COVID-19, Crises Policies and the Long Run

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The opinions expressed are those of the authors and do not necessarily reflect the views of the Bank of Finland.

Outline

- **Main objectives:**
  - Study the macroeconomic effect of the COVID-19 shock in a DSGE model with endogenous total factor productivity dynamics
  - Evaluate the role of economic policies in this context (over the short- and long-term)

- **Research questions:**
  1. What are the implications of the COVID-19 shock on inflation and productivity growth?
  2. What to expect with respect to the shape of the recovery and depth of the recession?
  3. What is the role of monetary policy and other crisis policies in this setup?

Previous literature

- **Macroeconomic effects of COVID-19** (Eichenbaum, Rebelo and Trabandt (2020), Guerrieri, Lorenzoni, Straub and Werning (2020), Fornaro and Wolf (2020), ...)
- **Hysteresis effects in TFP and deep recessions**
  - **Estimated DSGE models with endogenous technology growth** (Garga and Singh (2020, JME), Anzoategui et al. (2019, AEJ: Macro), Bianchi et al. (2019, JME); Moran and Queralto (2018, JME), Schmöller and Spitzer (2020))
  - Possibility of **stagnation traps** (Benigno and Fornaro (2018, RES))
- **Empirical evidence on hysteresis effects in TFP** (Jorda et al. (2020); Moran and Queralto (2018, JME))

Model

- Medium-scale DSGE model with endogenous total factor productivity dynamics
- Endogenous technology growth mechanism (Comin and Gertler (2006)):
  - Innovation through R&D
  - Technology adoption
- Otherwise standard DSGE model setup (Christiano et al. (2005); Smets and Wouters (2007))
  - Calvo price and wage rigidities
  - ELB constraint
- COVID-19 shock as a combination of:
  - Pandemic-induced adverse demand shock
  - Supply chain disruptions & capacity restrictions
  - Labor supply shock

Endogenous technology mechanism

- Departure from the standard exogenous TFP assumption
- Two-stage technology growth process (Comin and Gertler (2006)):
  1. Horizontal innovation through expanding varieties in intermediate goods (Romer (1990))
  2. Endogenous diffusion: costly technology adoption
- TFP decomposition:

$$TFP_t = \theta_t A_t^{\vartheta - 1}$$

  - θ_t: standard technology shock
  - A_t: endogenous component of TFP

R&D and innovation

- Competitive innovators invest in R&D to invent new intermediate goods
- Innovator i's production function: $V_t^i = \chi Z_t \frac{1}{Z_t^{\zeta} X_t^{1-\zeta}} X_t^i = \varphi_t X_t^i$
- Spillover from aggregate innovation stock Z_t and "congestion" externality ($\frac{1}{Z_t^{\zeta} X_t^{1-\zeta}}$, where $0 < \zeta < 1$)
- Aggregate R&D: $X_t = \int_i X_t^i di$
- Law of motion of technology stock: $Z_{t+1} = \phi Z_t + \varphi_t X_t$
- Innovator i's problem:

$$\max_{\{X_{t+j}^i\}_{j=0}^{\infty}} \mathbb{E}_t \sum_{j=0}^{\infty} \Lambda_{t,t+1+j} \left(J_{t+1+j} \varphi_{t+j} X_{t+j}^i - \left(1 + f^x \left(\frac{X_{t+j}^i}{X_{t+j-1}^i} \right) \right) X_{t+j}^i \right)$$

Technology adoption

- Adopter uses equipment E_t^i to render a technology useable in production
- Probability of successful adoption:

$$\lambda_t\left(E_t^i\right) = \kappa_\lambda \left(\frac{X_t}{A_t}\right)^\eta \left(E_t^i\right)^{\rho_\lambda}$$

- Adopters' problem:

$$J_t = \max_{E_t^i} -Q_t^a E_t^i + \phi \mathbb{E}_t \left\{\Lambda_{t,t+1}\left[\lambda_t\left(E_t^i\right) H_{t+1} + \left(1 - \lambda_t\left(E_t^i\right)\right) J_{t+1}\right]\right\}$$

- Optimality condition for adoption:

$$\rho_\lambda \kappa_\lambda \phi \left(\frac{X_t}{A_t}\right)^\eta \mathbb{E}_t\left[\Lambda_{t,t+1}\left(H_{t+1} - J_{t+1}\right)\right] = Q_t^a E_t^{1-\rho_\lambda}$$

- Law of motion for adopted technologies:

$$A_{t+1} = \phi\left[A_t + \lambda_t\left(Z_t - A_t\right)\right]$$

Intermediate goods production

- Intermediate goods output: $Y_t^m = \left[\int_0^{A_t} \left(Y_t^{i\,m}\right)^{\frac{\vartheta-1}{\vartheta}} di\right]^{\frac{\vartheta}{\vartheta-1}}$
- Price of intermediate good composite: $P_t^m = \left[\int_0^{A_t} \left(P_t^i\right)^{1-\vartheta} di\right]^{\frac{1}{1-\vartheta}}$
- Intermediate good production function: $Y_t^{i\,m} = \theta_t \left(K_t^i\right)^{\alpha} \left(L_t^i\right)^{1-\alpha}$
- Cost minimization:

$$\alpha \frac{\vartheta - 1}{\vartheta} \frac{P_t^m}{P_t} \frac{Y_t^m}{K_t} = R_t^k \tag{1}$$

$$(1-\alpha) \frac{\vartheta - 1}{\vartheta} P_t^m \frac{Y_t^m}{L_t} = W_t \tag{2}$$

- Aggregation:

$$Y_t^m = \theta_t A_t^{\frac{1}{\vartheta-1}} K_t^{\alpha} L_t^{1-\alpha} \tag{3}$$

Final good production

- Final good composite: $Y_t = \left[\int_0^1 Y_t^{i\,\frac{\mu-1}{\mu}} di\right]^{\frac{\mu}{\mu-1}}$
- Price level of final output: $P_t = \left[\int_0^1 P_t^{i\,1-\mu} di\right]^{\frac{1}{1-\mu}}$
- Final goods producer i's output (from cost minimization):

$$Y_t^i = \left(\frac{P_t^i}{P_t}\right)^{-\mu} Y_t \tag{4}$$

- Price indexation rule: $P_t^i = P_{t-1}^i \pi_{t-1}^{\iota_p} \bar{\pi}^{1-\iota_p}$
- Final good producer's problem (s.t. equ. 4)

$$\max_{P_t^*} \mathbb{E}_t \sum_{j=0}^{\infty} \xi_p^j \Lambda_{t,t+j} \left(\frac{P_t^* \prod_{k=1}^{j} \pi_{t+k-1}^{\iota_p} \bar{\pi}^{1-\iota_p}}{P_{t+j}} - \frac{P_{t+j}^m}{P_{t+j}} \right) Y_{t+j}^i \tag{5}$$

Capital producers: investment

- Capital producers turn final output into capital which they sell to households at price Q_t
- Capital adjustment costs
- Maximize expected discounted profits
- Marginal costs of generating investment goods equals their price:

$$Q_t = 1 + f_i\left(\frac{I_t}{I_{t-1}}\right) + \frac{I_t}{I_{t-1}} f_i'\left(\frac{I_t}{I_{t-1}}\right) - \mathbb{E}_t\left[\Lambda_{t+1}\left(\frac{I_t}{I_{t-1}}\right)^2 f_i'\left(\frac{I_t}{I_{t-1}}\right)\right] \tag{6}$$

- Law of motion for capital:

$$K_{t+1} = (1-\delta)\,K_t + I_t \tag{7}$$

Employment agencies

- Continuum of households $i \in [0,1]$ monopolistically supply specialized labor L_t^i
- Large number of competitive employment agencies:

$$L_t = \left[\int_0^1 {L_t^i}^{\frac{\omega-1}{\omega}} di \right]^{\frac{\omega}{\omega-1}} \tag{8}$$

- Labor demand for type i (from cost minimization):

$$L_t^i = \left(\frac{W_t^i}{W_t} \right)^{-\omega} L_t \tag{9}$$

- Wages:

$$W_t = \left[\int_0^1 {W_t^i}^{1-\omega} di \right]^{\frac{1}{1-\omega}} \tag{10}$$

Households

- Household i maximizes utility

$$\mathbb{E}_t \left\{ \sum_{j=0}^{\infty} \beta^j \left[log\left(C_{t+j} - bC_{t+j-1}\right) + \varrho B_{t+1} - \frac{\psi}{1+\nu} L_{i,t+j}^{1+\nu} \right] \right\} \quad (11)$$

subject to the budget constraint

$$\frac{W_t^i}{P_t} L_t^i + R_t \frac{B_t}{P_t} + \left(R_t^k + (1-\delta)\, Q_t \right) K_t + \Pi_t = C_t + \frac{B_{t+1}}{P_t} + Q_t K_{t+1} \quad (12)$$

- Optimal wage set subject to labor demand:

$$\max_{W_t^*} \mathbb{E}_t \sum_{j=0}^{\infty} \left\{ (\xi_w \beta)^j \left[\frac{U_{c,t+j}}{P_{t+j}} L_{t+j}^i W_t^* \prod_{k=1}^{j} (1+g)\, \pi_{t+k-1}^{\iota_w} \bar{\pi}^{1-\iota_w} - \frac{\psi}{1+\nu} \left(L_{t+j}^i \right)^{1+\nu} \right] \right\} \quad (13)$$

- Wage indexation: $W_t^i = W_{t-1}^i \,(1+g)\, \pi_{t-1}^{\iota_w} \bar{\pi}^{1-\iota_w}$

Monetary policy and the ELB

- Standard Taylor rule:

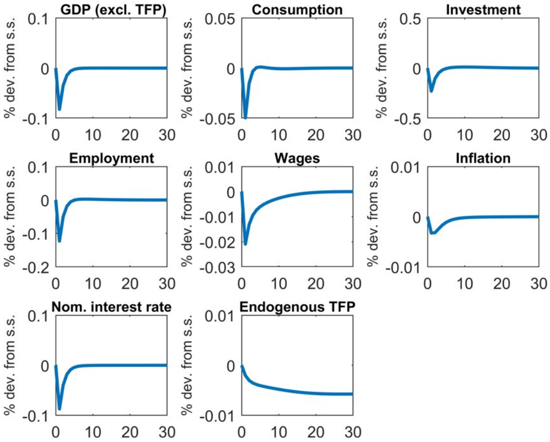
$$i_t = max\Big(\; r^* + \pi_t + \gamma_\pi \, (\pi_t - \bar{\pi}) + \gamma_y \, \tilde{y}_t \; , \; 0 \; \Big) \qquad (14)$$

- Output gap measure: $\tilde{y}_t = y_t - y_t^{pot}$
- Potential output: allocation under fully flexible prices and wages
- ELB constraint:

$$i_t \geq \bar{i}_{ELB} \qquad (15)$$

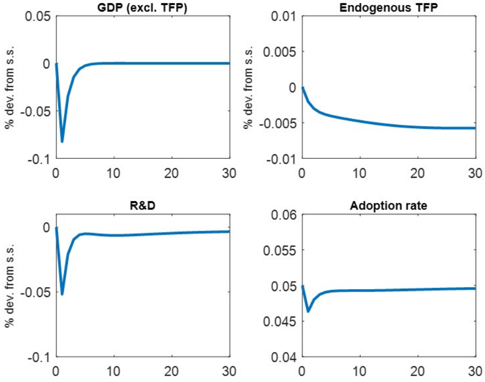
Health-induced demand shock: Macroeconomic response

- Adverse demand shock induced by the pandemic
- Risk of contracting the virus while consuming in exposed sector
- Depressing effect on inflation

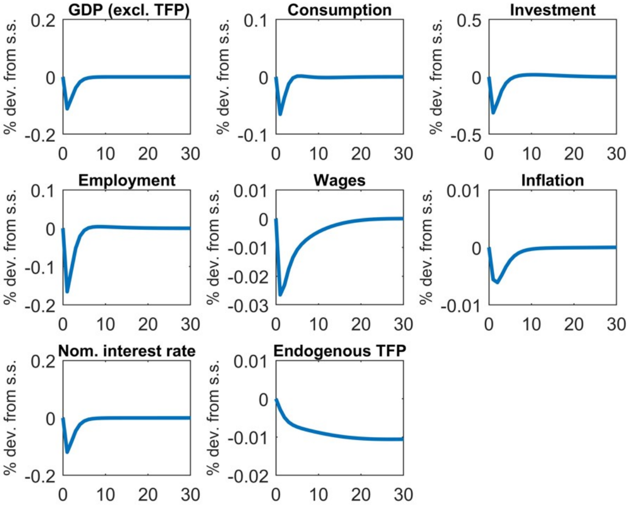


Health-induced demand shock: Technology and TFP

- Deceleration of TFP growth: Spillovers from exposed sector to unexposed productivity-improving sectors
- Persistence of the consumption shock also matters for the strengths of the hysteresis effects in TFP



Health-induced demand shock(persistent): Macroeconomic response



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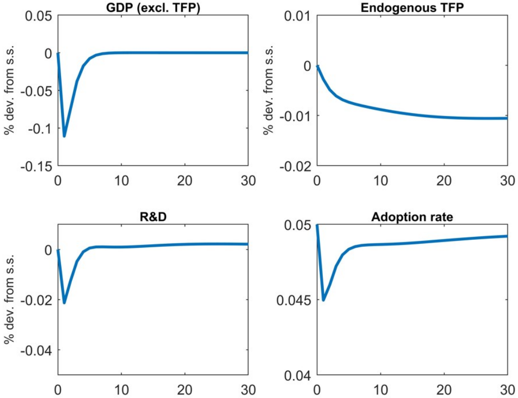
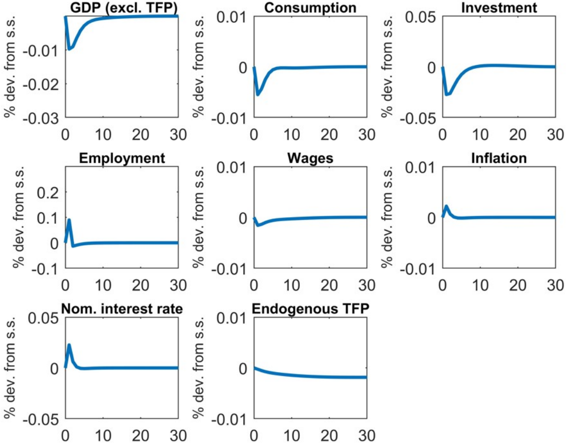


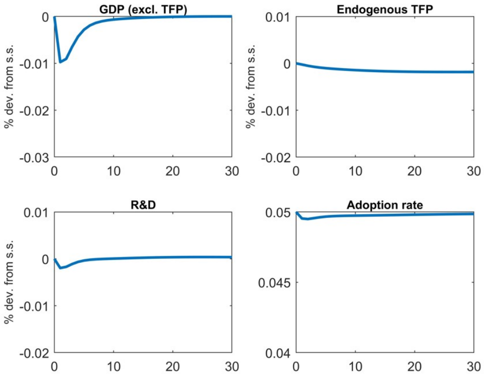
Supply-chain disruptions & capacity restrictions: Macroeconomic response

- Direct shock to total factor productivity (technology shock)
- GDP drops, inflationary
- Assumed subordinate relative to demand channel



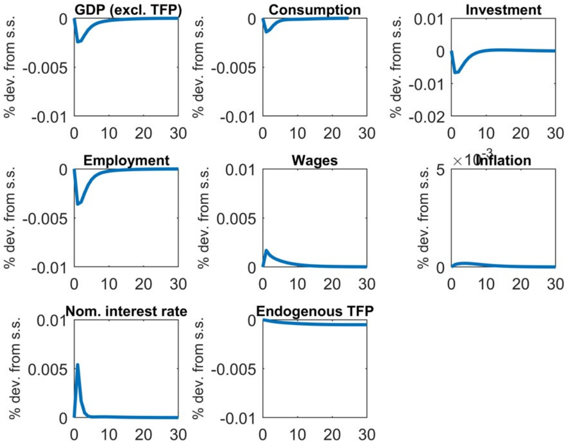
Supply-chain disruptions & capacity restrictions: Technology and TFP

- Slowdown in TFP growth
- Adverse TFP effect larger than the initial shock owed to adverse effects on technology-improving investments



Labor supply shock: Macroeconomic response

- Work-specific risks of contracting the virus
- Absences of infected persons from work
- Creates inflation
- Evaluated as relatively low strengths in this context



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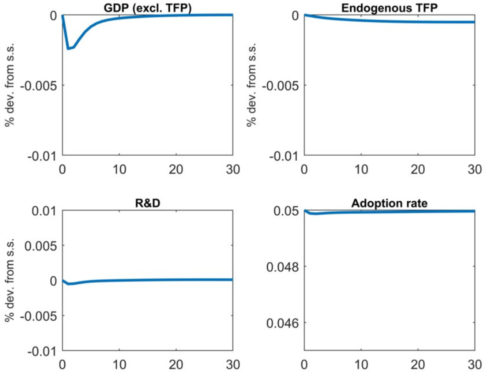
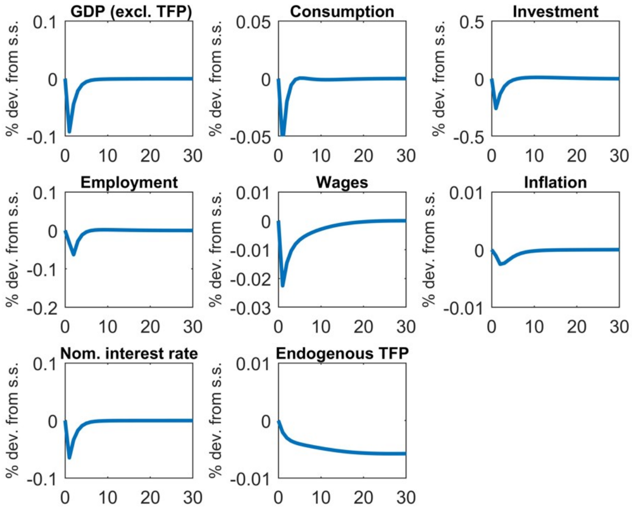
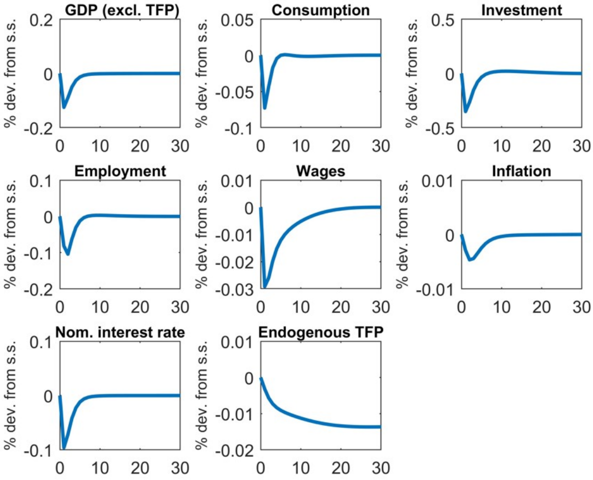


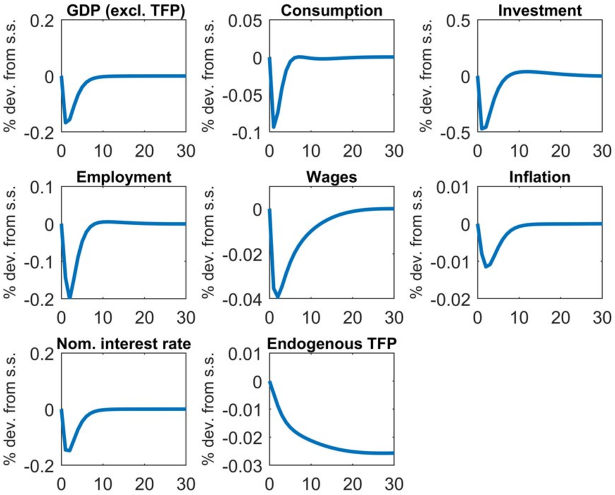
COVID-19: Combined effect of the shocks (short-lived)



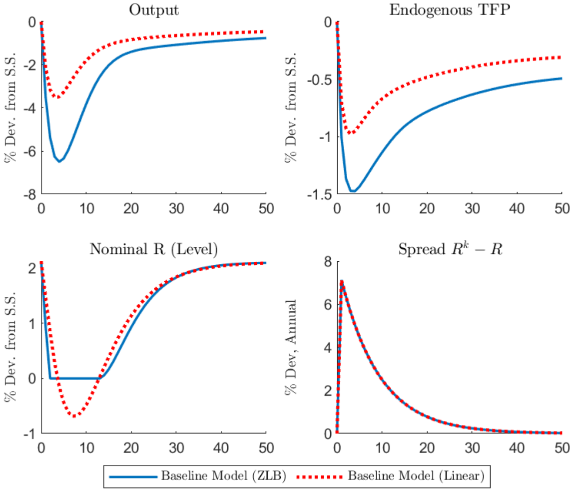
COVID-19: Combined effect of the shocks (prolonged)



COVID-19: Combined effect of the shocks (persistent)



Intensification of technology spillovers at the ELB



COVID-19 and Fiscal Policy

- **Increased role of fiscal policy** given the risk of demand-supply spillovers under hysteresis mechanism
- Higher importance of **fiscal-monetary interaction** at the ELB
- Strong role for **well-targeted fiscal policies** to break feedback to productivity
  - Investment in R&D and supporting innovation
  - Fostering technology adoption

Ongoing research

- Analysis of the role of **fiscal policy**
- **Different types of technologies (digital vs. non-digital)**:
  - Special role of digital goods in COVID-19 crisis mitigation
  - Allow for counteracting effect through digital technology adoption

Conclusions

- **Low inflation if demand channel predominant**
- **Intensification of the productivity slowdown in the baseline model**
  - Spillovers to unaffected sectors
  - Long-lasting effect of the covid-19 shock, even when in itself short-lived
  - Hysteresis effects
  - Long-lasting depressing effect on productivity via demand-supply feedback
- **Long-run losses increasing in shock persistence**: successful management of the pandemic of essence also from a long-run perspective
- **Increased role of monetary policy and other crises support policies owed to risk of demand-supply feedback**