POLICY STUDY 01|2021

GET German Economic Team
BELARUS

Quantitative analysis of COVID-19 shock in various macroeconomic models

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Outline

1. Anatomy of the Shock
2. Why quantitative analysis?
   - Demand for quantitative answers and policy scenarios
3. Institutions and policy horizon matter

   3.A What is the immediate impact? Expert judgment, SAM and CGE models

   3.B What is the impact in business cycle models?

   Macroeconomic modeling at business cycle frequency

   3.B.i IMF Quarterly Projection Model

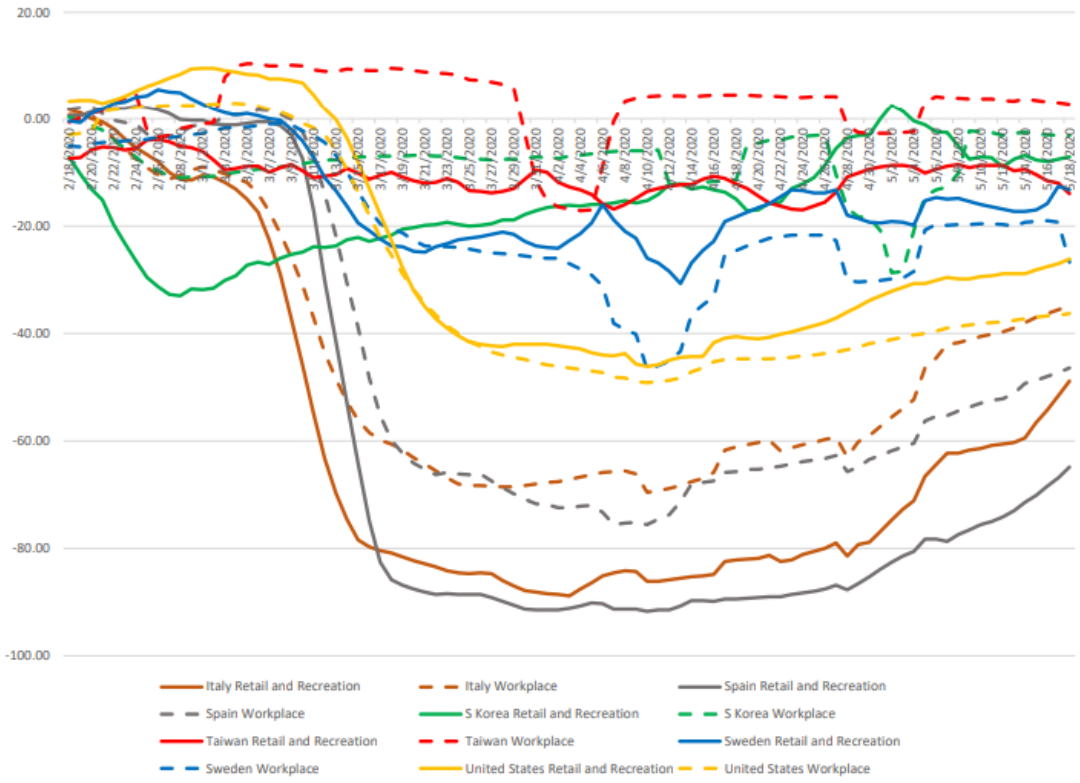
   3.B.ii DSGE models designed for “business cycle” analysis

   3.C Long-term view: development economics
4. Policy lessons

1. Anatomy of the Shock

1. Anatomy of the COVID shock: a perfect storm

Google Mobility Trends for selected economies to May 22, 2020



Source: Hevia and Neumeyer (2020), "A Perfect Storm: COVID-19 in Emerging Economies", in Djankov and Panizza, eds. (2020), "COVID-19 in Emerging Economies", CEPR Press.

- Domestic supply shock
- Domestic demand shock
- Global demand shock (from a small-open economy perspective)
- Monetary policy response
- Fiscal policy response

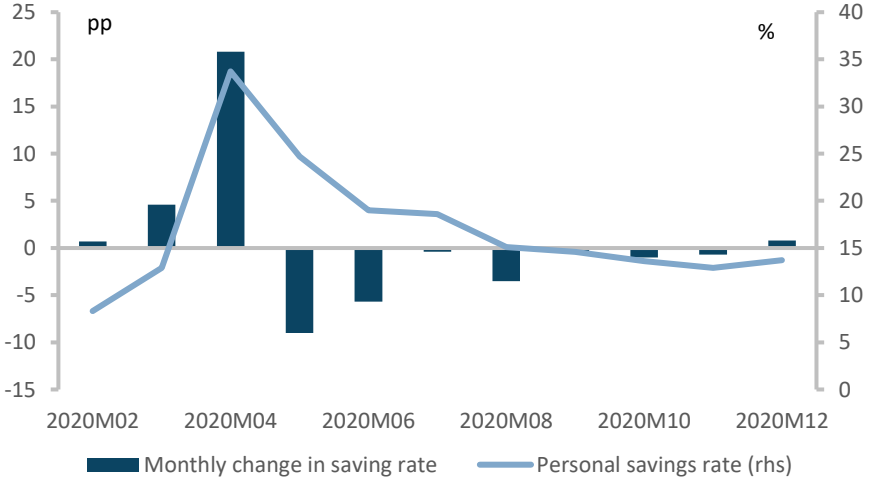
1. Anatomy of the shock: domestic demand/supply

COVID-19 and the world of work

Economic sector	Current impact of crisis on economic output	Share in global employment (%)
Education	Low	5.3
Human health and social work activities	Low	5.1
Public administration and defense; compulsory social security	Low	4.3
Utilities	Low	0.8
Accommodation and food services	High	4.3
Real estate; business and administrative activities	High	4.7
Manufacturing	High	13.9
Wholesale and retail trade; repair of motor vehicles and motorcycles	High	14.5

Source: ILO-Monitor: COVID-19 and the world of work, April 7, 2020

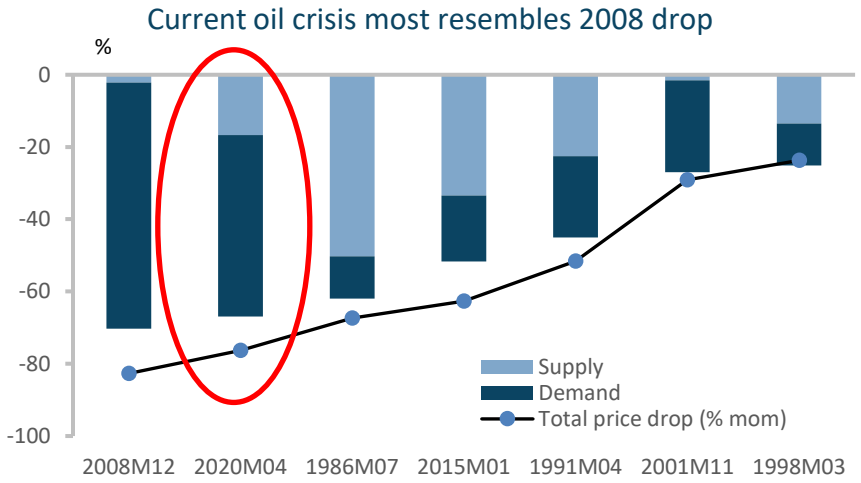
Monthly changes in the US savings rate



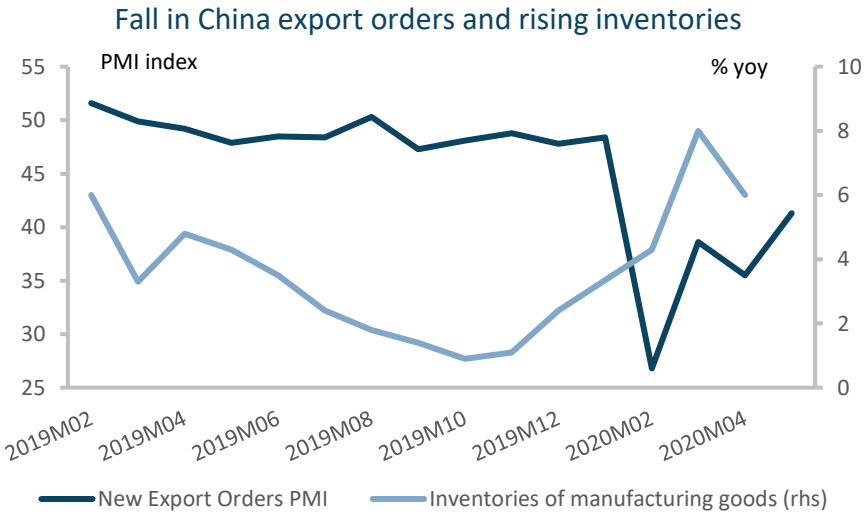
Source: Global Projection Model Network

- Domestic supply shock: Lockdowns
  - Domestic economic activity stops
  - People can't work
  - Production stops and jobs are lost
  - Supply chains unravel
- Domestic demand shock
  - Lost income (domestic and remittances)
  - Higher uncertainty leads to higher savings
    - Drop in equilibrium real interest rate

1. Anatomy of the shock: global demand/supply



Source: WB Global Economic Prospects June 2020
Note: WB estimate of contribution to largest oil price declines since 1970



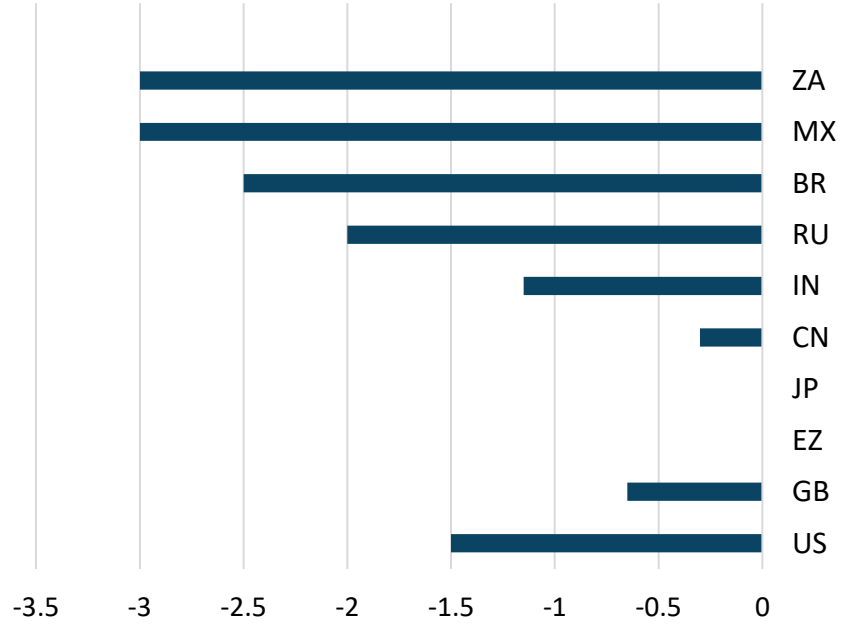
Source: Global Projection Model Network

- Global demand/supply shock
  - Fall in commodity prices
  - Fall in demand for tradable goods
    - Manufacturing
    - Collapse of tourism
      - Although a service, countries are exposed to international competition
  - Boarder closures
  - Reduction in remittance flows
  - Reduction or reversal of foreign direct investment

1. Anatomy of the shock: monetary policy

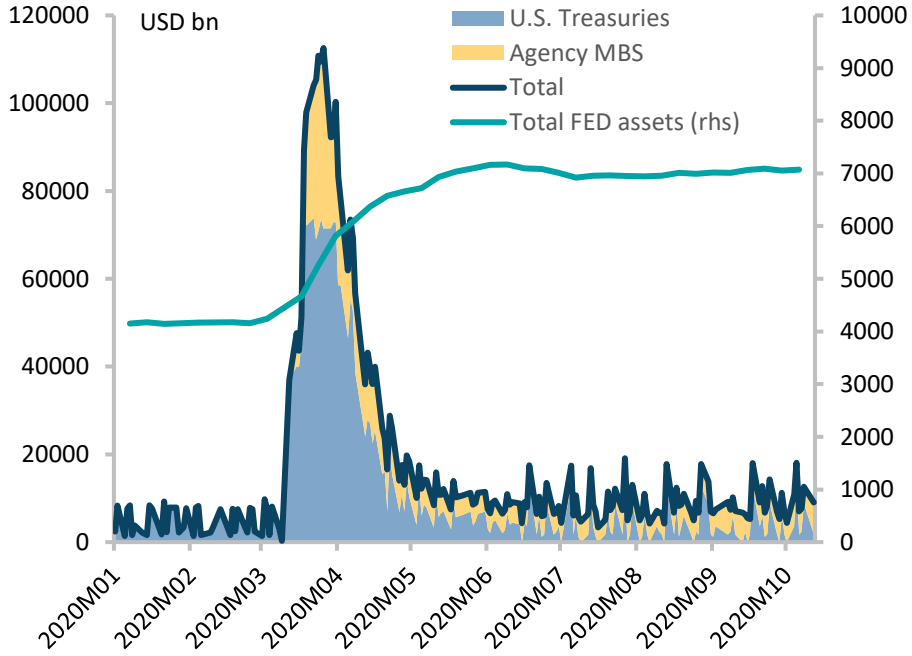
- Cuts in interest rates and start (extension) of asset purchase programs
  - Degree depends on policy stance in 2019 Q4

Cumulative interest rate cuts
(current IR vs. pre-crisis 01/2020)



Source: Global Projection Model Network

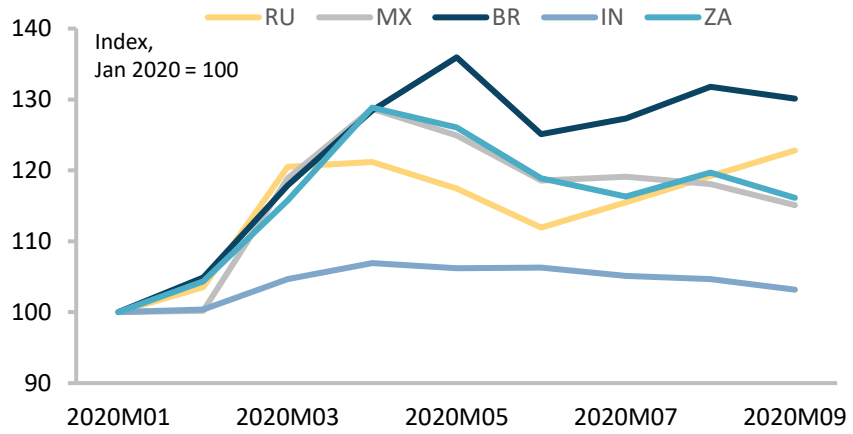
Fed balance sheet



Source: Global Projection Model Network

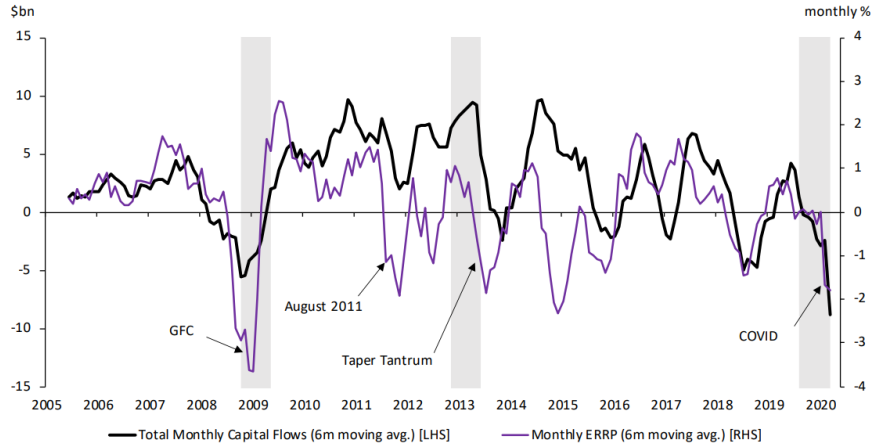
1. Anatomy of the shock: monetary policy

Emerging markets exchange rates



Source: Global Projection Model Network*; Note: 202001 = 100, up means depreciation*

Capital flows and ex-post risk premium for emerging markets

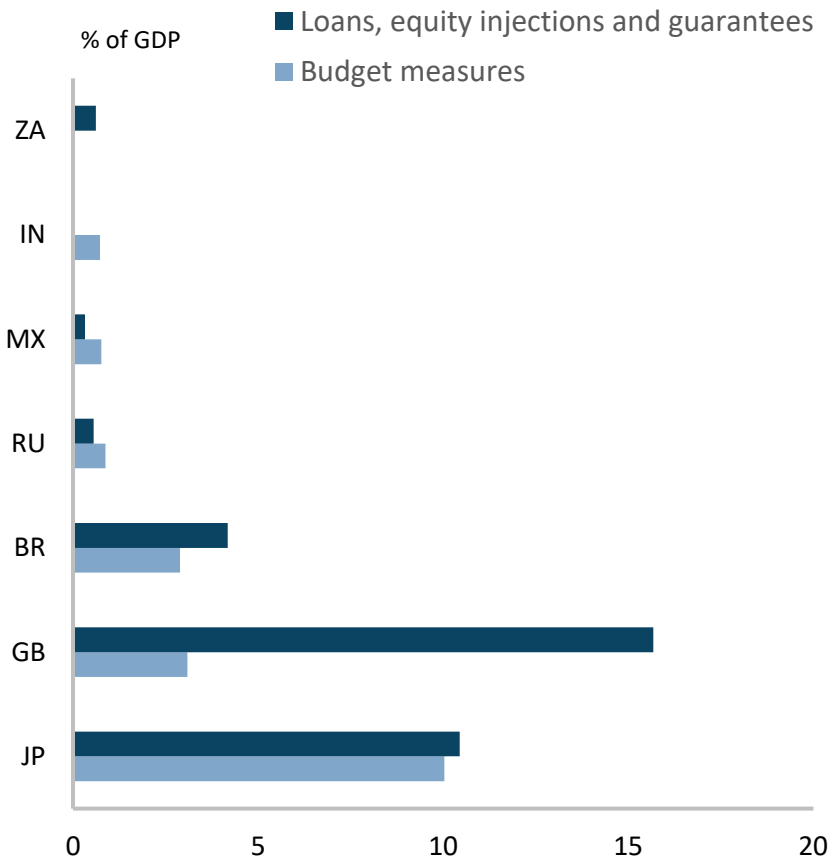


Source: Corsetti, Lloyd and Marin (2020)

- Emerging economies face(d) pressure on the exchange rate depreciation
  - Partially driven by depreciation of the equilibrium real exchange rate
    - Holds especially for commodity exporters and countries dependent on tourism
  - Partially driven by “currency” risk around “global disasters”
- The latter limits room for monetary policy response

1. Anatomy of the shock: fiscal policy

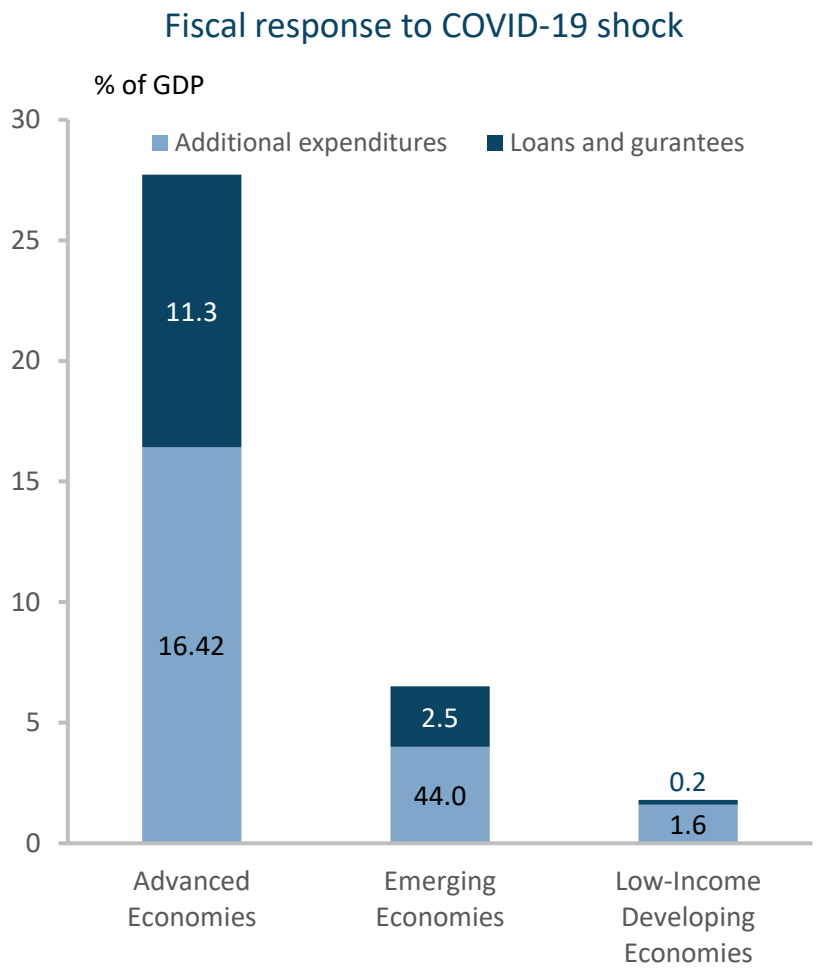
Comparison of fiscal responses
(selected countries)



Source: Global Projection Model Network

- Loans and guarantees
- Various transfers (compensation programs) for households and firms
- Tax breaks
- Government investment programs
- The size of the fiscal package varies depending on the starting level of the government debt
- There is limited room for maneuver in may countries because of the debt burden with connection to country risk premium

1. Anatomy of the shock: fiscal policy



Source: IMF Fiscal Monitor Database (April 2021) of Country Fiscal Measures in Response to the COVID-19 Pandemic

- Emerging and developing economies have usually limited room for maneuver
  - High debt burden
  - High country risk premium
  - Limited access to international financial markets

2. Why quantitative analysis?

2. Why quantitative analysis?

- Strong demand for quantitative answers
- Policy horizon of various institutions matters
  - Ministries of finance are interested in
    - Immediate (current year) impact because of necessary legal actions for budget adjustments
    - Medium-term impact because of debt-sustainability
  - Central banks care mostly about the medium-term
    - Implied by the usual “two-year” policy horizon derived from the price stability objective
  - IMF shares features of a ministry of finance and a central bank
    - From the immediate impact up to 5 years horizon
  - Development & planning ministries and various UN agencies
    - Talk a lot about the impact on 2030 Sustainable Development Goals, but most of the analysis they did is very short-term

2. Why quantitative analysis: rhetoric *versus* actual analysis

- Many government institutions claim that they use sophisticated models for forecasting and policy analysis
- Reality is often much simpler and a lot is done by expert judgment
- And that holds even more for the complex shock as COVID-19
  - Fed (March 2020) - temporarily did not publish forecast at all
  - Riksbank (since April 2020), Bank of England (in May 2020), Norges Bank (since May 2020), ECB (since September 2020) - suspended confidence intervals for their forecasts and offer alternative/illustrative scenarios instead
  - Riksbank, Norges Bank, Bank of England - adjust/create new short-term models to account for new information set from broader scope of high-frequency data
  - ECB - created/adjusted core models to account for pandemic effects
- CEPR and VoXEU published two books on economic consequences of COVID, yet only very little is not descriptive or judgmental
  - https://voxeu.org/content/covid-19-developing-economies
  - https://voxeu.org/content/shaping-africa-s-post-covid-recovery

3. Institutions and policy horizon matter

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- For the sake of clarity we distinguish

A. Expert judgment, social accounting matrix (SAM) and computational general equilibrium models (CGE)

B. Business cycle models of the monetary business cycle used dominantly by central banks

   i. QPMs

   ii. Business cycle DSGEs

C. DSGE models with longer horizon and emphasis on stock-flow consistency between investment and capital stock (physical and human)

3.A What is the immediate impact? Expert judgment, SAM and CGE models

Social accounting matrix and computational general equilibrium

3.A Expert judgment

- Many studies published by the World Bank, UN agencies and local central banks and ministries use supply-side approach when evaluating the immediate impact
- In its simplest form these use NACE Level 1 or Level 2 decomposition of value added (GDP in prices of production factors)
  - Identify sectors hit by the lockdown
  - Use number of “lockdown” days
  - Calculate daily loss in value added using historical data
  - Calculate drop in GDP
- Works for a particular quarter, but shortcomings are obvious
  - Missing linkages among sectors – one has to guess the exact extent of sector exposure
  - Missing linkages to global demand
  - Missing analysis of stock-flow consistency

3.A Social Accounting Matrix

- Links demand, supply and income side of the GDP
- Supply side is disaggregated in sectors ("activities") along NACE classification
  - Each sector is linked to others
    - For instance, 0.12 of the production in "transportation" is used as an intermediate input in "construction"
- At the same time goods and services ("commodities") produced by sectors ("activities") must be "purchased" by "institutions" forming the demand side
  - Household's (one of "institutions") purchase "commodities" produced by sectors
    - For instance, 0.08 of production in "transportation" is purchased by households forming "private consumption"
- And income from production goes in wages, rents and profits
  - Certain part of private consumption is financed through wages and these come from sectors in certain proportion
    - For instance, 0.73 of "private consumption" is financed trough wages and 0.19 of wages are made in "manufacturing"

3.A Social Accounting Matrix

- In order to create SAM one needs full national accounts although the income side can be neglected if there is not data
- SAM is constructed for a particular year often with a delay of several years
  - It can be moved forward using assumptions about sectoral growths
- When used for COVID-19 type of shock on has to form assumptions about (among others)
  - Decline of production in selected sectors (because of lockdowns or travel restrictions)
  - Decline of households' income (because of remittances for instance)
  - Decline of investment (because of lower FDIs)

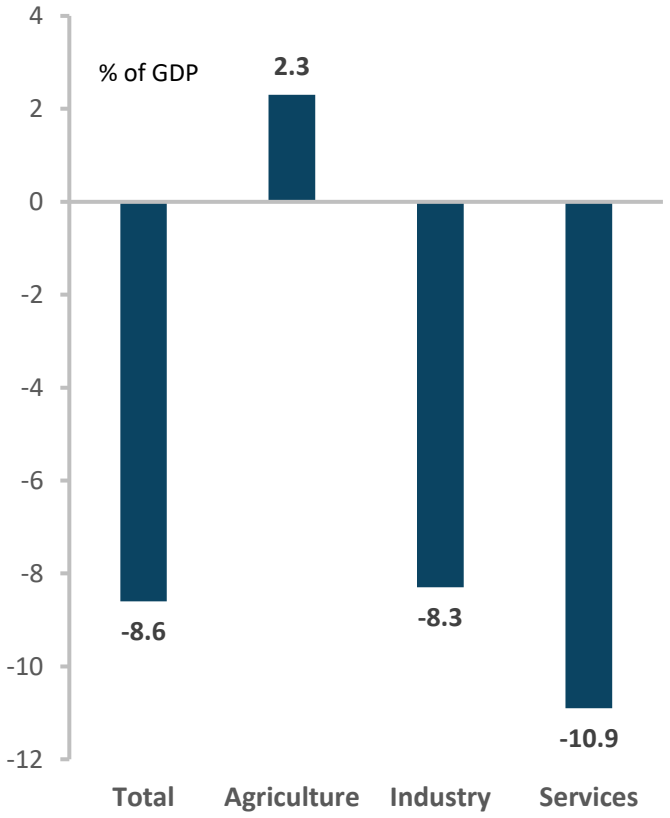
3.A SAM Example: Egypt

Assumptions about initial shock size

Sector	Size of shock, %
Crops [1]	1.4
Livestock [2]	10.0
Forestry	0.0
Fishing	0.0
Mining	0.0
Food processing [3]	10.0
Textiles	-30.0
Wood and paper	-8.3
Chemicals [4]	11.9
Metals and machinery	-20.0
Other manufacturing	-20.0
Energy and water	-9.0
Trade	-15.0
Transportation	-300
ICT	50.0
Hotels and food services	-42.7
Finance and business	-10.0
Public services	3.6
Other services	-20.0

+ Remittances and FDI down by 10% =

Estimates of change in sectoral GDP for Egypt due to COVID-19 (Q4 FY 2019/2020)



1: Wheat increases by 10%; all other crops remain unchanged
2: Cattle, dairy, poultry and other livestock
3: Meat processing and dairy products
4: Chemicals also include fertilizers, which have increased by 10%

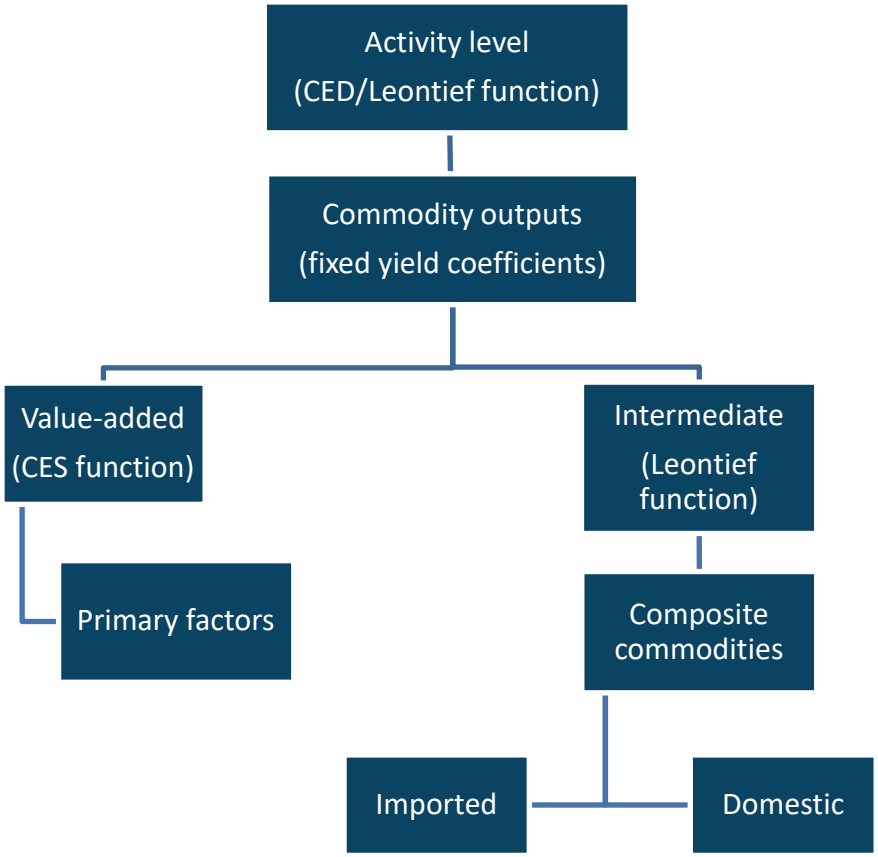
Source: Breisinger, C., M. Raouf, M. Wiebelt, A. Kamaly, and M. Karara. 2020. Impact of COVID-19 on the Egyptian economy: Economic sectors, jobs, and households. MENA Regional Program Policy Note 06. Cairo: International Food Policy Research Institute.

3.A Computational General Equilibrium

- Computational General Equilibrium (CGE) models add “extra” sophistication above the SAM
  - Again, World Bank or UN local offices use template models
- A standard CGE is based on a Social Accounting Matrix and links the …
  - “Activities” – production
  - “Commodities” – produced goods and services
  - “Institutions” – households, firms and the government
  - “Rest of the world” – current account
- … using complex production and demand functions instead of simple coefficients or shares
- Prototype CGE models can be acquired from
  - PEP – Partnership for Economic Policies, https://www.pep-net.org/pep-standard-cge-models

3.A Computational General Equilibrium

Example of production technology



Source: Lofgren et. al. (2001), "A Standard Computable General Equilibrium Model in GAMS", International Food Policy Research Institute: Trade and Macroeconomics Division Discussion Paper, No.75, May 2001

- "Activities" and "Commodities" follow economic activities based NACE classification
  - It can go up to NACE Level 4 with 629 classes of economic activities if the data is available
- Sectoral production functions and aggregation is done using complex combination of CES and Leontief production functions
- Households consumption is aggregated using linear expenditure system demand functions

3.A SAM or CGE?

- Why CGE and not just SAM?
  - The system of production functions opens the possibility to tax or subsidize selected “activity” and/or “commodity” by various taxes government transfers/subsidies programs
- The drawback of CGE (SAM) models is that they are not really suited for Covid-19 type of a shock
- CGE (and SAM) models are dominantly static
- And the global and persistent character of the shock is difficult to handle
- Any CGE model has to be “closed” by “closures” in three different areas
  - Government
    - Either tax rates or the budget deficit/surplus must be fixed
  - Savings-Investment nexus
    - Investment and savings rates must be fixed is some way (real value or nominal shares, etc.)
  - Rest of the world
    - Either current account deficit/surplus or the real exchange rate must be fixed

3.A Shortcoming of CGEs

- … but these are exactly elements that have been changing
  - Government
    - Budget deficits rose dramatically or expenditures had to be cut if the government had no room for additional borrowing
  - Savings-Investment nexus
    - Households savings jump up and down following waves of bad and good news
  - Rest of the world
    - Current account deficits worsened in emerging countries amid huge capital outflows and real exchange rates depreciated

3.B What is the impact in business cycle models?

Macroeconomic modeling at business cycle frequency

Semi-structural (QPM) and Structural (DSGE) models of the business cycle

3.B Structural and semi-structural models of the business cycle

- Central banks are the main users
- Business cycle models range from
  - New-Keynesian Reduced Form models ("semi-structural") that are best represented by the IMF QPM model
    - to
  - Micro-founded Dynamic Stochastic General Equilibrium models ("structural") designed for the analysis of the business cycle
- Both are based on "New-Keynesian" paradigm
- Focus on nominal rigidities in price and wage settings, which implies
  - Existence of the Philips curve (of whichever form)
  - Existence of the "output gap" as the deviation of the "actual" output from an "equilibrium" output
- In practice the line between those two may be rather thin and sometimes the models used for practical forecasting use elements of both
  - ECB-BASE is a perfect example of the combination (https://www.ecb.europa.eu/pub/pdf/scpwps/ecb.wp2315~73e5b1c3cd.en.pdf)

3.B.i What is a New-Keynesian Reduced Form model?

- This type of the model has become workhorse model for numerous central banks in developed and developing economies
  - Often called Quarterly Projection Model
  - Originating in the work of Berg, Karam and Laxton (2006) and Beneš, Hurník and Vávra (2008)
- Focuses on a business cycle frequency
  - Real variables – output, real interest rates, real exchange rate – are depicted in the form of "deviation" from an " flexible-price equilibrium"
  - "Deviations – gaps" are driven by behavioral equations
  - "Equilibriums" are driven by simplifying autoregressive processes
  - "Gaps" and "Equilibriums" sum up in observed values
- For "output"

Output gap

Observed output → $y_t = \hat{y}_t + \bar{y}_t$ ← Equilibrium output

3.B.i Output gap and demand shock

- The model is called “reduced-form” because it reduces components of aggregate demand in one variable – the output gap

$$\hat{y}_t = a_1 E_t \hat{y}_{t+1} + a_2 \hat{y}_{t-1} + a_3 \hat{r}_t + a_4 \hat{z}_t + \epsilon_t^{\hat{y}}$$

Output gap	Rational expectations	Habit persistence	Real interest rate gap	Real exchange rate gap	Stochastic demand shock

- And because its parameters are estimated/calibrated directly for the linear equation and are not derived from deep parameters present in optimization problems of households or firms (see slide)
- Demand shock $\epsilon_t^{\hat{y}}$ captures variation in all demand components

3.B.i Growth of equilibrium output

- The IS curve determines the output gap and one has to define a process for the equilibrium output to get what policy makers are really after and that is the output
- Since we deal with a business cycle model, the process for $\bar{y}$ is simplified
- Commonly the equilibrium growth is driven by exogenous autoregressive processes of following form

$$\Delta\bar{y}_t = \alpha\Delta\bar{y}_{t-1} + (1-\alpha)\Delta y^{ss} + \epsilon_t^{\Delta\bar{y}}$$

Growth of equilibrium output	Autoregressive component	Deterministic trend: steady-state growth of the equilibrium output	Stochastic shock in growth rate of the equilibrium output

- Shock in growth of the equilibrium output $\epsilon_t^{\hat{y}}$ captures all possible shocks hitting supply side of the economy

3.B.i Can QPM properly identify the COVID-19 shock?

- A common structure of the QPM model leaves us with two shocks that can be used for simulation of COVID-19 shock on output …
  - Demand shock $\epsilon_t^{\hat{y}}$
  - Shock in growth of the equilibrium output $\epsilon_t^{\Delta\bar{y}}$
- … which is not enough for accurate representation of the COVID-19 shock

3.B.ii A business-cycle DSGE model

- Several central banks went one step further and use a practical DSGE models for forecasting of the business cycle
  - Good early example is Czech National Bank's "g3" model
    - https://www.cnb.cz/cs/ekonomicky-vyzkum/publikace-vyzkumu/cnb-working-paper-series/Implementing-the-New-Structural-Model-of-the-Czech-National-Bank/
  - A recent example of the same is Swedish Riksbank's "MAJA"
    - https://www.riksbank.se/globalassets/media/rapporter/working-papers/2019/no.-391-maja-a-two-region-dsge-model-for-sweden-and-its-main-trading-partners.pdf
  - Somewhere between is the ECB's "ECB-BASE" which combines elements of both
- These models come from the same family as the QPM with
  - Derivation of private consumption and investment from optimization problems and through that disaggregation of aggregate demand
  - Use of production function with technology, labor and capital in one of production sectors, usually production of intermediate goods
    - This is a trick how to get technology, labor and capital involved

3.B.ii A practical business-cyle DSGE model

- It follows that instead of an aggregated IS curve one gets set of
  - Optimal conditions for household's consumption and investment behavior that determine
    - Private consumption
    - Supply of labor
    - Private investment (and through that level of capital)
    - Exchange rate (in an open economy)
  - Optimal conditions for firm's decision about
    - Production (and through that demand for labor and capital)
    - Imports and exports
    - Pricing

3.B.ii Production technology and equilibrium growth in the DSGE model

- One sector, usually producers of the intermediate good, produce using Cobb-Douglas production technology with labor, capital and level of technology
  - Constant returns on scale are common feature

$$y_t = A_t K_t^{\alpha} L_t^{1-\alpha}$$

- Importantly, in this setting it is growth of technology A_t that determines long-term growth of the economy (the balanced growth path)
- But these models do not have an ambition to explain $A_t$or ΔA_t and they use

$$\Delta A_t = \alpha \Delta A_{t-1} + (1-\alpha)\Delta \mathrm{A}^{\mathrm{ss}} + \epsilon_t^{\Delta A}$$

- Which makes them similar to the QPM

3.B.ii Decomposition of the COVID-19 shock in the DSGE model

- Naturally, the richer structure of the DSGE model leaves us with more shocks that can be used for simulation of COVID-19 on output …
  - Consumption shock
  - Investment shock
  - Labor supply
  - Shock in technology growth $\epsilon_t^{\Delta A}$
- … which is better than the QPM model, yet still not necessarily enough for complete representation of the COVID-19 shock
- Both business-cycle models handle long-term growth in simplified way that may not designed for handling of “one-off” supply shocks because it does not allow for permanent “level” shifts in equilibrium output or technology
- This may end up in inaccurate identification of the Covid-19 shock as a demand shock and/or equilibrium “growth” shock rather than a equilibrium “level” shock

3.B How to deal with the "Shock" in a QPM or business-cycle DSGE models?

- A modification is needed in order to allow for a combination of "level" and "growth" stochastic shocks

Level of equilibrium output

Stochastic shock in level of equilibrium output

$$\bar{y}_t = \bar{y}_{t-1} + g_t^{\bar{y}} + \epsilon_t^{\bar{y}}$$

$$g_t^{\bar{y}} = \alpha g_{t-1}^{\bar{y}} + (1-\alpha)\Delta g_{ss}^{\bar{y}} + \epsilon_t^{g^y}$$

Growth of equilibrium output

Autoregressive component

Deterministic trend: steady-state growth of equilibrium output

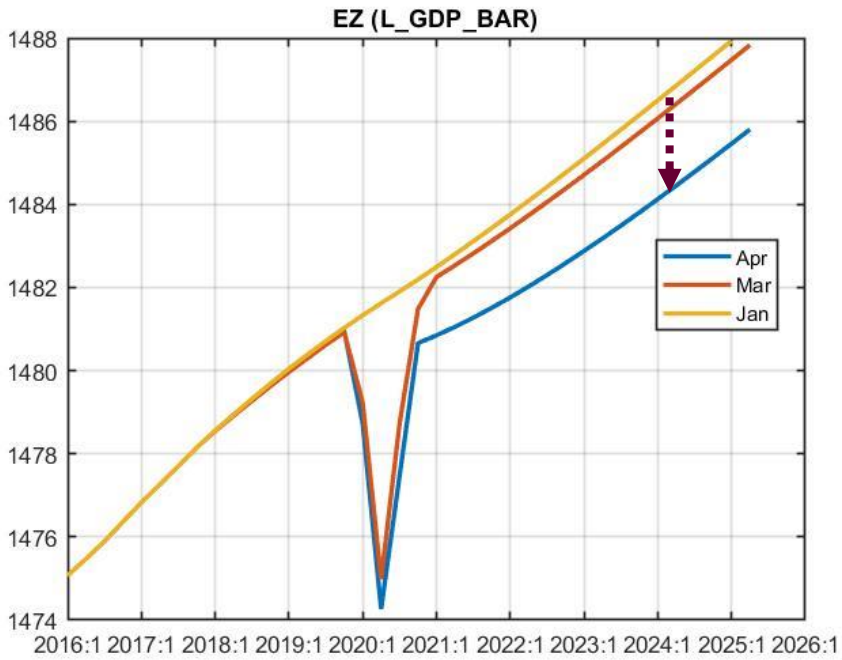
Stochastic shock in growth rate of equilibrium output

3.B Example of practical application in IMF Global Projection Model

- Global Projection Model is a multi-country version of the “QPM” style model on the basis of the IMF Global Projection Model
  - See www.igpmn.org for more details about the model
- The structure allows split the shocks in
  - Demand shock – standard “output gap” shock
  - Supply shock – allowing differentiate between the “level” shock and the “growth” shock
- In Spring 2020 forecast rounds the GPM Team
  - Explained 70-80% of the quarterly GDP decline as drop in equilibrium output and the rest as a negative output gap
  - Equilibrium was moved by one-off negative ”level” shock followed by one-off positive shock when lockdowns were eased
  - The “slope” of the equilibrium was modified through the equilibrium “growth” shock depending on country growth prospects

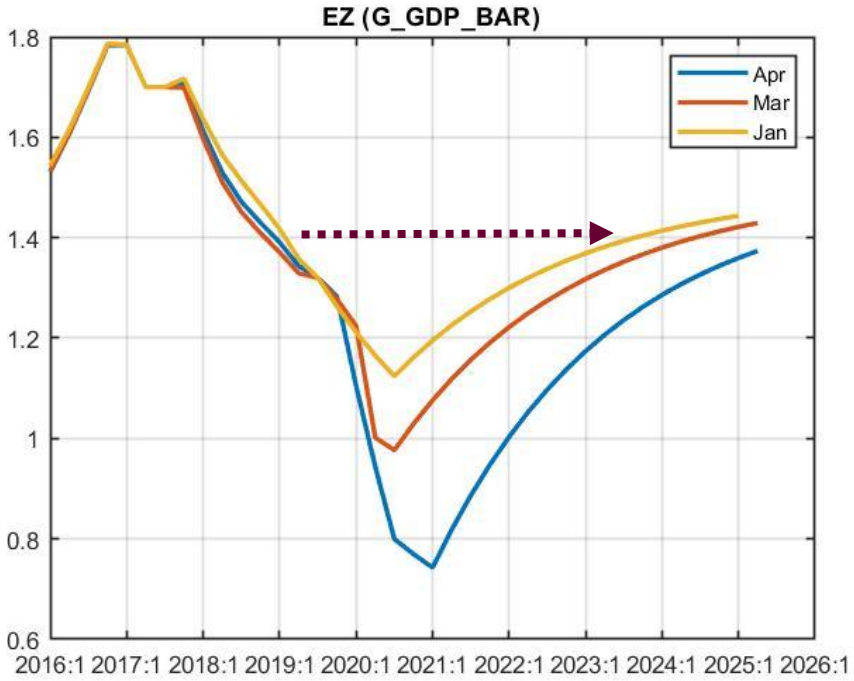
3.B Practical application - Eurozone

Level of equilibrium output



Source: Global Projection Model Network

Growth of equilibrium output

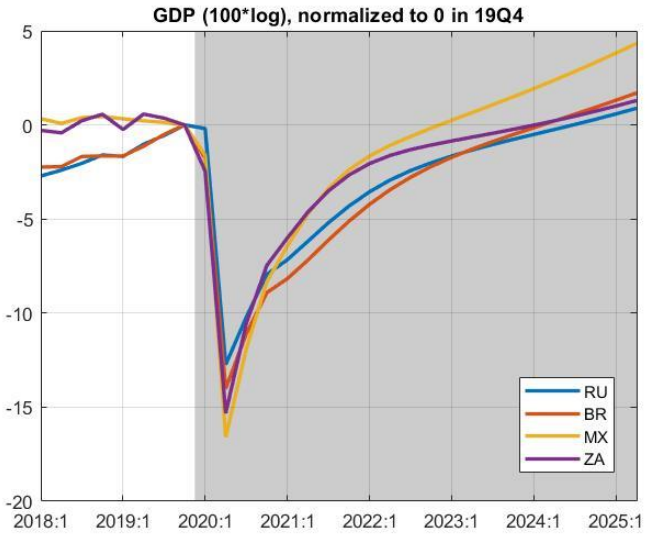


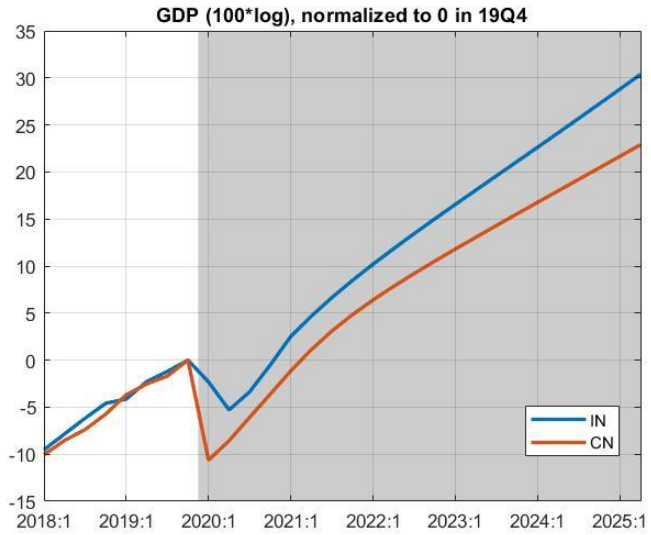
Source: Global Projection Model Network

3.B Practical application – emerging economies

Level of output normalized to 0 in Q4 2019

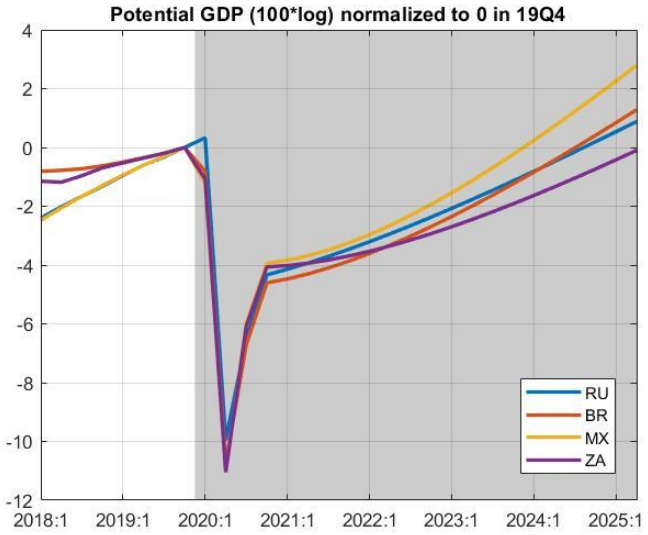
Russia
Brazil
Mexico
South Africa

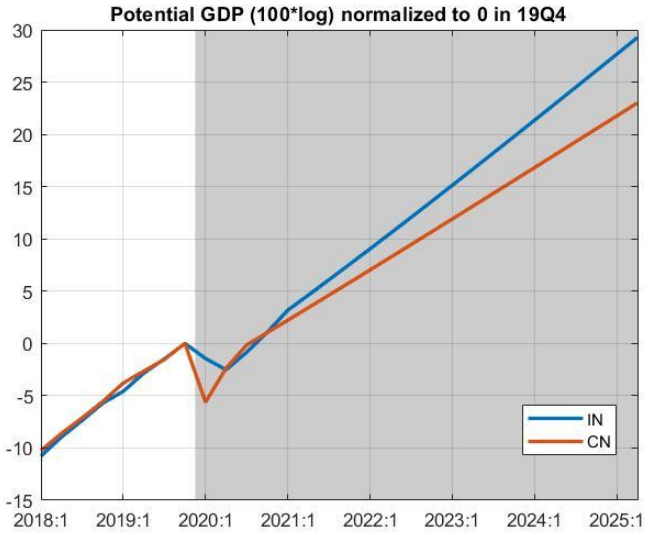




India
China

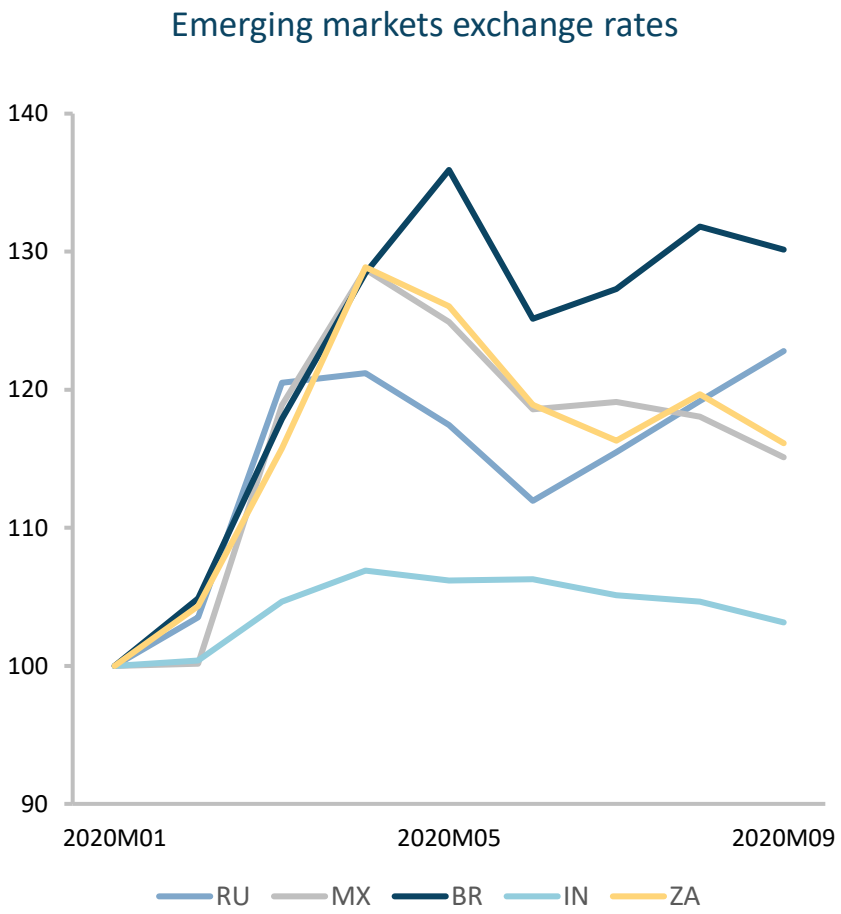
Level of equilibrium output normalized to 0 in Q4 2019





Source: Global Projection Model Network

3.B How to deal with the "Shock" in a QPM-style model



Source: Global Projection Model Network; Note: 202001 = 100, up means depreciation

- In addition to drop in GDP, in the emerging markets, exchange rates sharply depreciated and government bond yields spiked in response to the Covid-19 shock
- Rating agencies made a record number of rating downgrades during Covid-19 crisis
- Partially driven by equilibrium depreciation, partially driven by currency risk

3.B How to deal with the "Shock" in a QPM-style model

- Similarly to equilibrium output same modification is needed also for the equilibrium real exchange rate

Level of equilibrium real exchange rate

Stochastic shock in level of equilibrium real exchange rate

$$\bar{z}_t = \bar{z}_{t-1} + g_t^{\bar{z}} + \epsilon_t^{\bar{z}}$$

$$g_t^{\bar{z}} = \gamma g_{t-1}^{\bar{z}} + (1-\gamma)\Delta \mathrm{g}_{\mathrm{ss}}^{\bar{z}} + \epsilon_t^{g^z}$$

Equilibrium real exchange rate depreciation/ appreciation

Autoregressive component

Deterministic trend: steady-state equilibrium real exchange rate depreciation/ appreciation

Stochastic shock in equilibrium real exchange rate depreciation/ appreciation

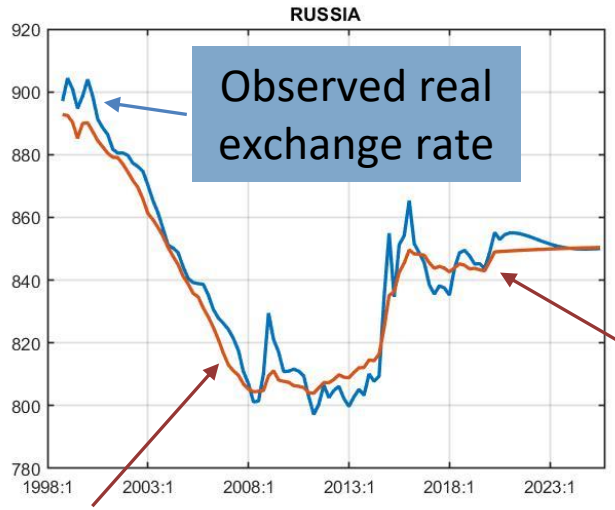
3.B How to deal with the "Shock" in a QPM-style model

- At the same time there is no adjustment needed when it comes to the process driving equilibrium real interest rate because that is in "level"

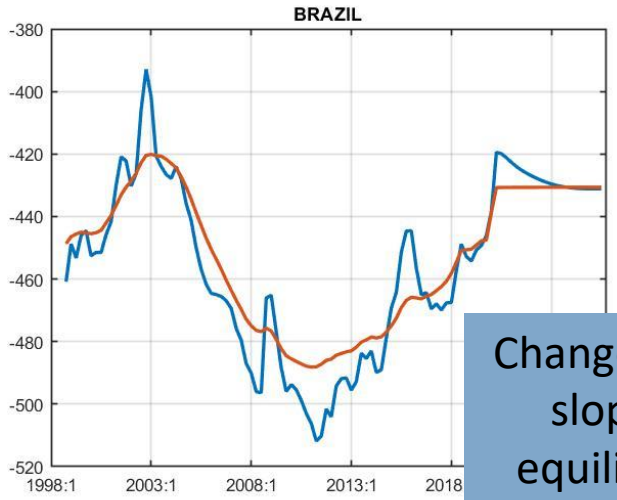
$$\bar{r}_t = \gamma \bar{r}_{t-1} + (1-\gamma)\bar{r}^{SS} + \epsilon_t^{\bar{r}}$$

- Level of equilibrium real interest rate
- Autoregressive component
- Steady-state equilibrium real interest rate
- Stochastic shock in equilibrium real interest rate

3.B How to deal with the "Shock" in a QPM-style model



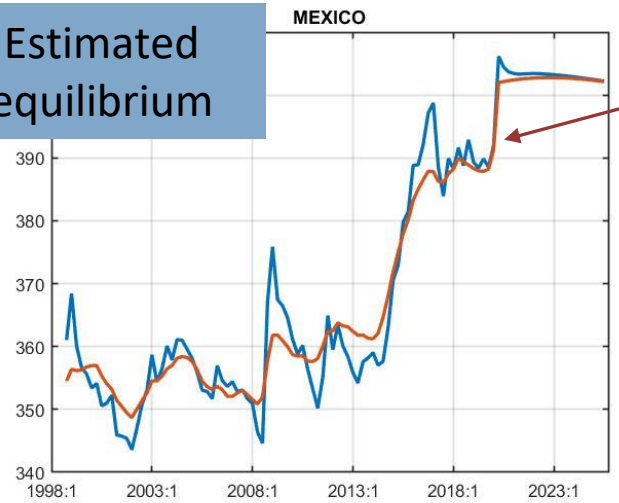
Observed real exchange rate

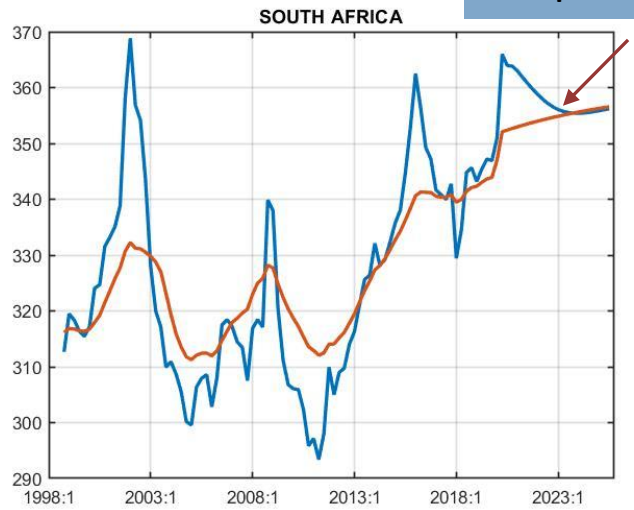


Change in the slope of equilibrium depreciation

"Level" shift in equilibrium

Estimated equilibrium





Source: Global Projection Model Network

3.B Example of practical application – one more step worth consider

Example in IRIS syntax

```
mult.std_SHK_L_GDP_BAR_US
= tseries();

mult.std_SHK_L_GDP_BAR_US
(qq(2020,1):qq(2020,2)) =
[7, 90];

mult.std_SHK_L_GDP_BAR_EZ
= tseries();

mult.std_SHK_L_GDP_BAR_EZ
(qq(2020,1):qq(2020,2)) =
[6 12];
```

Standard deviation for the equilibrium "level" shock is doubled in 2020Q2 in comparison to 2020Q1, which is still multiple of usual size

- Despite the "dual" specification for equilibria, a QPM style model has tendency to explain the huge observed drop in GDP as a demand shock when using Kalman filtration for the estimation of directly unobserved equilibria and shocks
- That is because of historical distribution of GDP fluctuations in demand and supply shocks (relative size of their standard deviations)
- It is convenient to use "multipliers" for the calibration of standard deviations in Kalman filtration

3.B Example of practical application of a DSGE model

- A QPM-style model is not able to answer question regarding the long-term impact
  - One can adjust the growth of the equilibrium output and speed of equilibrium real exchange rate depreciation (and other equilibria)
  - BUT, the “chosen” numbers as surely based on one’s expert judgment
- A DSGE model helps in this respect because of the
  - Stock-flow consistency between investment and capital
  - Possibility of optimizing and hand-to-mouth households
  - Split of production between tradable and non-tradable sector helps to explain the real exchange rate
  - Possible presence of fiscal sector with government consumption, investment in infrastructure, various taxes and transfers
  - Debt sustainability to explain risk premium
  - Commodity sector if convenient

3.B Example of practical application of a DSGE model

- Adam, Henstridge and Lee (2020) use a relatively complex DSGE model developed originally inside the IMF to support debt sustainability analysis in relation do development programs
  - See Zanna et. al (2019) for the original publication
- The model's production technology
  - Nontradables

$$q_t^n = A_t^n \left(\frac{z_{t-1}^e}{A_{t-1}} \right)^{\phi^n} (k_{t-1}^n)^{\alpha_n} (A_t L_t^n)^{1-\alpha_n}$$

Labor augmenting technology

Capital

Labor

  - Tradables

$$q_t^x = A_t^x \left(\frac{z_{t-1}^e}{A_{t-1}} \right)^{\phi^x} (k_{t-1}^x)^{\alpha_x} (A_t^{xn} A_t L_t^x)^{1-\alpha_x}$$

Sectoral total factor productivity

Effective infrastructure capital

Export specific technology

3.B Example of practical application in a DSGE model

- Despite all the sophistication the long-term growth remains driven by the growth of technology A_t
  - After a few years the growth returns to the ΔA_{ss}, which is a chosen constant
- That means that permanent effects of lower physical and especially human capital are not captured
- But at least the process for technology allows for the level shift …

$$A_t = A_{t-1}(1 + g_t^A) + \epsilon_t^A$$

$$g_t^A = \rho^A g_{t-1}^A + (1 - \rho^A) g_{SS}^A + \epsilon_t^{g^A}$$

- … allowing for permanent level shifts in technology

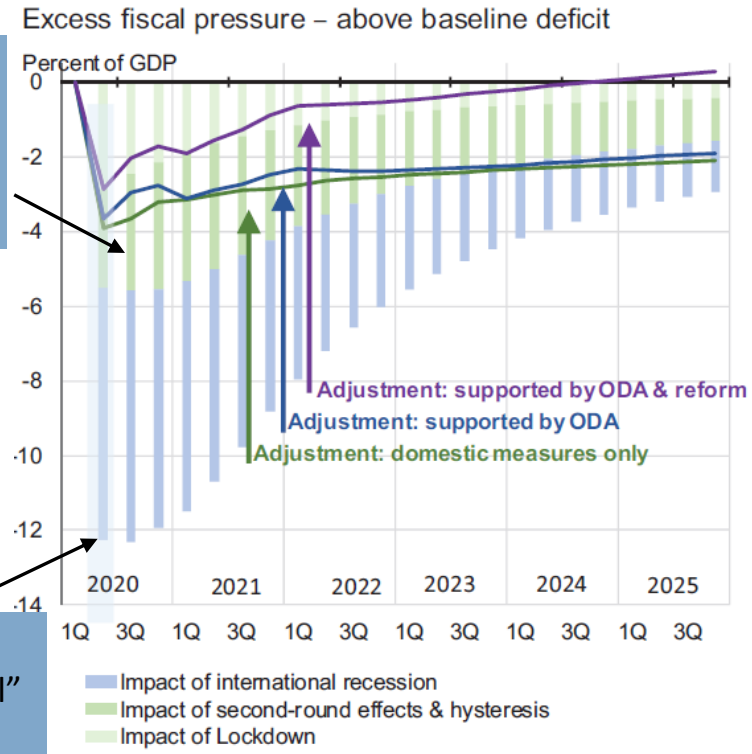
3.B Example of practical application in a DSGE model

- Adam, Henstridge and Lee (2020) calibrate the COVID-19 shock as follows (for Uganda)
  - Domestic side
    - A temporary withdrawal of labor across the economy
    - A temporary reduction in total factor productivity in both sectors
    - A temporary loss of private capital – a hysteresis effect

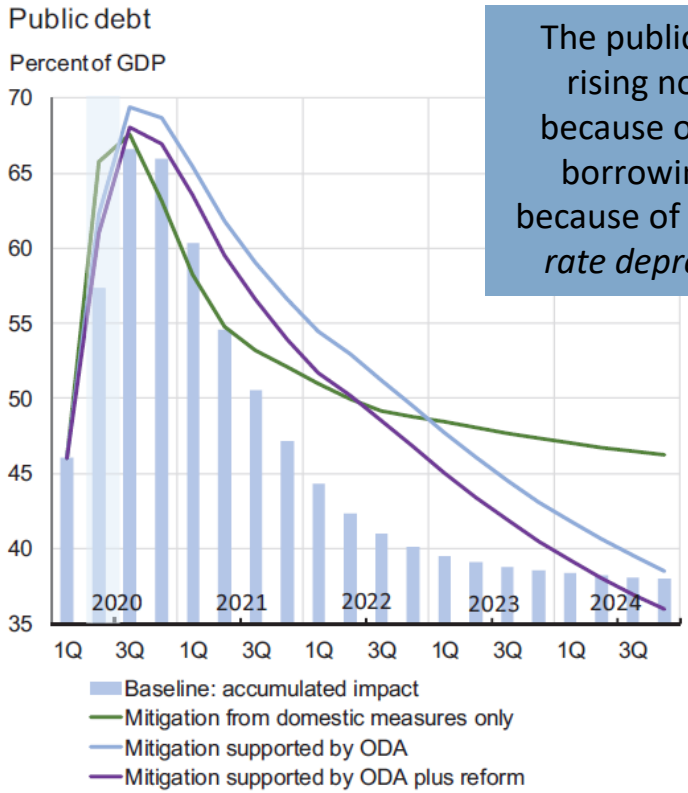
      and
    - Increased spending on transfers
    - Increased government spending
  - External side
    - Contraction in global demand *via* income terms of trade (tourism)
    - Substantial fall in remittance flow
    - Sudden stop in net FDI and portfolio private capital flows

3.B Example of practical application in a DSGE model … Uganda

Size of the budget deficit with forced adjustments



Size of a "theoretical" budget deficit if the country could borrow without any constraint

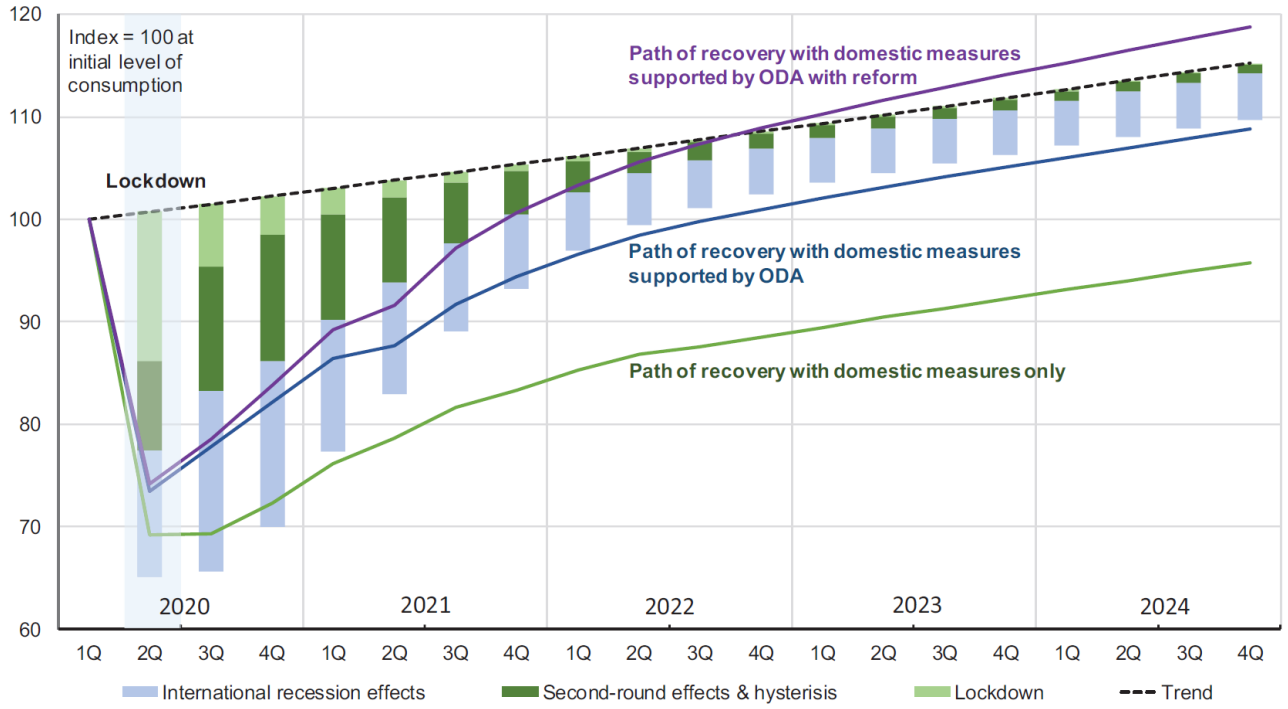


The public debt is rising not only because of "new" borrowing, but because of *exchange rate depreciation*

Source: Adam, Henstridge and Lee (2020), "After the lockdown: using epidemiological and macroeconomic models to set out the adjustment to the aftermath of the covid-19 pandemic", Oxford Policy Management, June 2020.

3.B Example of practical application in a DSGE model … Uganda

Simulated paths for aggregate private consumption



Source: Adam, Henstridge and Lee (2020), "After the lockdown: using epidemiological and macroeconomic models to set out the adjustment to the aftermath of the covid-19 pandemic", Oxford Policy Management, June 2020.

- Domestic measures
  - Limited room for additional borrowing
  - Need to cut government investment in the size of 8% of GDP for two years
  - Residual deficit financing is tilted from taxation and domestic borrowing

3.C Long-term view: development economics

3.C The long-term analysis remains an issue

- A proper analysis of the long-term should cover …
  - Explicit handling of accumulation of human capital and its impact on technology diffusion
    - Expenditures on education and research
  - Explicit handling of demographic changes
- … endogeneity of changes in technology
- Similar models have been developed in academic literature, but their practical application remains an issue

4. Policy lessons

4. Policy lessons

- Policy horizon matters
  - At the business-cycle frequency the shock is bets described by combination of
    - Local negative supply shock depending on the local lockdown
    - Local negative demand shock
    - Lower external demand
    - Lower FDI's
    - Lower remittances (if relevant)
    - Higher risk premium if the country is an emerging economy
  - Standard business-cycle models work reasonably well in this situation if the models allow for permanent shifts in equilibrium output or technology
    - Three types of shocks are needed to identify the shock reasonably well
      - Demand shock – output gap or consumption/investment
      - Level of the equilibrium output or technology
      - Growth of the equilibrium output or technology

4. Policy lessons

- Beyond the business-cycle the impact remains judgmental regardless of the model sophistication
  - Although some DSGE models capture the link between physical investment and capital, the balance growth path remains driven exogenously
- The link between human capital, research & development and growth is theoretically well captured in many existing versions of endogenous growth models …
- … but these models remain to be brought to truly practical application

Literature

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Annex

ECB

- Suspended publishing of confidence bands and publishes alternative scenarios (since September 2020)
  - The assumptions in these scenarios concern the evolution of the pandemic and the severity and duration of containment measures, as well as the timing and successful implementation of medical solutions.
- Extension the ECB-BASE model for a standard pandemic susceptible-infected-recovered (SIR) model in order to capture the short-term effect of the pandemic
  - https://www.ecb.europa.eu/pub/economic-bulletin/focus/2021/html/ecb.ebbox202101_04~c4250012ae.en.html
- The rest of the ECB-BASE remains the same and will be discussed below

Sveriges Riksbank

- Suspended confidence bands for GDP forecasts (since April 2020) and offers alternative scenarios instead
  - Normally, the Riksbank's forecasts can be seen as a weighing together of scenario s for economic developments, in which the different weights denote the probabili ties of the scenarios occurring. In the current circumstances, they offer various scenarios due to significantly different assumptions in each of them
- Created an initiative to broaden information/data sets for tracking the near-term activity in response to COVID-19 shock
  - https://c19impact.com/superset/dashboard/7/
  - https://www.riksbank.se/globalassets/media/rapporter/ekonomiska-kommentarer/engelska/2020/real-time-indicators-provide-information-support-during-rapid-cyclical-turnarounds.pdf
- For assessing long-term impacts from COVID-19, MAJA (DSGE) model is used
  - https://www.riksbank.se/globalassets/media/rapporter/ppr/fordjupningar/engelska/2020/the-long-term-economic-effects-of-the-pandemic-are-uncertain-article-in-monetary-policy-report-november-2020.pdf

Norges Bank

- Stopped publishing confidence bands for model forecasts (since May 2020) and creates forecast for few alternatives instead
  - Near term is build on assessments of developments in individual industries under the two alternative assumptions regarding the path for the vaccination rate and containment measures in Norway and abroad
    - Given that the projections build on concrete assumptions are linked to non-modelled factors such as infection rates, containment measures and vaccine availability, the period for short-term forecasts has been extended by two additional quarters.
  - After the normalization of situation the forecast uses core macro model NEMO

About the German Economic Team

Financed by the Federal Ministry for Economic Affairs and Energy, the German Economic Team (GET) advises the governments of Moldova, Georgia, Ukraine, Belarus and Uzbekistan on economic policy matters. Furthermore, GET covers specific topics in other countries, such as Armenia. Berlin Economics has been commissioned with the implementation of the consultancy.

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