DEUTSCHE BUNDESBANK
EUROSYSTEM

Gauging the Effects of the German COVID-19 Fiscal Stimulus Package

Natascha Hinterlang, Stéphane Moyen, Oke Röhe and Nikolai Stähler |

8th Conference on New Developments in Business Cycle Analysis |

13/12/2021

Motivation

- Major economic recession following COVID-19 pandemic and lockdown measures in Germany
- Heterogeneity across sectors and reduction in international trade as key characteristics
- Large fiscal stabilisation and stimulus packages in place

$\Rightarrow$ What are the macroeconomic effects of these fiscal measures?

$\Rightarrow$ Who benefits?

Approach

- Multi-sectoral DSGE model (Bouakez et al., 2018; 2020) with international trade (Bergholt and Sveen, 2014)
- Seven NACE sectors
- Two types of households: Optimizer and Rule-of-Thumber (RoT)

$\Rightarrow$ assess the macroeconomic effects of the fiscal intervention compared to a counterfactual baseline pandemic scenario

Related literature

- Modeling of COVID-19 shocks and crisis:
  Atkeson (2020), Eichenbaum et al. (2020), Farhi and Baqaee (2020), Brinca et al. (2020), Balleer et al. (2020)
- Effects of fiscal policy responses:
  Bayer et al. (2020), Pfeiffer et al. (2020), Elenev et al. (2020), Kaplan et al. (2020), Faria-e-Castro (2021)
- Multi-sectoral DSGE:
  Bouakez et al. (2018, 2020), Bergholt and Sveen (2014)

Households and firms

- Economy populated by a share of rule-of-thumbers and remaining share of optimizers that maximize utility subject to standard budget constraint ▸ HH opt. problem
- Labor and capital agencies sell input factors to intermediate goods producers operating in different sectors
- Seven sectors: Agriculture, Mining, energy & water supply, Manufacturing, Trade, transport, accomod. & food, IT, Prof., scient. & techn. services, Culture
- CES production function: Goods are produced with labor, private and public capital and a bundle of intermediate inputs subject to Rotemberg capital adjustment costs and idiosyncratic productivity shocks ▸ Firm opt. problem

Firm default

- Wholesalers sell CES bundles of consumption and investment goods
- Working capital channel: Firms need to pay factor inputs before production by taking up a bank loan subject to a sector-specific lending rate including a finance premium ▸ Bank opt. problem
- Along the lines of Agenor et al. (2014): Firm declares default if its revenue cannot cover its costs ▸ Default threshold

Government, trade and market clearing

- Monetary policy rate assumed to be constant
- The fiscal authority finances government consumption investment, transfers to households or firms and interest payments on outstanding debt by taxing labor income (including social security contributions) and consumption, the issuance of new debt and lump-sum taxes ▸ Gov. BC
- Germany as a small open economy: exports and prices for foreign goods assumed to be exogenously given
- All markets must clear

Calibration

- Germany, quarterly frequency
- Common parameters from the literature
- Sector-specific parameters calibrated to (WIOD) data:
  - Factor intensities
  - Inter-sectoral trade shares of intermediate inputs
  - Shares in (government) consumption and investment goods
  - Home biases
  - Capital and labor weights
  - Probabilities of default
  - Productivity of public capital
  - Price adjustment costs and mark-ups

▸ Common ▸ Sector specific ▸ Sector trade shares ▸ Home biases

Conditional forecast setup

Crisis as a combination of 6 types of pandemic shocks:

- Consumption preference shock
- Sector-specific shocks to the costs of consumption
- Aggregate labor disutility shock
- Aggregate TFP shock
- Sector-specific shocks to exports and import prices

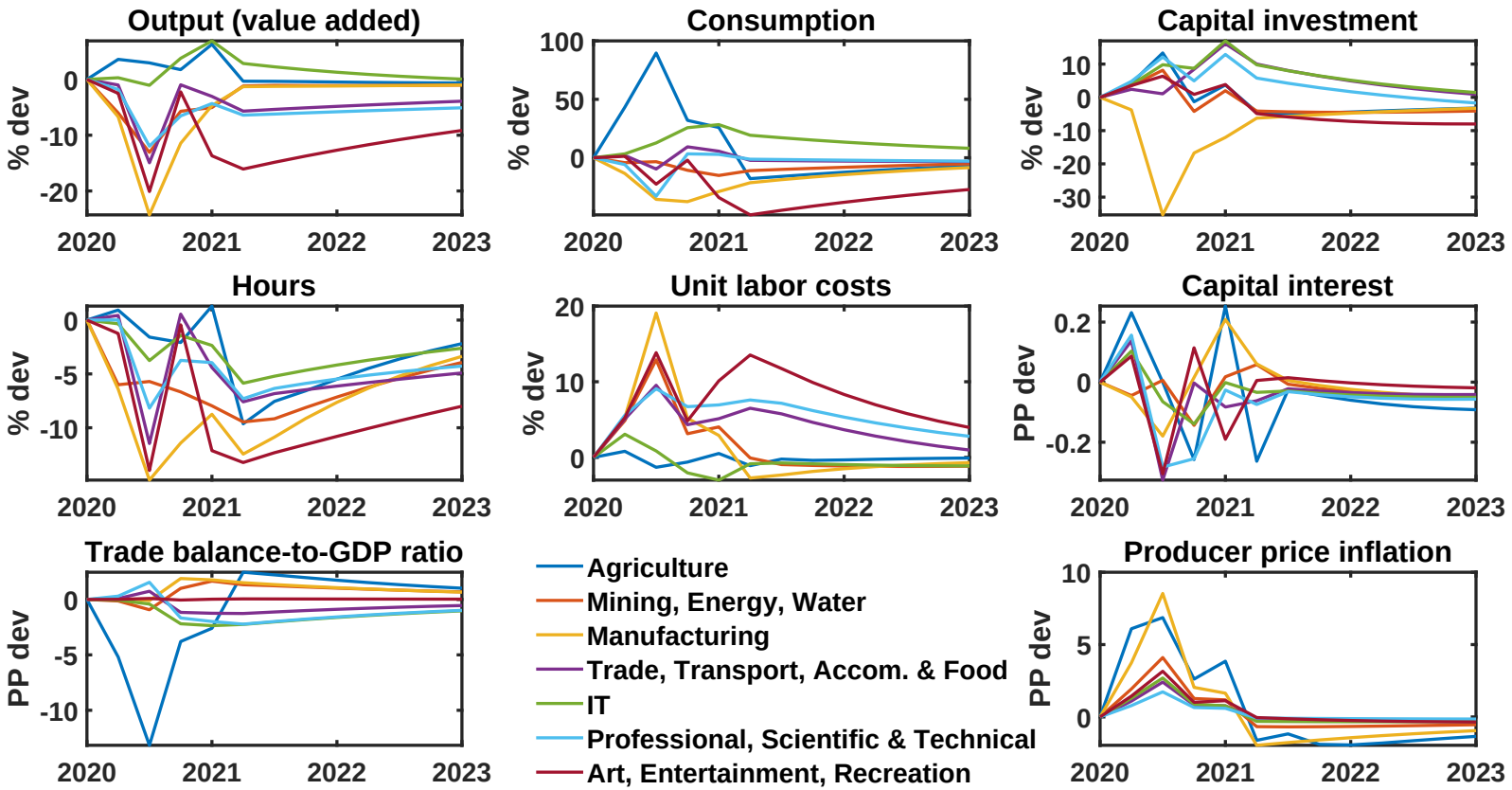
+ Fiscal shocks

$\Rightarrow$ match sectoral output, aggregate consumption, hours worked, wage income, sectoral exports and imports, fiscal variables from 2020:Q1-2021:Q1
$\Rightarrow$ exclude fiscal shocks in order to obtain baseline pandemic scenario

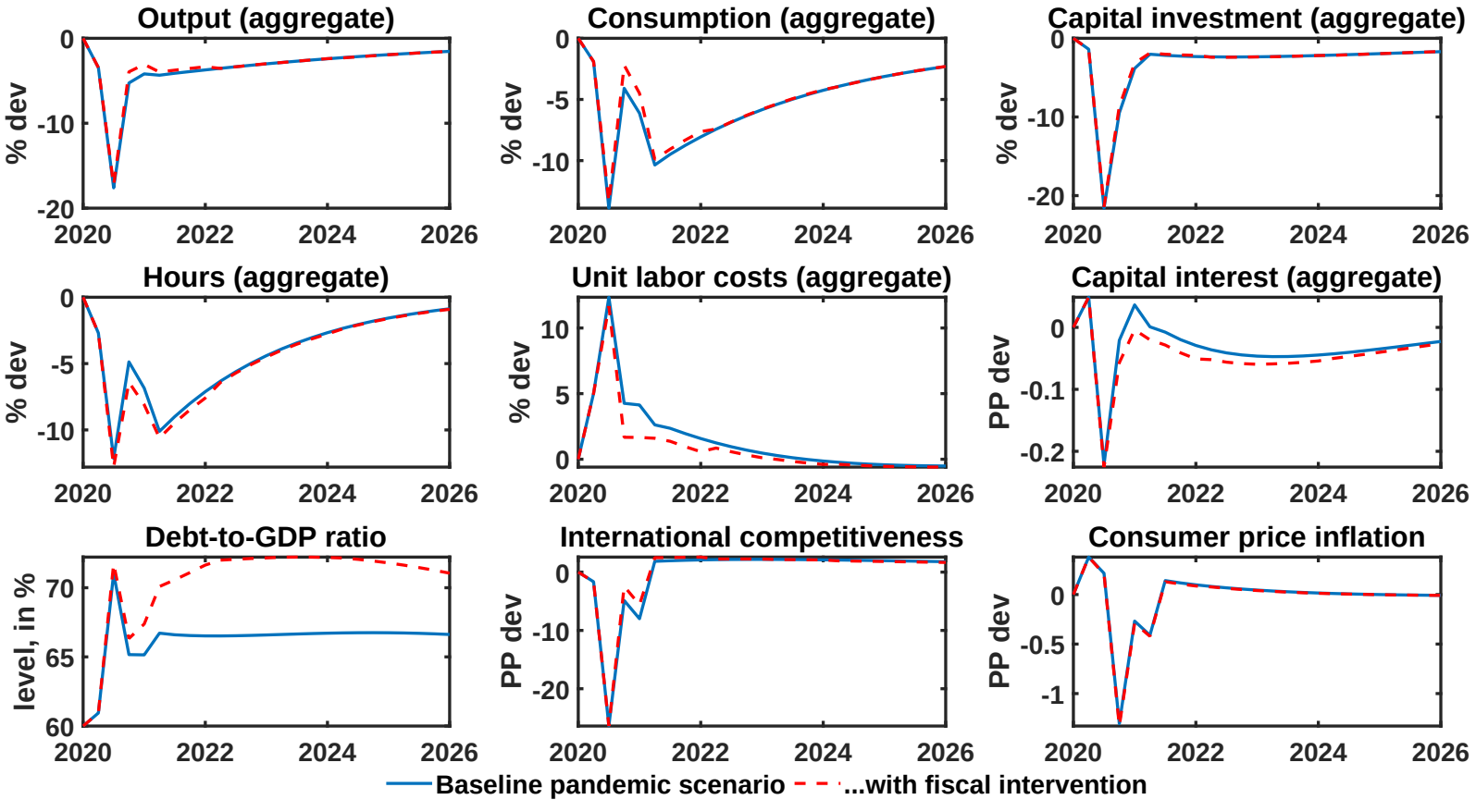
Fiscal measures

Stimulus Measure [% of Trend-GDP]	2020	2021	2022	2023	Fiscal instruments
Emergency assistance					
Measures aimed at households:					
Transfers	0.1	0.1	0.0	0.0	TR
Measures aimed at firms:					
Liquidity support	1.1	0.4	0.0	0.0	S
Indirect taxes	0.0	0.1	0.0	0.0	τ^c
Fiscal stimulus package					
Measures aimed at households:					
Transfers	0.1	0.0	0.0	0.0	TR
Direct taxes	0.2	0.0	0.0	0.0	τ^w
Indirect taxes	0.7	0.3	0.1	0.1	τ^c
Measures aimed at firms:					
Liquidity support	0.3	1.0	0.2	0.2	S
Social security contributions	0.1	0.0	0.0	0.0	τ^{sc}
Public investment	0.1	0.1	0.0	0.0	I^g
Total	**2.7**	**2.0**	**0.3**	**0.3**	

Sectoral IRFs baseline pandemic scenario



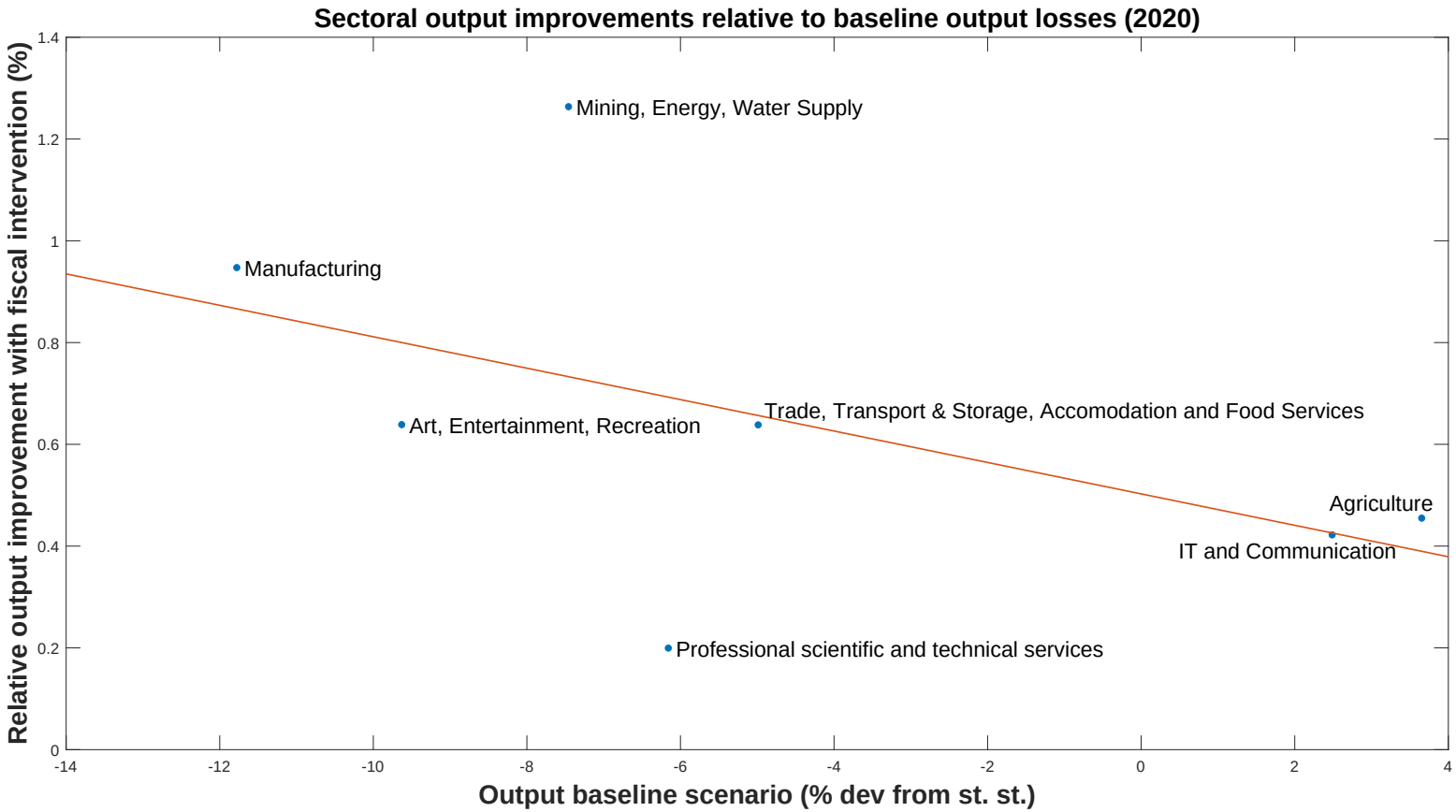
Effects on aggregate variables



Relative Default

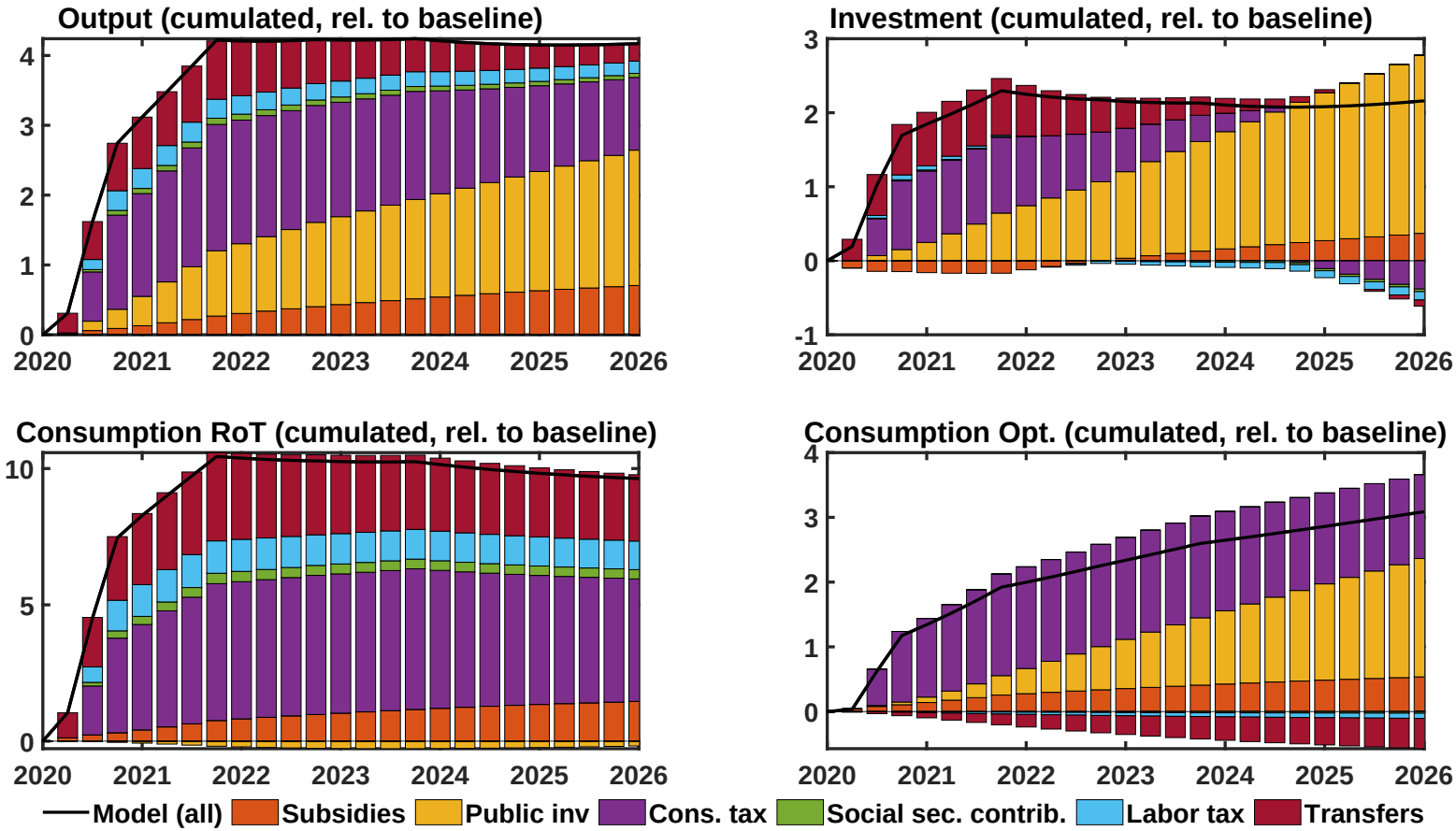
Sectoral output improvements 2020

▸ 2021 ▸ 2022



Multiplier & contribution of single measures

Long-run present value multiplier: $M = 0.2$



▸ Prim. Deficit ▸ Multiplier ▸ Welfare

Conclusion

- Setup allows to model key characteristics of crisis
- Notable short- to medium-run stabilization of aggregate output and consumption through fiscal intervention
- Welfare costs reduced by $\approx$ 5% in CE, by 20% for RoT
- Costs and benefits of (single) fiscal measures differ and depend on specific focus
  - $\Rightarrow$ Output stabilization vs. redistribution
  - $\Rightarrow$ Aggregate vs. sectoral effects
  - $\Rightarrow$ Short- vs. long-run impact

$\Rightarrow$ Results may provide guidance for possible future fiscal measures

Thank you!

Household optimization problem

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \left[\epsilon_t^C \frac{{C_t^i}^{1-\sigma}}{1-\sigma} - \kappa_N \epsilon_t^{\kappa_N} \frac{{N_t^i}^{1+\zeta}}{1+\zeta} \right]$$

s.t.

$$\left(1+\tau_t^c\right) C_t^o + B_t^o + D_t^o + \frac{P_t^I}{P_t^C} I_t^o + \frac{P_t^I}{P_t^C} S\left(I_t^o, K_{t-1}^o\right) K_{t-1}^o + T_t^o = \left(1-\tau_t^w\right) w_t N_t^o$$

$$R_{t-1}^d \frac{D_{t-1}^o}{\pi_t^C} + R_{t-1} \frac{B_{t-1}^o}{\pi_t^C} + \left[\left(1-\tau_t^k\right) r_t^k + \delta^k \tau_t^k\right] K_{t-1}^o + TR_t^o + \Pi_t^o + \Psi_t.$$

Back

Firm optimization problem

$$\max P_{z,h,t}(j) \cdot y_{z,t}(j) - R^{l}_{z,t} \cdot P^{C}_{t} \cdot L^{f}_{z,t}(j) + S_{z,t} - FC_z - \frac{\kappa^{p}_{z}}{2} \left(\frac{P_{z,h,t}(j)}{P_{z,h,t-1}(j)} - 1 \right)^2 \cdot y_{z,t}(j)$$

s.t.

$$y_{z,t}(j) \leq \varepsilon_z \cdot \varrho_t(j) \cdot {K^{g}_{t-1}}^{\eta_{Kg,z}} \cdot \left(N_{z,t}(j)^{\alpha_{N,z}} \cdot K_{z,t-1}(j)^{1-\alpha_{N,z}} \right)^{\alpha_{H,z}} \cdot \left(H_{z,t}(j) \right)^{1-\alpha_{H,z}}$$

Back

Bank optimization problem

$$\max \sum_{z=1}^{Z} R^{l}_{z,t} L^{f}_{z,t} - R_t (1-\mu) D^{s}_{t}$$

s.t.

$$(1-\mu) \cdot D^{o}_{t} = \sum_{z=1}^{Z} L^{f}_{z,t}$$

Back

Default threshold

$$\varrho_t(j) < \frac{P_t^C R_{z,t}^l L_{z,t}^f + FC_z - S_{z,t} + \frac{\kappa_z^p}{2}\left(\frac{P_{z,h,t}}{P_{z,h,t-1}} - 1\right)^2 P_{z,h,t}(j) y_{z,h,t}(j)}{P_{z,h,t}\varepsilon_{z,t}\ {K_{t-1}^g}^{\eta_{Kg}} \left(N_{z,t}^{\alpha_{N,z}} K_{z,t-1}^{1-\alpha_{N,z}}\right)^{\alpha_{H,z}} (H_{z,t})^{1-\alpha_{H,z}}}$$

Back

Government budget constraint

$$B_t = R_{t-1} \cdot \frac{B_{t-1}}{\pi_t^c} + PD_t,$$

with

$$PD_t = \frac{P_t^G}{P_t^C} \cdot G_t + \frac{P_t^{I^g}}{P_t^C} \cdot I_t^g + TR_t$$
$$-\tau_t^c \cdot C_t - (\tau_t^w + \tau_t^{sc}) \cdot w_t \cdot N_t - \tau_t^k \cdot \left(r_t^k - \delta^k\right) \cdot K_{t-1} - (1-\mu) \cdot T_t^s$$

Back

Calibration: Common parameters

Back

Variable/Parameter	Symbol	Value
Discount factor	β	0.992
Share of rule-of-thumb households	μ	0.450
Elasticity of intertemporal substitution	σ	1.500
Inverse of Frisch elasticity of lab. supply	ζ	2.000
Labor disutility scaling	κ^N	6.331
Capital depreciation rate	δ^k	0.025
Capital adjustment costs	κ^I	25
Government spending-to-GDP ratio	G/Y	0.200
Government investment-to-GDP ratio	I^g/Y	0.020
Consumption tax rate	$\bar{\tau}^c$	0.183
Labor tax rate	$\bar{\tau}^n$	0.304
Capital gains tax rate	$\bar{\tau}^k$	0.214
Social security contribution rate	$\bar{\tau}^{sc}$	0.167
Transfer to borrowers	$\bar{TR}^b$	0.266
Lump-sum tax	$\bar{T}^s$	-0.015
AR(1) coefficient lump-sum tax	ρ_{fp}	0.900
Debt-reaction coefficient lump-sum tax	ζ_{debt}	0.005
AR(1) coefficient pandemic shocks	ρ_{fp}	0.900

Calibration: Sector-specific parameters

Back

Variable/Parameter	Symbol	Value
Density function of idiosyncr. productivity shock	$f(\varrho_{z,t})$	$U(0.5, 1.5)$
Substitution elasticities:		
Elasticity of substitution, consumption	σ_C	0.5000
Elasticity of substitution, investment	σ_I	0.5000
Elasticity of substitution, government cons.	σ_G	0.5000
Elasticity of substitution, government investm.	σ_{Ig}	0.5000
Elasticity of substitution, labor	ν_N	0.8000
Elasticity of substitution, capital	ν_K	0.8000
Elasticity of substitution, intermediates	σ_z	-9.0000
Elasticity of substitution, home vs. foreign	$\sigma_{hb,x}$	1/3
Labor weight:	$\omega_{N,z}$	
Agriculture	$\omega_{N,1}$	0.0263
Mining, Energy, Water Supply	$\omega_{N,2}$	0.0146
Manufacturing	$\omega_{N,3}$	0.2876
Trade, Transport & Storage, Accomod. and Food Services	$\omega_{N,4}$	0.3651
IT and Communication	$\omega_{N,5}$	0.0451
Professional Scientific and Technical Services	$\omega_{N,6}$	0.1819
Art, Entertainment, Recreation	$\omega_{N,7}$	0.0794

Calibration: Sector-specific parameters

Back

Variable/Parameter	Symbol	Value
Capital weight:	$\omega_{K,z}$	
Agriculture	$\omega_{K,1}$	0.0598
Mining, Energy, Water Supply	$\omega_{K,2}$	0.1061
Manufacturing	$\omega_{K,3}$	0.3061
Trade, Transport & Storage, Accomod. and Food Services	$\omega_{K,4}$	0.2453
IT and Communication	$\omega_{K,5}$	0.0499
Professional Scientific and Technical Services	$\omega_{K,6}$	0.1516
Art, Entertainment, Recreation	$\omega_{K,7}$	0.0842
Labor & capital factor intensity:	$\alpha_{H,z}$	
Agriculture	$\alpha_{H,1}$	0.4069
Mining, Energy, Water Supply	$\alpha_{H,2}$	0.4334
Manufacturing	$\alpha_{H,3}$	0.3303
Trade, Transport & Storage, Accomod. and Food Services	$\alpha_{H,4}$	0.5167
IT and Communication	$\alpha_{H,5}$	0.5161
Professional Scientific and Technical Services	$\alpha_{H,6}$	0.5971
Art, Entertainment, Recreation	$\alpha_{H,7}$	0.6740

Calibration: Sector-specific parameters

Back

Variable/Parameter	Symbol	Value
Labor factor intensity:	$\alpha_{N,z}$	
Agriculture	$\alpha_{N,1}$	0.7044
Mining, Energy, Water Supply	$\alpha_{N,2}$	0.4125
Manufacturing	$\alpha_{N,3}$	0.6662
Trade, Transport & Storage, Accomod. and Food Services	$\alpha_{N,4}$	0.7006
IT and Communication	$\alpha_{N,5}$	0.5641
Professional Scientific and Technical Services	$\alpha_{N,6}$	0.5624
Art, Entertainment, Recreation	$\alpha_{N,7}$	0.6441
Productivity of public capital:	$\eta_{Kg,z}$	
Agriculture	$\eta_{Kg,1}$	0.1000
Mining, Energy, Water Supply	$\eta_{Kg,2}$	0.0900
Manufacturing	$\eta_{Kg,3}$	0.0800
Trade, Transport & Storage, Accomod. and Food Services	$\eta_{Kg,4}$	0.1200
IT and Communication	$\eta_{Kg,5}$	0.0500
Professional Scientific and Technical Services	$\eta_{Kg,6}$	0.1000
Art, Entertainment, Recreation	$\eta_{Kg,7}$	0.0900

Calibration: Sector-specific parameters

Back

Variable/Parameter	Symbol	Value
Share in consumption good:	$\psi_{C,z}$	
Agriculture	$\psi_{C,1}$	0.0247
Mining, Energy, Water Supply	$\psi_{C,2}$	0.0640
Manufacturing	$\psi_{C,3}$	0.2780
Trade, Transport & Storage, Accomod. and Food Services	$\psi_{C,4}$	0.4234
IT and Communication	$\psi_{C,5}$	0.0905
Professional Scientific and Technical Services	$\psi_{C,6}$	0.0367
Art, Entertainment, Recreation	$\psi_{C,7}$	0.0827
Share in investment good:	$\psi_{I,z}$	
Agriculture	$\psi_{I,1}$	0.0026
Mining, Energy, Water Supply	$\psi_{I,2}$	0.0225
Manufacturing	$\psi_{I,3}$	0.6841
Trade, Transport & Storage, Accomod. and Food Services	$\psi_{I,4}$	0.0827
IT and Communication	$\psi_{I,5}$	0.0943
Professional Scientific and Technical Services	$\psi_{I,6}$	0.1086
Art, Entertainment, Recreation	$\psi_{I,7}$	0.0052

Calibration: Sector-specific parameters

Back

Variable/Parameter	Symbol	Value
Share in gov. consumption and investment good:	$\psi_{x,z}$	
Agriculture	$\psi_{x,1}$	0.0002
Mining, Energy, Water Supply	$\psi_{x,2}$	0.0070
Manufacturing	$\psi_{x,3}$	0.3181
Trade, Transport & Storage, Accomod. and Food Services	$\psi_{x,4}$	0.3070
IT and Communication	$\psi_{x,5}$	0.0053
Professional Scientific and Technical Services	$\psi_{x,6}$	0.0517
Art, Entertainment, Recreation	$\psi_{x,7}$	0.3108
Price adjustment costs:	κ_z	
Agriculture	κ_1	23.9620
Mining, Energy, Water Supply	κ_2	77.0530
Manufacturing	κ_3	29.3420
Trade, Transport & Storage, Accomod. and Food Services	κ_4	476.6780
IT and Communication	κ_5	114.3870
Professional Scientific and Technical Services	κ_6	476.5490
Art, Entertainment, Recreation	κ_7	121.5360

Calibration: Sector-specific parameters

Back

Variable/Parameter	Symbol	Value
Mark-up:	θ_z	
Agriculture	θ_1	1.01/0.01
Mining, Energy, Water Supply	θ_2	1.35/0.35
Manufacturing	θ_3	1.15/0.15
Trade, Transport & Storage, Accomod. and Food Services	θ_4	1.35/0.35
IT and Communication	θ_5	1.85/0.85
Professional Scientific and Technical Services	θ_6	1.76/0.76
Art, Entertainment, Recreation	θ_7	1.80/0.80
Default probability (in %):	$\bar{\varrho}_z$	
Agriculture	$\bar{\varrho}_1$	5.4000
Mining, Energy, Water Supply	$\bar{\varrho}_2$	5.7000
Manufacturing	$\bar{\varrho}_3$	6.7000
Trade, Transport & Storage, Accomod. and Food Services	$\bar{\varrho}_4$	8.1000
IT and Communication	$\bar{\varrho}_5$	11.9000
Professional Scientific and Technical Services	$\bar{\varrho}_6$	10.5000
Art, Entertainment, Recreation	ϱ_7	10.2

Calibration: Sector-specific parameters

Back

Variable/Parameter	Symbol	Value
Home bias consumption:	$hb_{C,z}$	
Agriculture	$hb_{C,1}$	0.3936
Mining, Energy, Water Supply	$hb_{C,2}$	0.9100
Manufacturing	$hb_{C,3}$	0.6367
Trade, Transport & Storage, Accomod. and Food Services	$hb_{C,4}$	0.9341
IT and Communication	$hb_{C,5}$	0.8793
Professional Scientific and Technical Services	$hb_{C,6}$	0.9295
Art, Entertainment, Recreation	$hb_{C,7}$	0.9876
Home bias investment:	$hb_{I,z}$	
Agriculture	$hb_{I,1}$	0.9662
Mining, Energy, Water Supply	$hb_{I,2}$	0.9733
Manufacturing	$hb_{I,3}$	0.5525
Trade, Transport & Storage, Accomod. and Food Services	$hb_{I,4}$	0.8421
IT and Communication	$hb_{I,5}$	0.8948
Professional Scientific and Technical Services	$hb_{I,6}$	0.9494
Art, Entertainment, Recreation	$hb_{I,7}$	0.9548

Calibration: Inter-sectoral trade shares

Back

Producer $\tilde{z}$	**Consumer** z A	B-D-E	C	G-H-I	J	M-N	R-S
A	0.1459	0.0015	0.0034	0.0039	0.0003	0.0026	0.0039
B-D-E	0.0524	0.4387	0.0681	0.0374	0.0156	0.0203	0.0494
C	0.3087	0.2299	0.6467	0.1665	0.1654	0.0780	0.1343
G-H-I	0.2018	0.1517	0.1528	0.5513	0.1044	0.0700	0.1279
J	0.0077	0.0222	0.0187	0.0515	0.5097	0.1502	0.1004
M-N	0.2768	0.1455	0.1060	0.1765	0.1607	0.6458	0.1832
R-S	0.0067	0.0105	0.0043	0.0129	0.0440	0.0330	0.4009

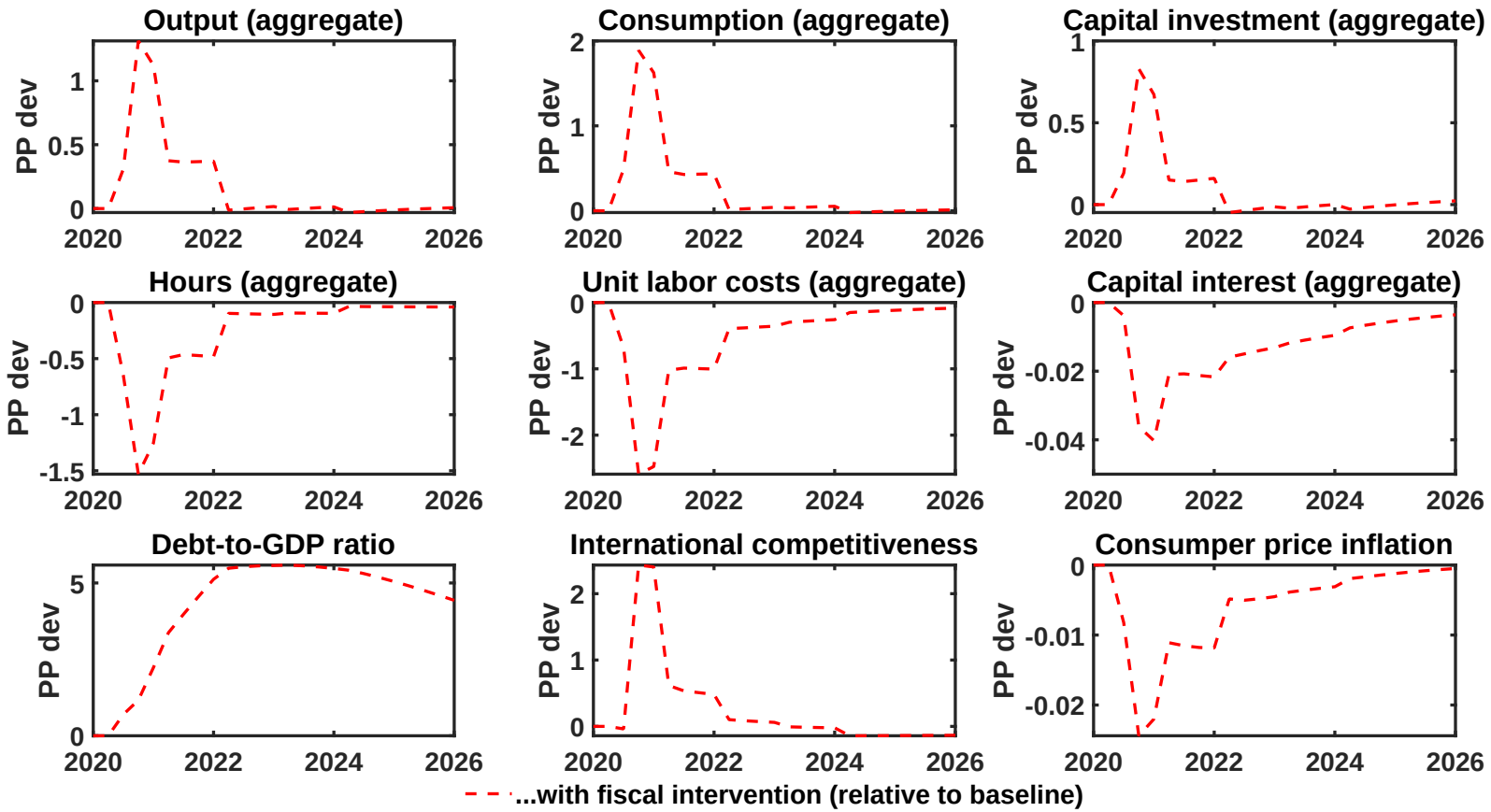
Calibration: Home biases

Back

Producer $\tilde{z}$	**Consumer** z A	B-D-E	C	G-H-I	J	M-N	R-S
A	0.7606	0.7576	0.7758	0.7284	0.7344	0.7823	0.7626
B-D-E	0.8194	0.6642	0.4347	0.7943	0.8443	0.8684	0.8714
C	0.5835	0.7096	0.6017	0.6631	0.6062	0.7083	0.6116
G-H-I	0.9017	0.7922	0.8254	0.9088	0.8901	0.8683	0.8722
J	0.8723	0.8629	0.8534	0.8861	0.9036	0.8885	0.8927
M-N	0.9541	0.8834	0.8870	0.9354	0.9267	0.9159	0.9501
R-S	0.9787	0.9901	0.9629	0.9887	0.9919	0.9933	0.9994

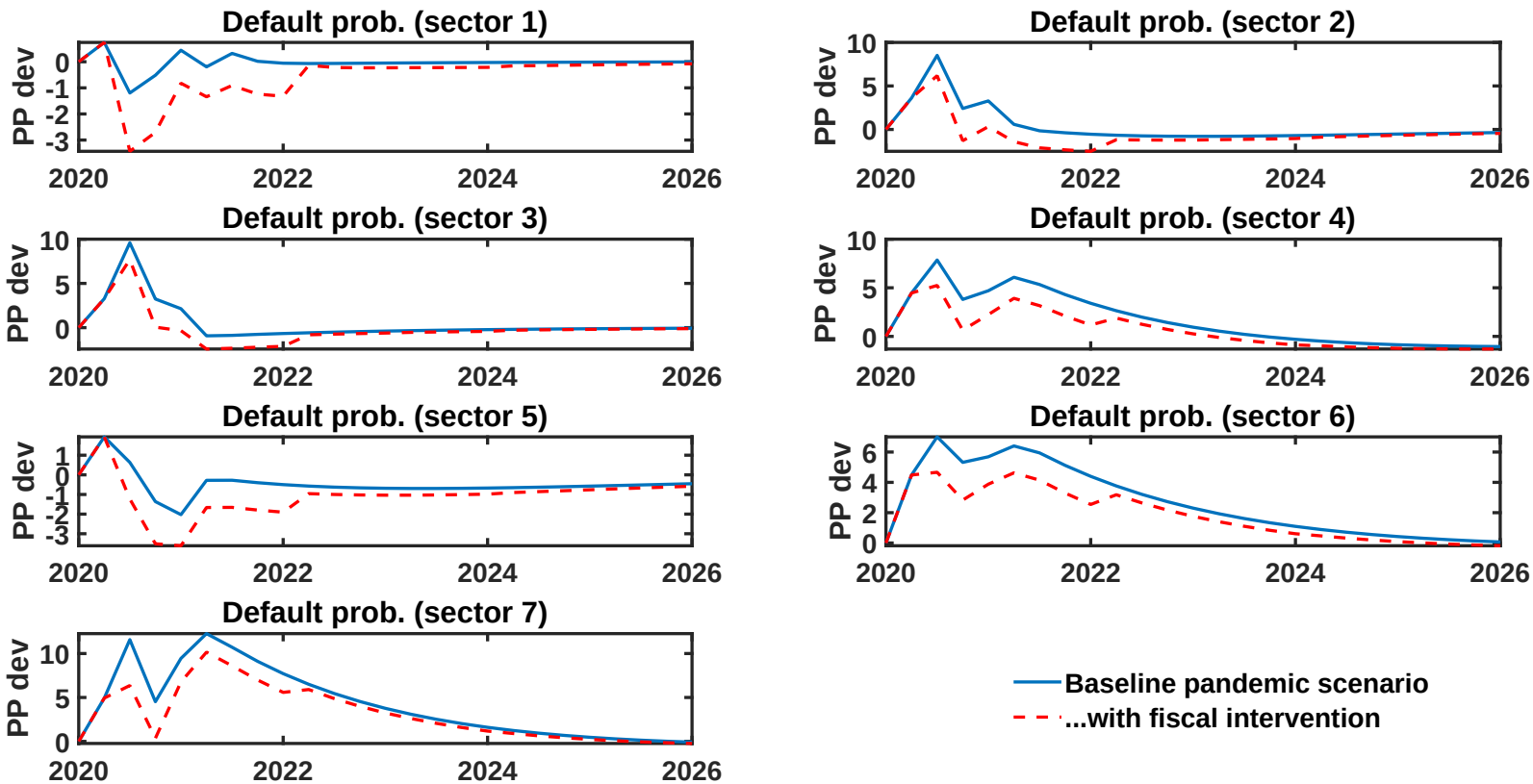
Effects on aggregate variables (relative)

Back



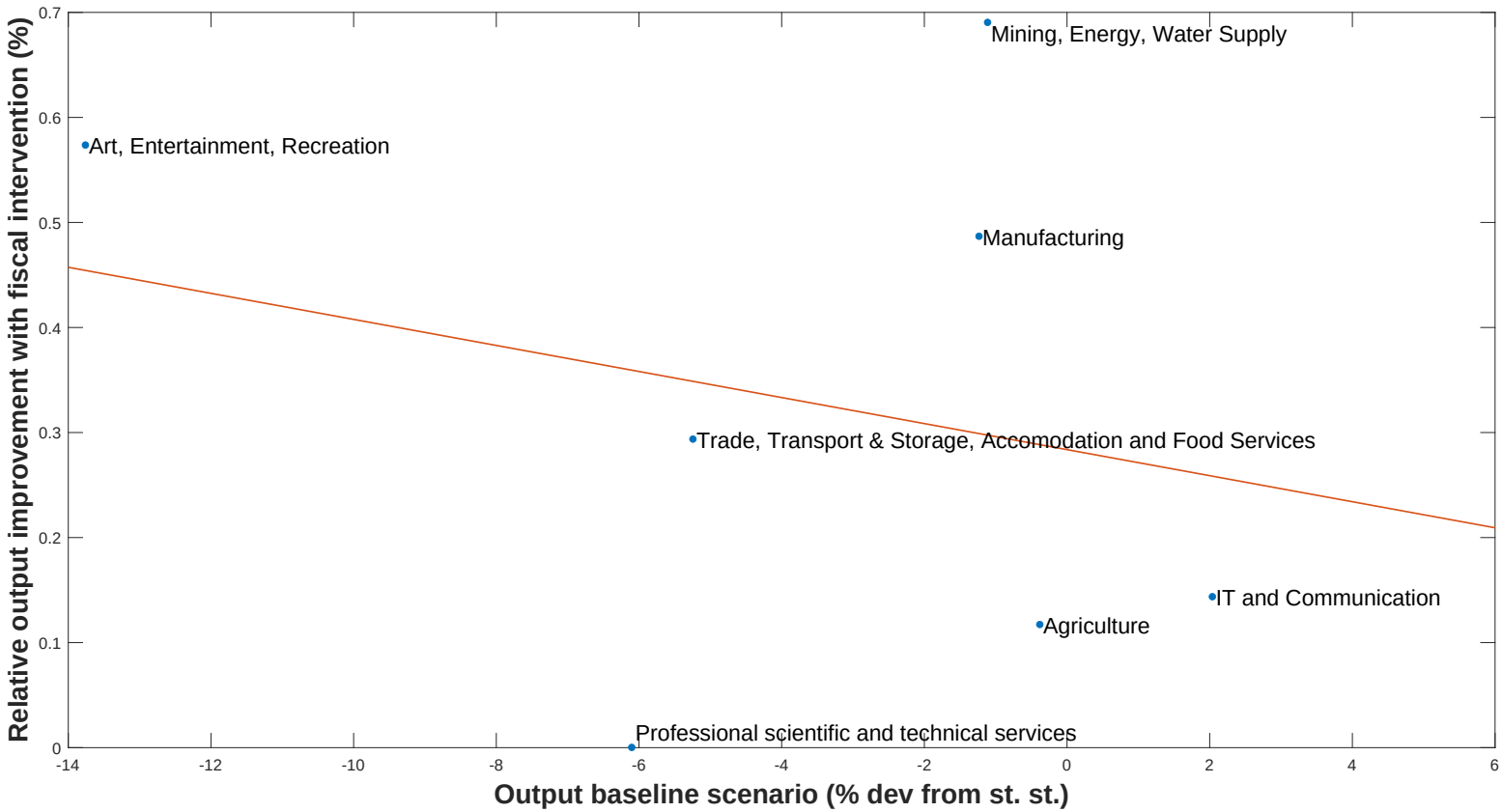
Effects on sectoral default probabilities

Back



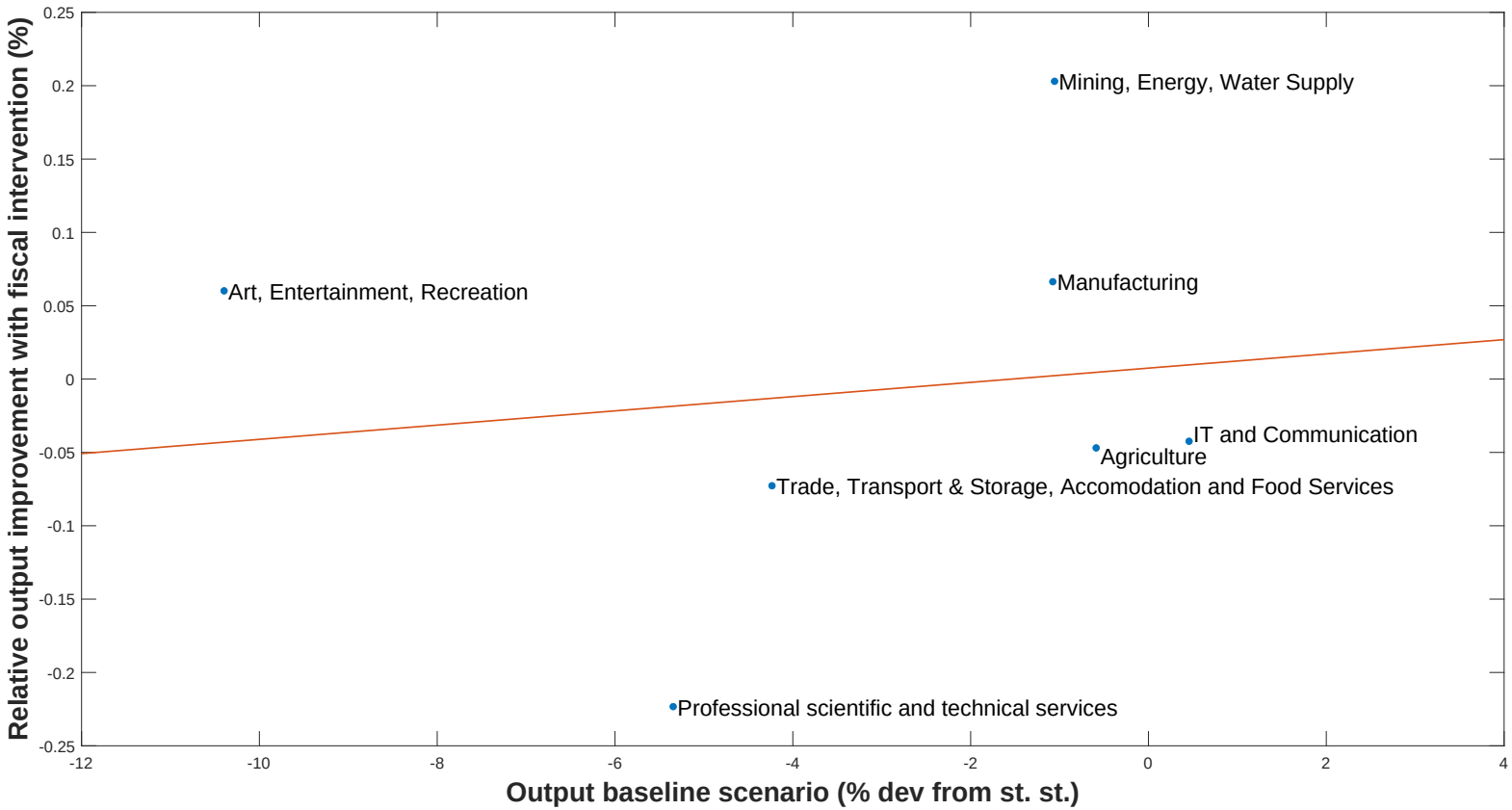
Sectoral output improvements 2021

Back



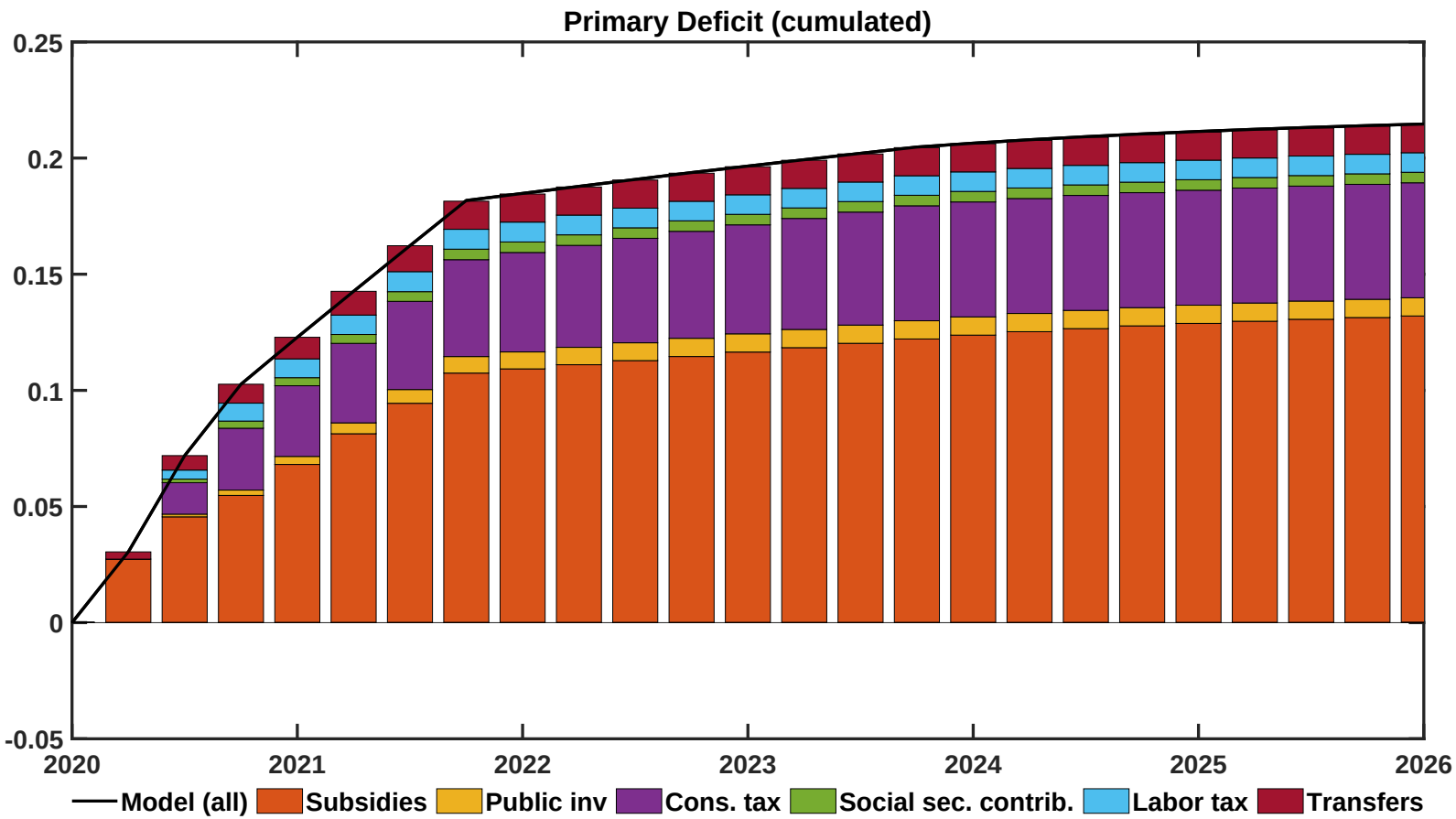
Sectoral output improvements 2022

Back



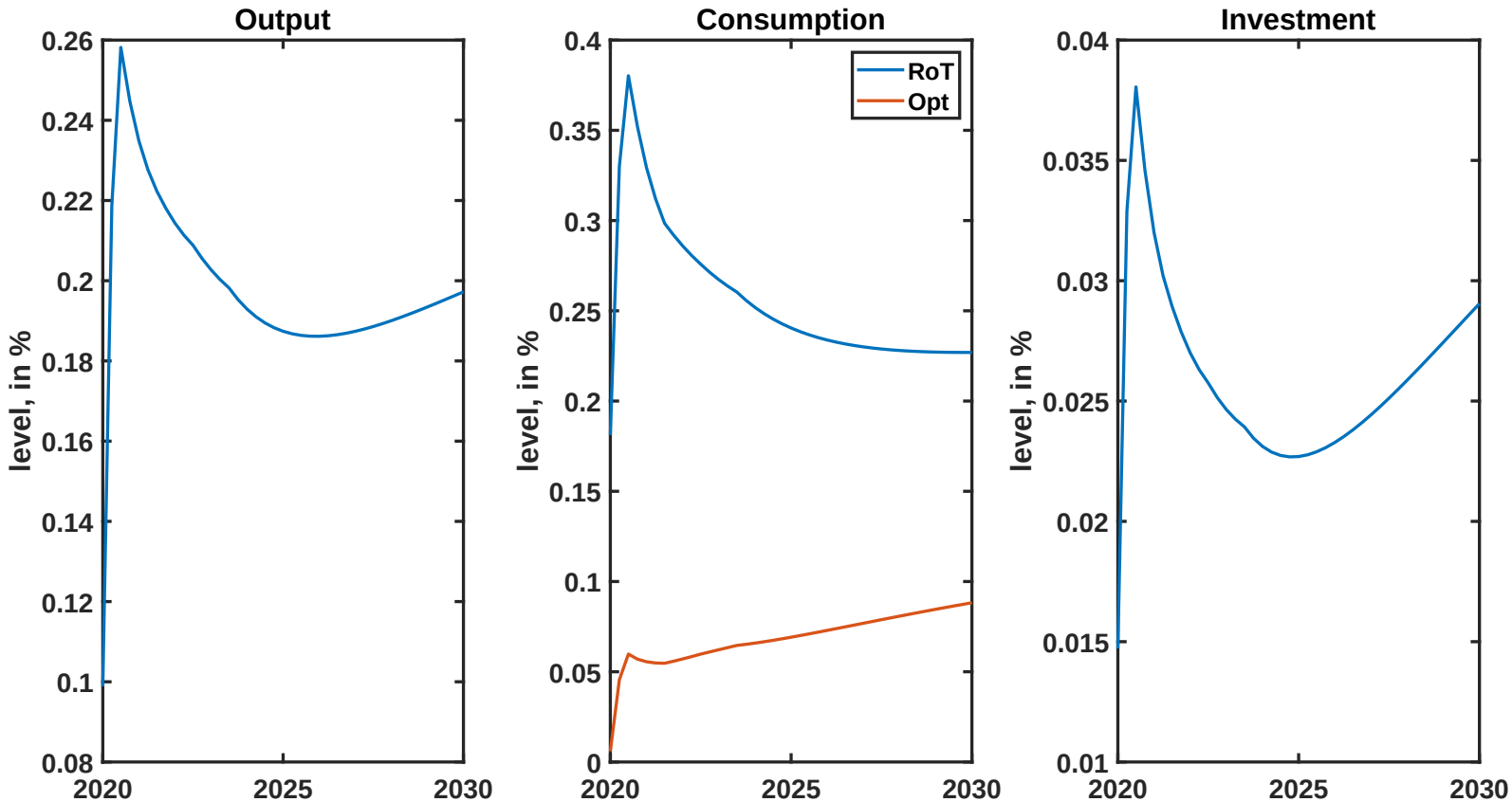
Contribution to primary deficit

Back



Multipliers

Back



Welfare analysis

Back

	Optimizer	Rule-of-thumb	Total
Baseline pandemic scenario	-4.83	-0.94	-3.08
...with fiscal intervention	-4.72	-0.75	-2.94

Notes: Welfare presented as life-time consumption equivalents for different household types. Aggregate economy-wide welfare is calculated as $ce = (1 - \mu) \cdot ce^o + \mu \cdot ce^r$.