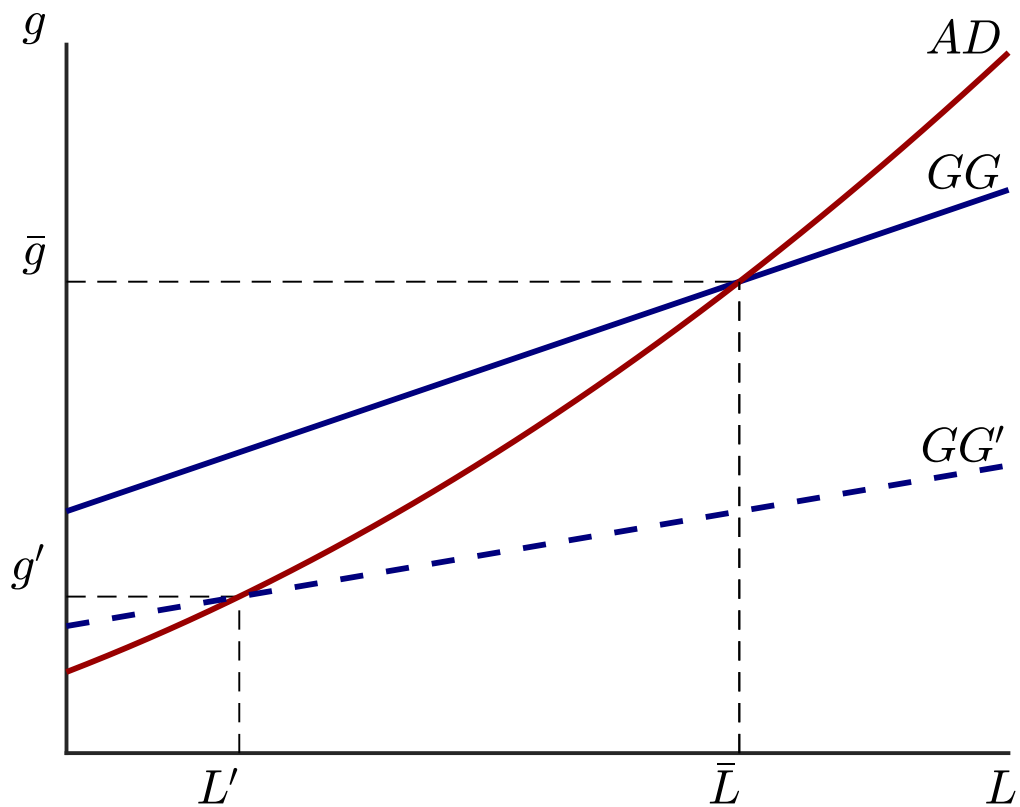
1. Central bank follows the rule $1 + r_t = (1 + \bar{r})(L_t / \bar{L})^{\varphi}$, $\bar{\varphi} < \varphi < \infty$
2. Supply shock is permanent, $Z_t = Z$ for all t

Then (AD) and (GG) become two equations in g and L

$$g = \beta(1 + \bar{r}) \left(\frac{L}{\bar{L}} \right)^{\varphi} \tag{AD}$$

$$g = \beta(\chi \omega Z L + \eta) \tag{GG}$$

Effect of supply disruption in $L - g$ diagram



- Low growth implies negative output gap driven by weak demand
- Output gap implies low growth driven by weak incentives to invest

Lessons for monetary policy

$\Longrightarrow$ Scarring effects call for *less tight* monetary policy response if goal is to stabilize the output gap

$\Longrightarrow$ Tightening too much not only triggers a negative output gap, but implies additional scarring (consistent with evidence by Moran and Queralto, 2018; Garga and Singh, 2020; Jorda et al., 2020)

4. Implications for inflation.

Overview

In this section we establish that scarring effects imply additional inflation which pops up with a delay

$\Longrightarrow$ May help explain why supply shocks can trigger inflation spells which are highly persistent

Determinants of inflation

Consider firms' first order condition for labor

$$P_t = \frac{1}{1-\alpha}\left(\frac{1}{\alpha}\right)^{\frac{2\alpha}{1-\alpha}} \frac{W_t}{A_t Z_t}. \tag{2}$$

The impact of the shock on inflation is mediated by two forces

1. The impact of the shock on wages W_t
2. The impact of the shock on productivity, Z_t and A_t

Assume now wages follows the law of motion

$$\frac{W_t}{W_{t-1}} = \bar{g}^{1-\omega}\left(g_t \frac{Z_t}{Z_{t-1}}\right)^{\omega}\left(\frac{L_t}{\bar{L}}\right)^{\xi}, \tag{3}$$

with ω indexation to productivity, ξ sensitivity w.r.t. unemployment (*Phillips curve*)

Scarring effects and inflation

Assume again central bank closes the output gap ($r_t = \bar{r}_t \Rightarrow L_t = \bar{L}$). Combining (2)-(3) and denoting $\pi_t \equiv P_t / P_{t-1}$,

$$\pi_t = \bar{g}^{1-\omega} \left(\bar{g}_t \frac{Z_t}{Z_{t-1}} \right)^{\omega-1}. \tag{4}$$

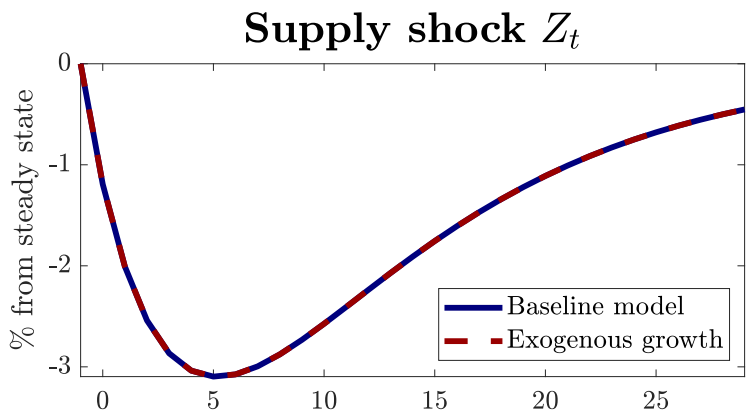
Scarring implies *additional* inflation

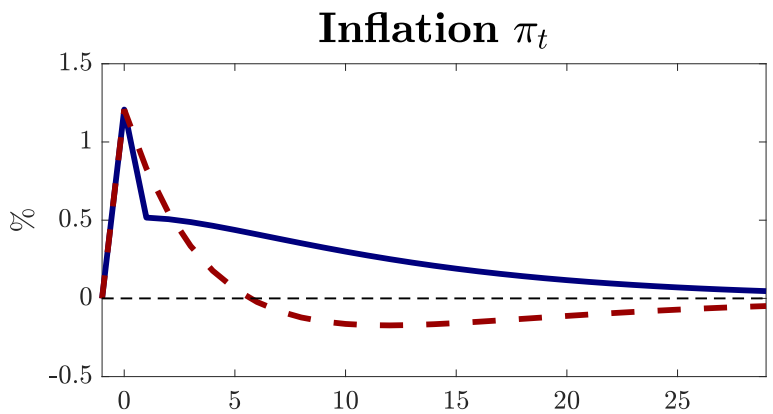
- Decline in growth means firms' marginal cost is higher
- Assumes that nominal wages not perfectly indexed to productivity (i.e. wages do not fall)

Additional inflation pops up with a *delay* ($\pi_{t+1} \uparrow$ as $\bar{g}_{t+1} \downarrow$)

- Declines in investment take time to translate into productivity losses
- Inflation may remain high, even after the shock has ended

Scarring effects and inflation





$\Longrightarrow$ As supply shock fades (*disinflationary* phase), inflation can remain stubbornly high

Lessons for monetary policy

Assume central bank has incentives to dampen inflation (add inflation costs to the model)

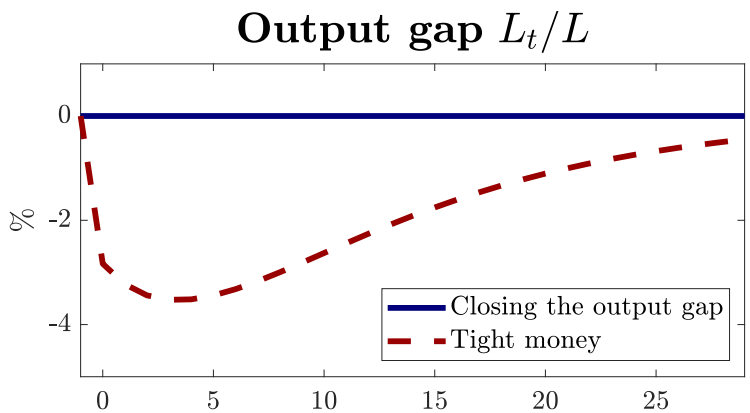
$\Longrightarrow$ A policy of tight money can backfire, due to the supply-demand doom loop

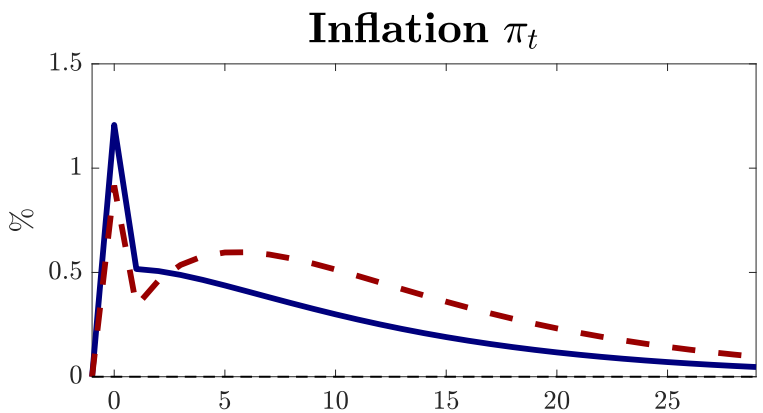
Combine again (2)-(3), this time for an arbitrary output gap

$$\pi_t = \bar{g}^{1-\omega} \left(g_t \frac{Z_t}{Z_{t-1}} \right)^{\omega-1} \left(\frac{L_t}{\bar{L}} \right)^{\xi}. \tag{5}$$

- Tight money implies $L_t \downarrow$ hence $\pi_t \downarrow$, but due to $g_{t+1} \downarrow$ also $\pi_{t+1} \uparrow \Longrightarrow$ shifts inflation from the present into the future
- Especially acute when indexation of wages to productivity is weak and the Phillips curve is flat

Scarring effects and inflation





- By destroying productive capacity, a tight monetary stance pushes inflation into the future
- Implies additional trade-offs for monetary policy

5. Conclusion.

We have revisited the economics of supply disruptions through the lens of a Keynesian growth model with scarring effects

Main results

1. Scarring reduces aggregate demand by a negative wealth effect
2. Scarring implies persistent high rates of inflation

$\Longrightarrow$ Important lessons for monetary policy