UiO : University of Oslo

Empirical econometric modelling of Covid-19 effects in Norway

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Contents

Modelling background: Trends, interventions and structural breaks in models of the macro economy

Consider a model with 1st order dynamics and two time series Y_t and X_t:

$$
\begin{aligned}
Y_t &= Y_{t-1} + c_{10} + c_{1d} D_{1t} + \alpha_{11}(Y_{t-1} + \beta_{12} X_{t-1}) + \varepsilon_{1t} \quad (1) \\
X_t &= X_{t-1} + c_{20} + c_{2d} D_{2t} + \alpha_{21}(Y_{t-1} + \beta_{12} X_{t-1}) + \varepsilon_{2t} \quad (2)
\end{aligned}
$$

- Can be the reduced form of a SEM
- β_{12} is the cointegration parameter.
- Equilibrium correction coefficients: $\alpha_{11} < 0$ and $\alpha_{21} \geq 0$.
- D_{1t} and D_{2t} are dummies: Impulse indicators or step-dummies.
- The properties of the solutions for Y_t and X_t can be studied through the final form equations.

For the case of $\alpha_{11} < 0$,$\alpha_{21} > 0$, the system with final form equations becomes:

$$\begin{aligned}
\Delta Y_t &= \gamma_{10} - \gamma_2 \Delta Y_{t-1} + c_{1d} D_{1t} - (\alpha_{21}\beta_{12} + 1) c_{1d} D_{1t-1} && (3)\\
&+ \alpha_{11}\beta_{12} c_{2d} D_{2t-1} + \epsilon_{1t}, \\
Y_t &= \Delta Y_t + Y_{t-1}, && (4)\\
\Delta X_t &= \gamma_{20} - \gamma_2 \Delta X_{t-1} + c_{2d} D_{2t} - (1 + \alpha_{11}) c_{2d} D_{2t-1} && (5)\\
&+ \alpha_{21} c_{1d} D_{1t-1} + \epsilon_{2t}, \\
X_t &= \Delta X_t + X_{t-1}, && (6)
\end{aligned}$$

- Hence, shocks captured by D_1 and D_2 will have permanent effects on the solutions for Y_t and X_t.
- Illustration next page for:

$$D_{1t} = D_{2t} = \begin{cases} 1 & \text{, if } t = 11 \\ 0 & \text{for all other } t \end{cases} \qquad (7)$$

Figure: Simulation of a cointegrated two-variable system subject to impulse indicators in period 11. The cointegration parameter $\beta_{12} = -1$, and $\alpha_{11} = -0.12$, $\alpha_{21} = 0.1$ are assumed to be invariant to the shock.

- Figure 1 illustrates that in general for cointegrated systems, temporary shocks have permanent effects on the solution paths of the endogenous variables.
- The effects of a negative shock do not in general "go away" unless there are counteracting shocks, simultaneously or later in the solution period.
- If structural breaks in β_{12},α_{11} or α_{21} after $t = 11$, shifts in γ_{10}, γ_{20}, and γ_2 will affect the solutions for ΔY_t and ΔX_t.
- Another special case may be that cointegration is lost: Y_t and X_t then change from $I(1)$ to $I(2)$.

As a first exercise: Investigate effects of Covid-19 indicator variables in empirical models of the Norwegian economy.

Covid-19 indicators in NAM

- Norwegian Aggregate Model (NAM) is an quarterly empirical econometric model.
- Indicator variables for the eight quarters from 2020q1 to 2021q4 were included in all the empirical equations. Retained if the t-values were significant at the 5 % level.

Table: Number of equations where Covid-19 impulse indicators are included

Quarter	Impulse Indicator	Model version	
		Standard	Extended
		133 eqs	145 eqs
2020q1	$I_{\text{Covid},t}$	12	23
2020q2	$I_{\text{Covid},t-1}$	26	38
2020q3	$I_{\text{Covid},t-2}$	16	27
2020q4	$I_{\text{Covid},t-3}$	12	23
2021q1	$I_{\text{Covid},t-4}$	10	20
2021q2	$I_{\text{Covid},t-5}$	14	23
2021q3	$I_{\text{Covid},t-6}$	12	22
2021q4	$I_{\text{Covid},t-7}$	3	5

Examples of NAM model equations with or without Covid-19 impulse indicators

With	Without
Value added, service production	Value added, Manufacturing
	Value added, Other products
Private consumption	Capital formation private business
Imports	
Export of services	Exports of products (non-oil)
Foreign export markets	
	Wage formation
Foreign producer prices	Value added deflators
Foreign short interest rate	
Policy interest rate	

GDP for Mainland-Norway. Simulated joint effects of the Covid-19 impulse indicators in NAM

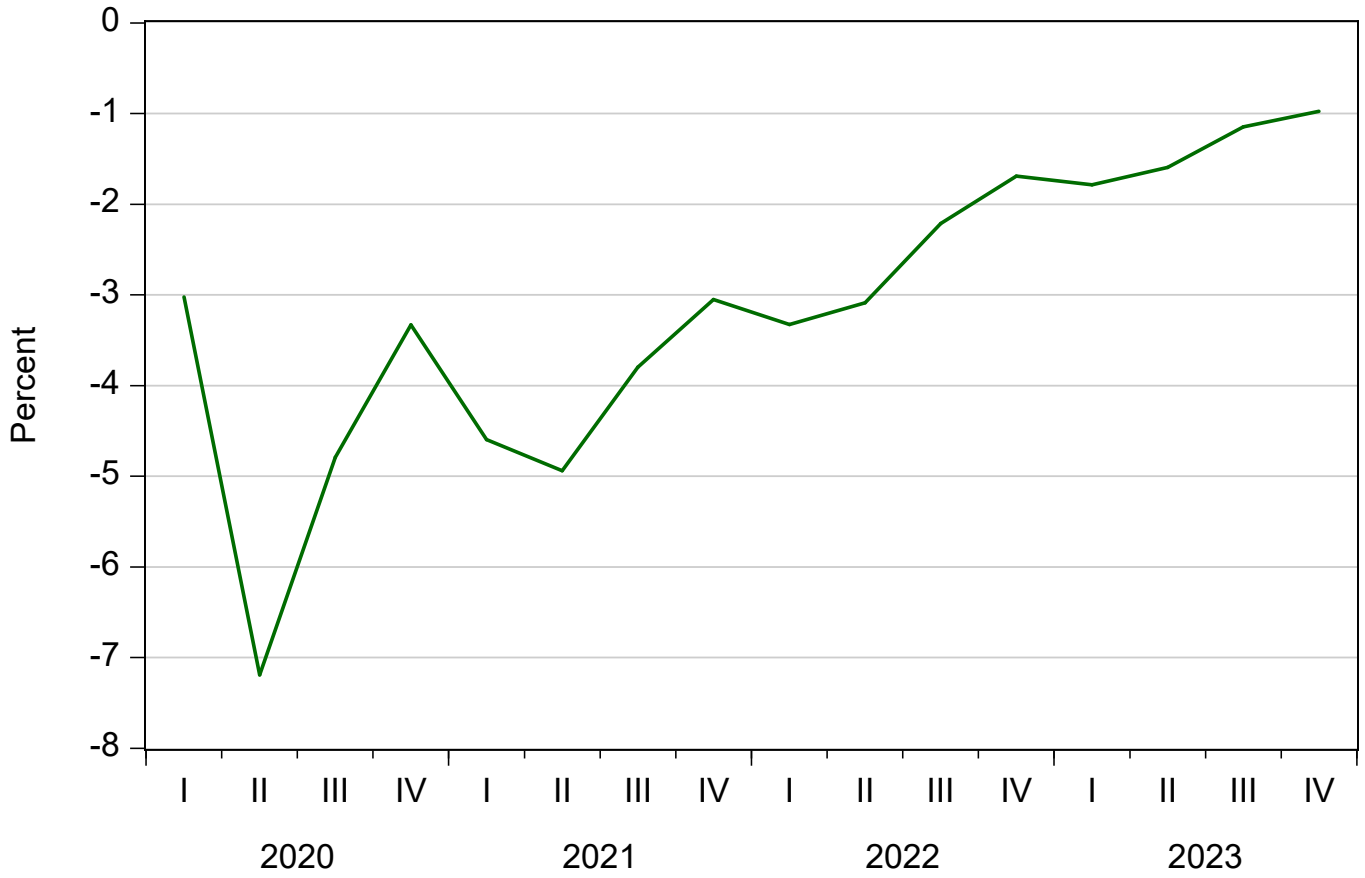

Figure: Percentage deviation between baseline and “No-Covid”.

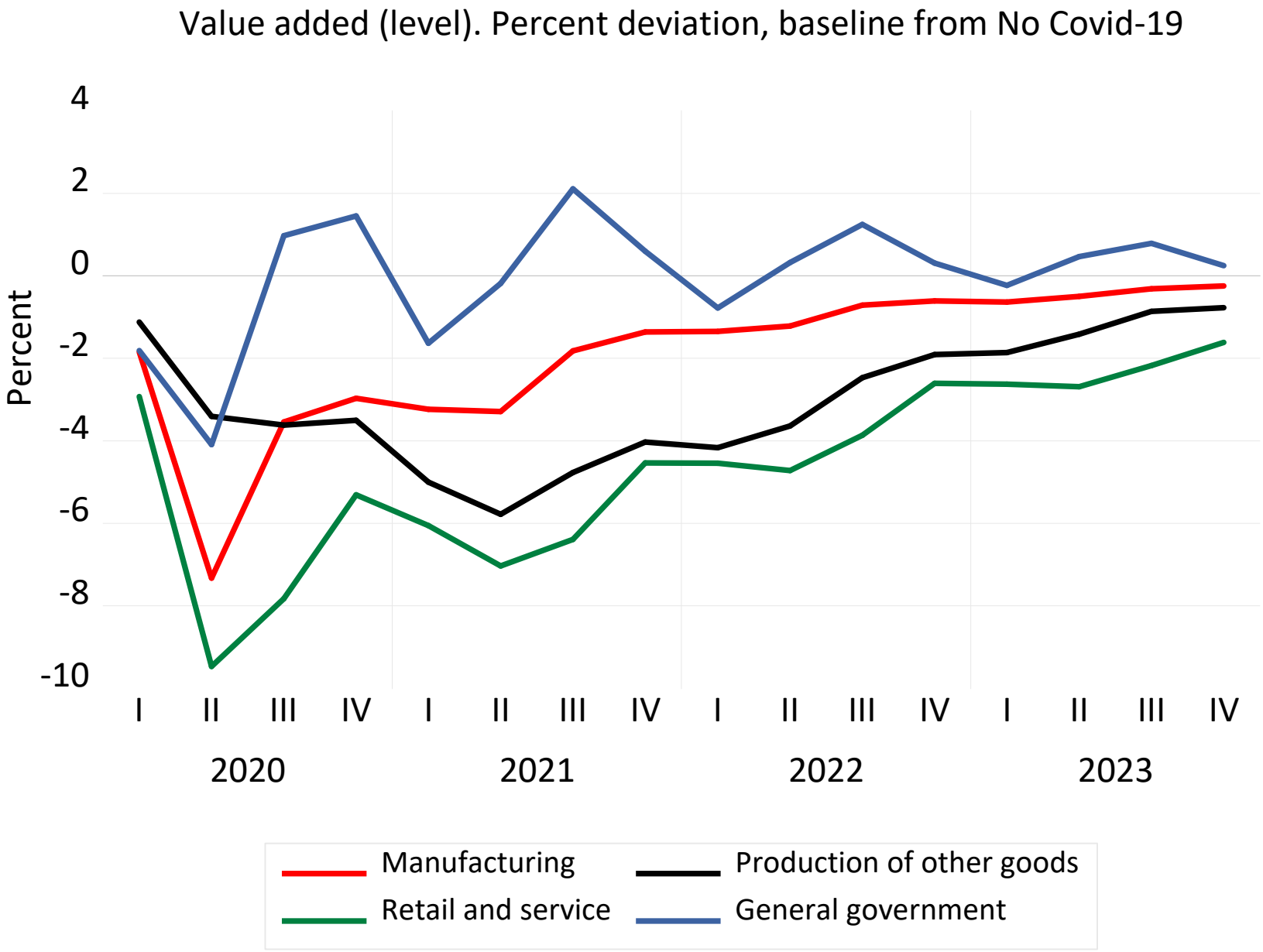
Value added (level). Percent deviation, baseline from No Covid-19
Percent
4
2
0
-2
-4
-6
-8
-10
I
II
III
IV
I
II
III
IV
I
II
III
IV
I
II
III
IV
2020
2021
2022
2023
Manufacturing
Production of other goods
Retail and service
General government

Table: Cumulated effects of Covid-19 impulse indicators, in percent of annual level in 2019

	2020q4	2021q4	2022q4	2023q4
GDP Mainland-Norway	-4.7	-8.9	-11.6	-13.1
Value added, Manufacturing	-4.0	-6.5	-7.5	-7.6
Value added, Other products	-2.9	-7.8	-10.9	-12.4
Value added, Service	-6.7	-13.0	-17.2	-19.6
Value added, Government	-0.9	-0.7	-0.3	0.0

Comparison with empirical final form equations

By using automatic variable selection (Autometrics in PcGive) we can estimate a final form equation for GDP Mainland-Norway.

1. Start from a general unrestricted model (GUM) with twelve autoregressive terms. An AR model with long lags can approximate an ARMA model (with fewer parameters).
2. Use impulse indicator saturation (IIS) in Autometrics to simplify lag-structure, and to retain significant impulse indicators.
3. The final model equation can be simulated, and the deviation between baseline and 'No-covid scenario' can be compared with the simulation results for NAM.

- Tried target rate 1% and the more liberal 3.5%.
- The 3.5% rate keeps more of the "known history" of shocks (eg. banking crisis).
- A single Covid-dummy is retained with 1% rate. Two with 3.5%.

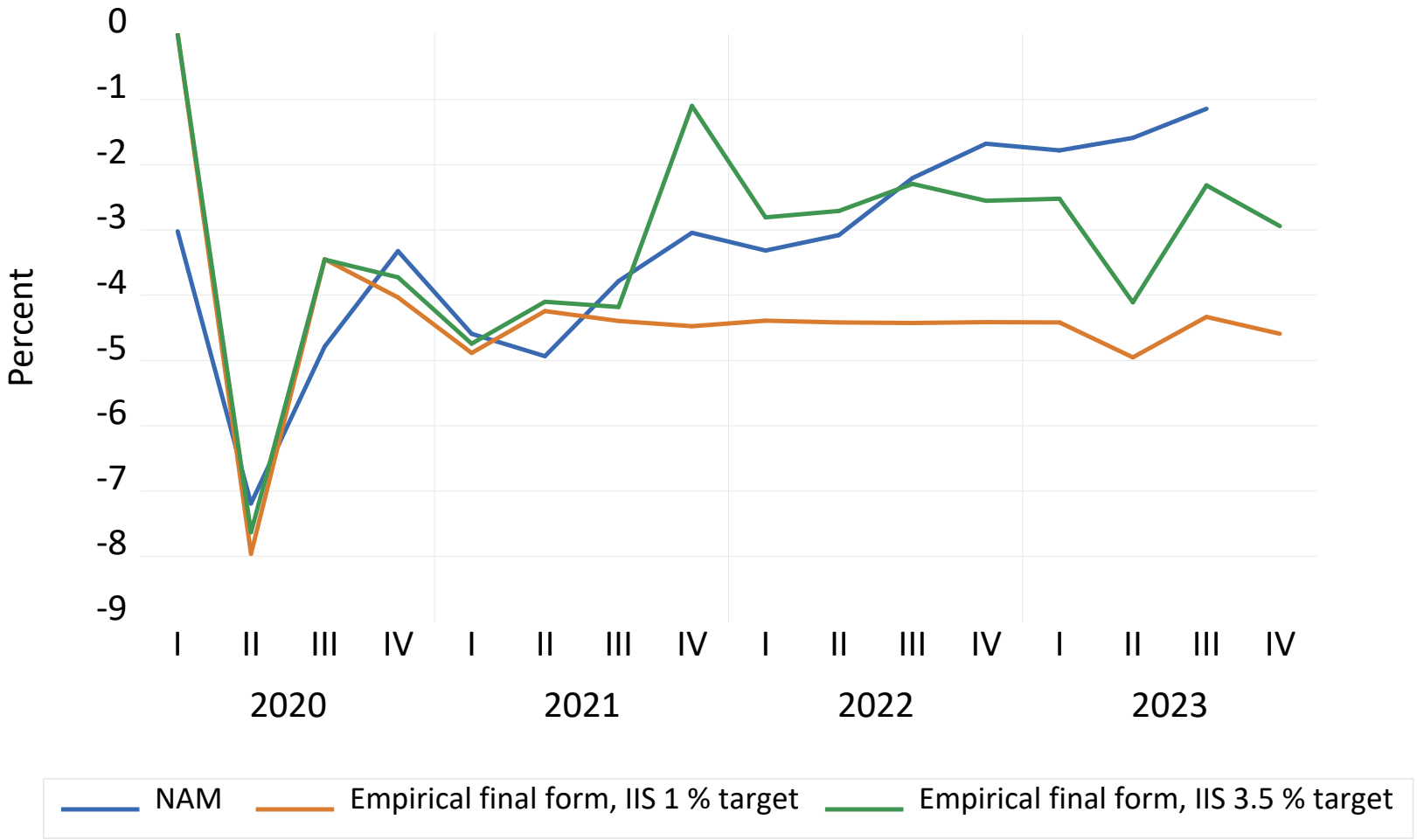

Figure: GDP for Mainland-Norway. Simulated effects of the Covid-19 impulse indicators in NAM, and in two empirical final form models. Percentage deviation between baseline and the No-Covid scenario.

Suggestions for research

- In this talk, simulated effects have assumed invariance in other parameters than in the intercepts of model equations.
- Have not addressed the question about changes in “normal economic behaviour” as a consequence result of the pandemic.
- Note as interesting that simulated GDP effects in NAM are reproduced in the empirical final form models.
- They are automatized, rest on only a few decisions, and are fully transferable between researchers
- But the economic interpretability is richer in NAM, and in other multiple equation models
- Suggests that “transferable” multiple equation models can represent a common ground for:
  - Objective empirical decisions on impulse indicators
  - Testing of the degree of invariance in cointegration parameters and adjustment coefficients.
  - Partial integration of health policy indicators in macro models.