Assessing the impact of COVID-19 in Asia and the Pacific and designing policy responses

An Excel-based Model

Manual

UNITED NATIONS ESCAP
Economic and Social Commission for Asia and the Pacific

COVID-19 RESPONSE

Contents

Background

COVID-19 is an unprecedented socio-economic crisis and calls for unprecedented policy responses. In addition to being a severe health crisis that is upending people's lives, it is wreaking havoc on economies and societies at a global scale. The Asia-Pacific region is no exception.

To flatten the curve of the pandemic, all the countries in the region have introduced measures, such as quarantines, suspension of productive activities, lockdowns, social distancing and closure of public places. While contributing to slowing the spread of COVID-19, such measures have adversely impacted the regional economies, with the short-term economic losses expected to be much greater than those experienced during the Asian Financial Crisis and the Global Financial Crisis. In particular, a significant number of people could lose their jobs and be forced into extreme poverty ($1.9 per day) in 2020.[1] For the least developed countries (LDCs), ESCAP (forthcoming)[2] estimates that the economic downturn (as IMF projects in April 2020) would push 5.9 million people into extreme poverty ($1.90 per day), and 12.4 million, using the $3.20-per-day poverty line. This brings the poverty rates back to the levels seen 5-10 years ago (with some variation across LDCs).

To support frontier health responders, affected businesses (especially micro, small and medium enterprises) and households, and economic and financial stability, the majority of countries in the region have adopted supportive monetary and fiscal policies. Some of these policy packages are of unprecedented scale (visit ESCAP's COVID-19 Policy Responses Tracker for more details: https://www.unescap.org/covid19/policy-responses). That said, as COVID-19 is not fully contained yet (as of mid-August 2020), more policy packages are pending to be announced to relieve the immediate adverse impacts. Countries are also designing longer term policies to enhance resilience to future shocks.

To help countries ensure effective policy design and to align policy responses with the 2030 Agenda for Sustainable Development, modelling work is helpful to support in-depth analysis to assess: through what channels and how severely the economies have been affected; how effective the current macroeconomic policy easing will be; what other policy measures the Asia-Pacific economies should introduce; whether all the countries have capacity to roll out more stimulus packages; and what economic, social and environment consequences could be incurred.

In this context, the Macroeconomic Policy and Financing for Development Division of ESCAP has developed an Excel-based model to assess the impact of COVID-19 and simulate policy responses, with the support by Ms. Dawn Holland. It produces a snapshot of the socio-economic situation facing the country/territory, and allows simple policy scenarios to be studied.

[1] According to World Bank and ADB's estimates. Source: https://blogs.worldbank.org/opendata/updated-estimates-impact-covid-19-global-poverty; https://data.adb.org/dataset/covid-19-economic-impact-assessment-template.
[2] ESCAP (forthcoming). Technical note on assessing the short-term impact of COVID-19 on poverty in Asia-Pacific least developed countries.

This manual explains how to access the simulation tool, how the model works, and how the users can run policy scenarios.

Overview of the model

The purpose of the model is to inform economists and policymakers of the likely impact of the Covid-19 crisis on key economic, social and environment indicators, and to allow simple scenarios to be undertaken.

There are a vast number of factors that will determine the socio-economic consequences of the current crisis on individual economies - for example, the ability to cope with the health crisis in terms of the number of doctors, nurses, hospital beds, etc.; the extent and duration of lockdown measures introduced to protect health and health systems both at home and abroad; the economy's reliance on income flows from tourism or remittances; depth of integration into global value chains; and industrial structure of the economy. A model can only incorporate a subset of the many potential factors that will influence socio-economic developments in a country at a given point in time. This simple tool includes a set of key factors that are expected to be most relevant and that are available for a large number of countries.

The model is based around two central interactive spreadsheets. These are backed by a large database that is set up on a series of updateable spreadsheets in the same workfile. The first worksheet presents a "country overview" that illustrates key factors that are expected to affect the impact of the crisis on the economy, putting this into a regional and global context. These include measures of the spread of the pandemic, the country's exposure to external shocks, the stringency of measures that have been required to contain the pandemic, the industrial structure of production and trade, social conditions that impact the capacity to cope with the crisis, and the magnitude of macroeconomic policy measures introduced in response to the crisis.

The factors illustrated in the "country overview" are then integrated into an economic model to assess their likely impact on key variables. The second worksheet "Scenarios" compares ESCAP's pre-COVID-19 estimates for key variables (GDP growth, inflation, employment growth, fiscal balance, government debt, poverty, inequality, CO_2 emissions and air pollution) to a post-COVID-19 projection, based on the model projections.

The estimated impact of the crisis on GDP is decomposed into the model estimated impact of domestic lockdown measures; the impact of global spillovers; the impact of underlying social conditions; the impact of the macroeconomic policy response to the crisis; and "other factors" that are not explicitly specified in the model.

The "Scenarios" worksheet also allows the user to develop alternative scenarios, by modifying policy choices, the stringency of lockdown measures at home and abroad, and the oil price, as well as the impact of "other factors" that are not explicitly captured by the model. Individual countries will face many other country-specific developments and issues that are not captured

here, as this model is designed only to assess the COVID-19 shock. Advanced users may also choose to modify some of the elasticities underpinning the model, which are designed to capture average behavior across the region, rather than tailored to an individual country. This process is described under "Technical notes" below.

The data that back the model are updated on a regular basis. The last update was done on 10 November 2020.

Caveat! The model is not designed to deliver a complete forecast for any country or territory. All forecasts are assessed relative to a set of pre-COVID baseline projections, and *only* the COVID shock is explicitly modelled. While this is the by far the dominant shock facing most economies, individual economies will face many other country-specific shocks that are not captured here. In addition, the model is parameterized to capture average expected behavior across the region, rather than tailored to individual countries or territories. Advanced users can modify all parameters and elasticities in the model to tailor it to an individual country or territory, although there is often little information on which to base country-specific values.

The modelled results are those of the users and do not reflect the views of ESCAP.

Suggested citation: (author), based on ESCAP (2020). Assessing impact of COVID-19 in Asia and the Pacific and designing policy responses: An Excel-based model.

Countries/country groups to cover

The model allows for analysis of 58 countries and territories in the Asia-Pacific region that are systematically monitored by ESCAP. For several countries, only a partial analysis is possible due to data limitations.[3] For individual countries, any missing data that is required to run the model (such as the stringency of lockdown measures) is substituted by the regional average.

Accessing the model

The model can be downloaded from ESCAP's website: https://www.unescap.org/resources/assessing-impact-covid-19-asia-and-pacific-and-designing-policy-responses-excel-based.

Users should use Microsoft Excel to open it.

[3] These include: American Samoa; Cook Islands; Democratic People's Republic of Korea; Federal States of Micronesia; French Polynesia; Guam; Hong Kong, China; Macao, China; Marshall Islands; Nauru; New Caledonia; Niue; Northern Mariana Islands; Palau; and Tuvalu.

Using the model

Inputs and outputs of the model

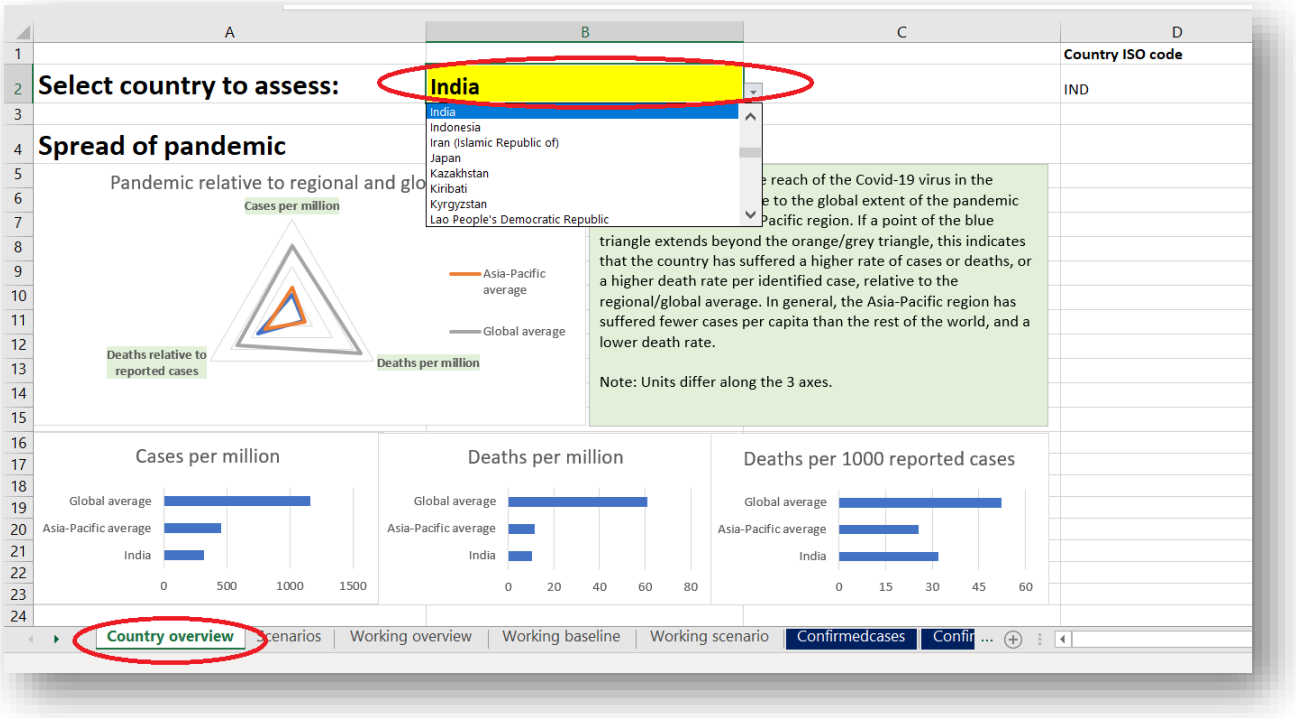
The model provides a "country overview", illustrating key factors that are expected to affect the impact of the crisis on the economy, putting this into a regional and global context. These include measures of the spread of the pandemic, the country's exposure to external shocks, the stringency of measures that have been required to contain the pandemic, the industrial structure of production and trade, social conditions, and the policy backdrop.

These factors are then integrated into an economic model to assess their likely impact on key variables (namely, GDP growth, inflation, employment, fiscal balance as a share of GDP, public debt as a share of GDP, poverty headcount ratio at $1.9 per day and $5.5 per day thresholds, Gini coefficient, CO_2 emissions and PM2.5 concentration). Scenarios can be developed by modifying policy options, the stringency of lockdown measures at home and abroad, and the oil price.

In detail:

<u>Step 1</u>: Select country to assess

From the dropdown menu on the "Country overview" page, select the country of interest.

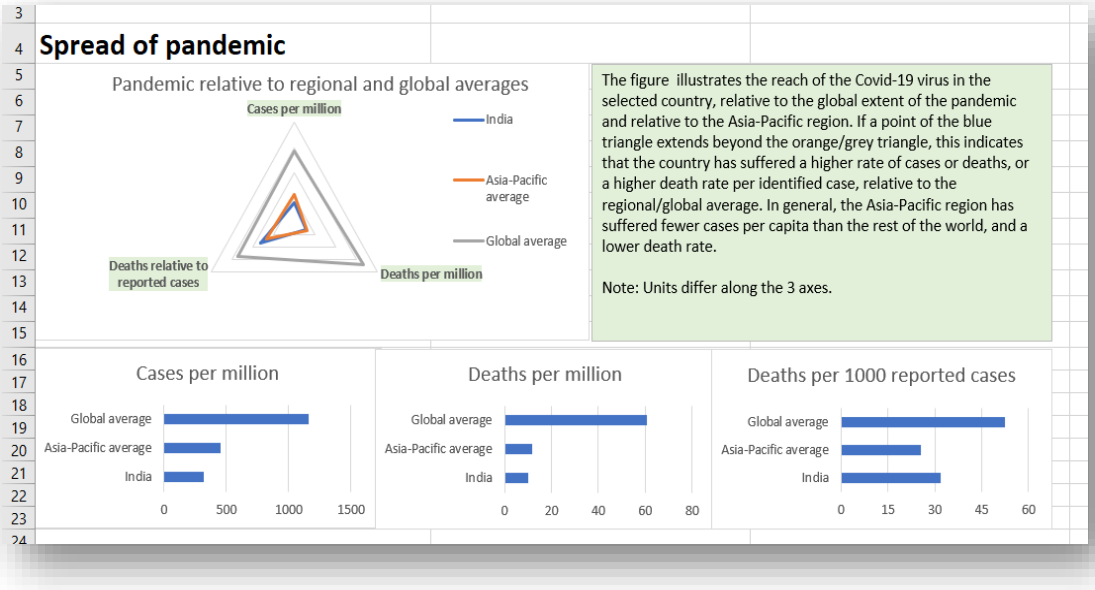


<u>Step 2:</u> Review a snapshot of the socio-economic situation facing the country

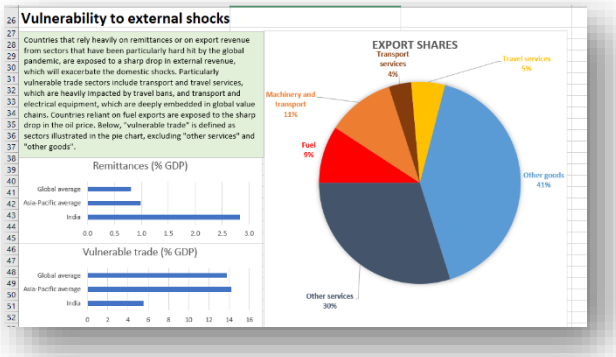
After the country of interest is selected, the "Country overview" and "Scenarios" pages provide a snapshot of the socio-economic situation facing the country in the time of COVID.

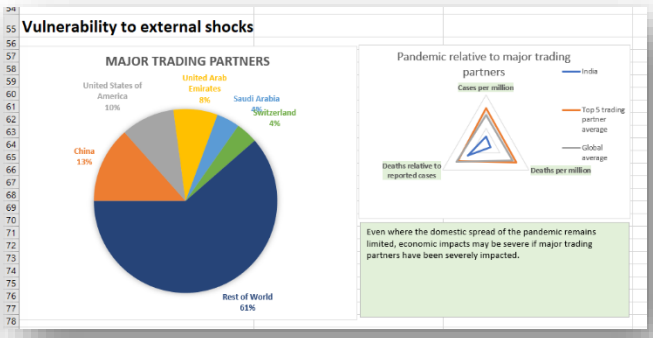
First, the **"Country overview" page** illustrates:

(1) the reach of the COVID-19 pandemic in the selected country as of the last update, relative to the global and regional extent;

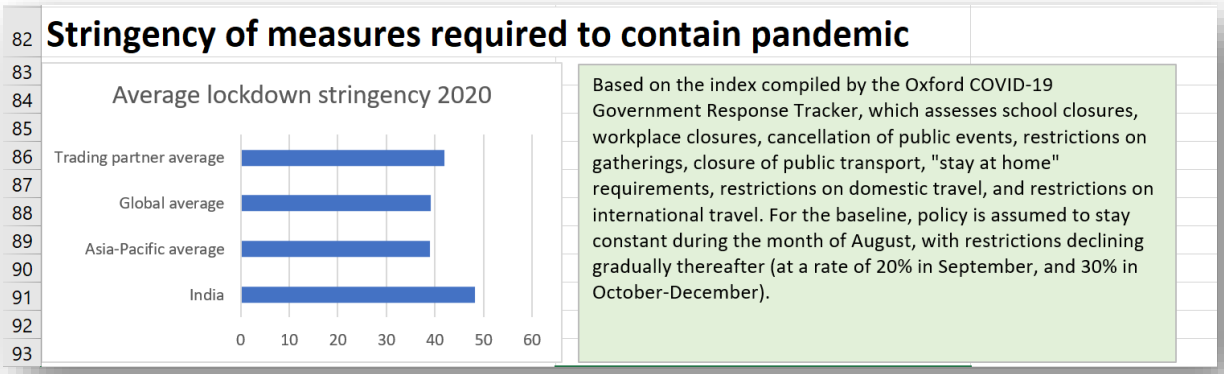


(2) the country's vulnerability to external shocks (countries that rely heavily on remittances or on export revenue from sectors that have been particularly hard hit by the pandemic, such as transport or travel services, are exposed to a sharp drop in external revenue, which will exacerbate the domestic shocks);

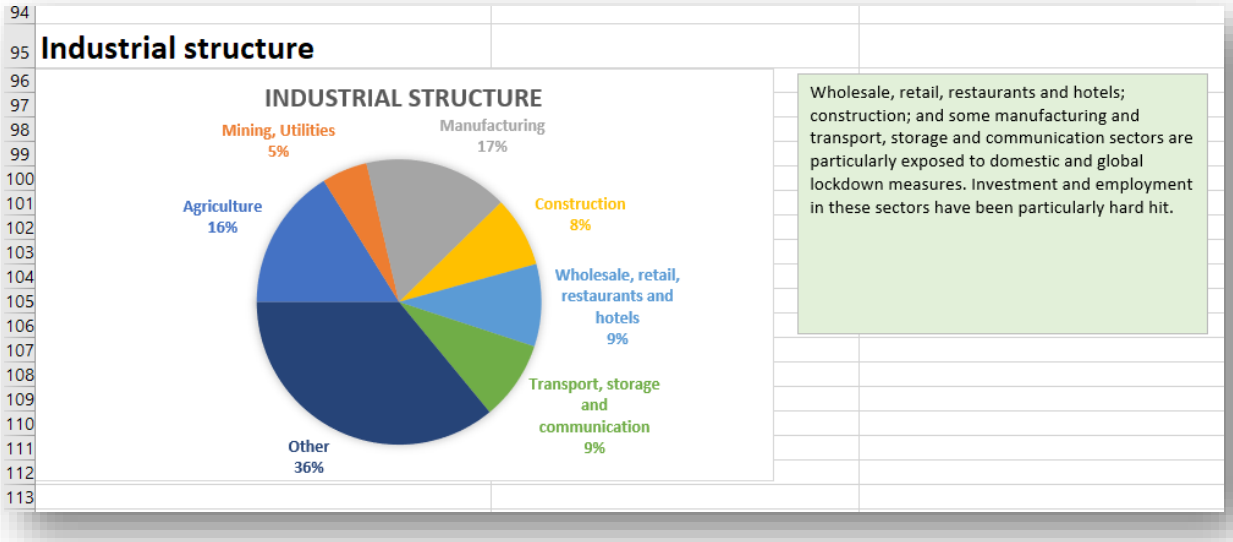




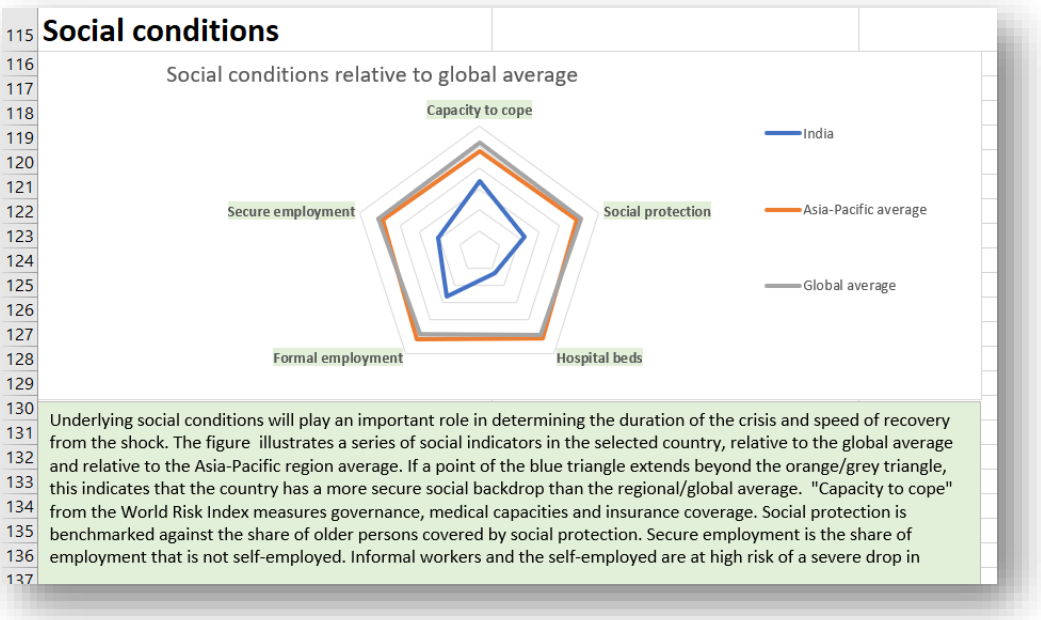
(3) stringency of policy responses to contain the pandemic in the selected country and its major trading partners;



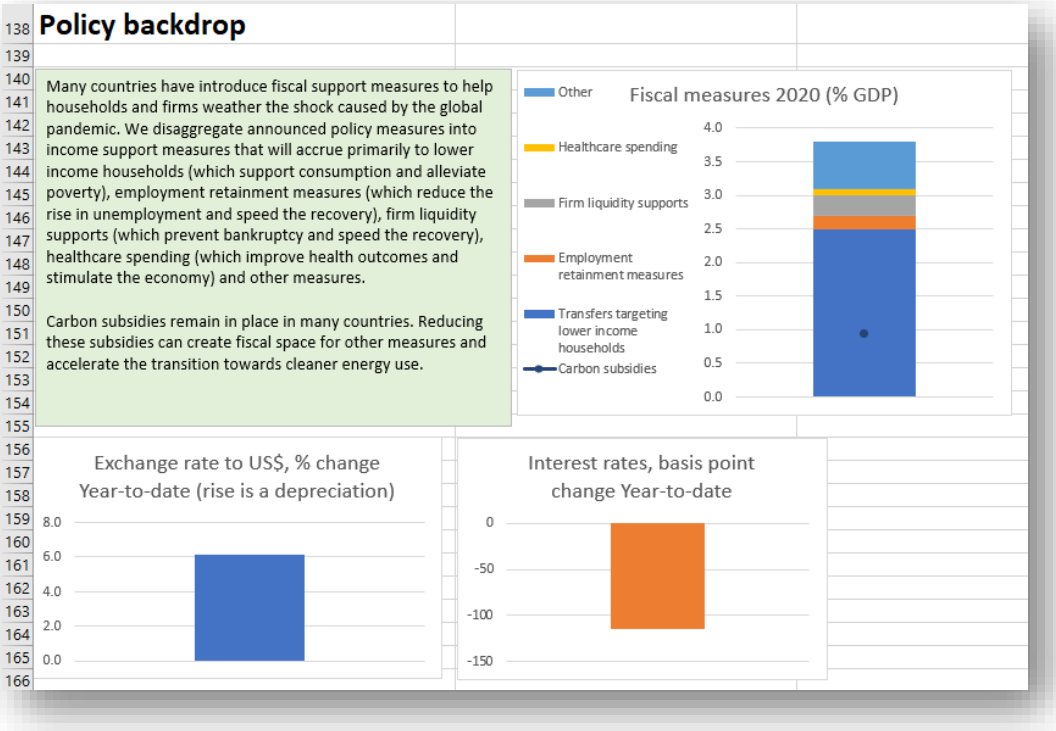
(4) the country's domestic industrial structure, which illustrates its exposure to domestic and international lockdowns (some sectors such as retail, restaurants and hotels, construction, and transport have been particularly hard hit);



(5) underlying pre-COVID-19 social conditions which contribute to determine the duration of the crisis and speed of recovery from the shock;



(6) policy backdrop, which illustrates the announced fiscal support measures (as of the last update) and is disaggregated into healthcare spending, firm liquidity supports, employment retainment, income support, and other measures;



Second, the **"Scenarios" page** illustrates:
(Note: the country to be presented here is selected on the "Country overview" page.)

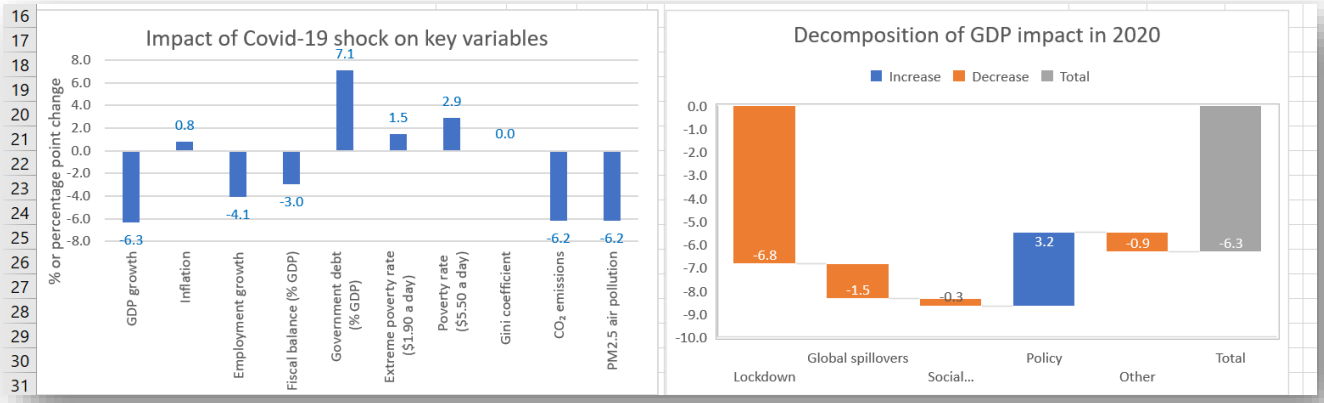
(7) A list of economic, social and environmental indicators and their estimates under pre- and post-COVID-19 baseline scenarios; and

India To modify country under analysis, please select new county on the "Country overview" worksheet

Post-Covid-19 baseline estimates	2019	2020	2021
Real GDP growth	5.0	0.9	6.8
Inflation	4.8	3.3	4.2
Employment	1.3	-3.4	1.2
General government net lending/borrowing	-7.4	-9.5	-6.0
General government gross debt	69.0	75.7	74.0
Poverty headcount ratio at $1.90 a day (2011 PPP)	10.1	10.0	8.2
Poverty headcount ratio at $5.50 a day (2011 PPP)	65.5	65.3	58.3
Gini coefficient	37.8	37.8	37.8
CO_2 emissions	2776.2	2791.1	2968.5
PM2.5 air pollution, mean annual exposure	92.2	88.5	89.8

Pre-Covid-19 estimates	2019	2020	2021
Real GDP growth	5.0	6.7	6.4
Inflation	4.8	3.9	3.7
Employment	1.3	1.3	1.2
General government net lending/borrowing	-7.4	-7.1	-7.0
General government gross debt	69.0	68.5	67.7
Poverty headcount ratio at $1.90 a day (2011 PPP)	10.1	9.6	9.3
Poverty headcount ratio at $5.50 a day (2011 PPP)	65.5	62.9	60.4
Gini coefficient	37.8	37.8	37.8
CO_2 emissions	2776.2	2949.9	3126.8
PM2.5 air pollution, mean annual exposure	92.2	93.5	94.6

(8) COVID-19's impact (by comparing indicators in pre- and post-COVID-19 baseline scenarios) and a decomposition of the modelled impact on GDP in 2020.



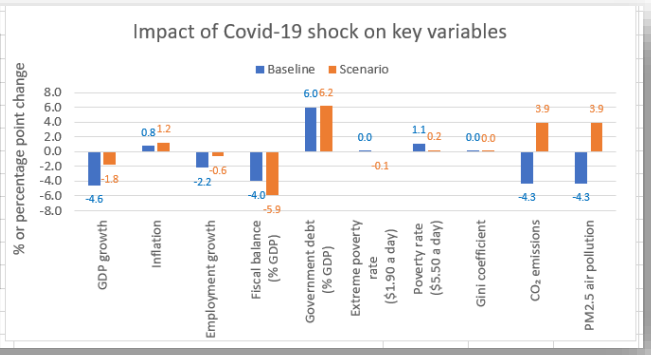
<u>Step 3:</u> Revise policy variables to carry out scenario analysis

On the **"Scenarios" page**, users can view the baseline assumption of policy variables, including fiscal spending, policy rate changes, and lockdown stringency (in the selected country and its major trading partners), as well as oil prices and the impact of "other factors" on GDP growth in 2020 and 2021. Users can modify these assumptions in the highlighted yellow area to test the impact of different policy combinations and assumptions.

	A	B	C	D	E	F	G	H
32	**Baseline forecasts can be modified by amending the key assumptions below**							
33								
34						**Cells highlighted in yellow can be modified as needed**		
35	**Baseline assumptions**					**Scenario assumptions**		
36		**2020**	**2021**				**2020**	**2021**
37	Total fiscal measures (% GDP)	4.1	-2.1			Total fiscal measures (% GDP)	8.7	-0.8
38	Transfers targeting lower income households (%	1.0	-0.5			Transfers targeting lower income households (%	1.0	-0.5
39	Employment retainment measures (%GDP)	0.0	0.0			Employment retainment measures (%GDP)	1.0	-0.5
40	Firm liquidity supports (%GDP)	0.0	0.0			Firm liquidity supports (%GDP)	1.0	-0.5
41	Healthcare spending (%GDP)	2.1	-1.0			Healthcare spending (%GDP)	1.0	-0.5
42	Other (% GDP)	1.0	-0.5			Other (% GDP)	1.0	-0.5
43	Carbon subsidies (%GDP)	0.3	0.3			Carbon subsidies (%GDP)	4.0	2.0
44	Interest rates (basis point change)	-30	0			Interest rates (basis point change)	-100.0	0.0
45	Average national lockdown stringency	56.1	9.0			Average national lockdown stringency	40.0	7.0
46	Average lockdown stringency in trading partners	37.3	5.9			Average lockdown stringency in trading partners	40.0	7.0
47	Oil price	38.3	47.8			Oil price	38.3	47.8
48	"Other" impacts on GDP growth (percentage point	0.2	-1.1			"Other" impacts on GDP growth (percentage point	0.0	0.0

Based on the modified key assumptions, the following lines report how the economic, social, and environmental indicators would change accordingly (the table on the left), and compare them with the change under the post-COVID-19 baseline scenario (the bar chart on the right).

50	**Post-Covid-19 scenario**			
51		2019	2020	2021
52	Real GDP growth	6.1	4.1	7.4
53	Inflation	2.9	3.5	0.5
54	Employment	-0.3	-1.0	0.4
55	General government net lending/borrowing	-6.4	-12.5	-12.0
56	General government gross debt	55.6	67.1	76.7
57	Poverty headcount ratio at $1.90 a day (2011 PPP) (%	0.4	0.3	0.1
58	Poverty headcount ratio at $5.50 a day (2011 PPP) (%	18.6	17.4	15.3
59	Gini coefficient	38.5	38.5	38.5
60	CO_2 emissions	10181.9	10685.2	11221.5
61	PM2.5 air pollution, mean annual exposure	53.8	56.3	62.2



Maintaining the model

The model is based around two central interactive spreadsheets, backed by a large database that is set up on a series of updateable spreadsheets in the same workfile.

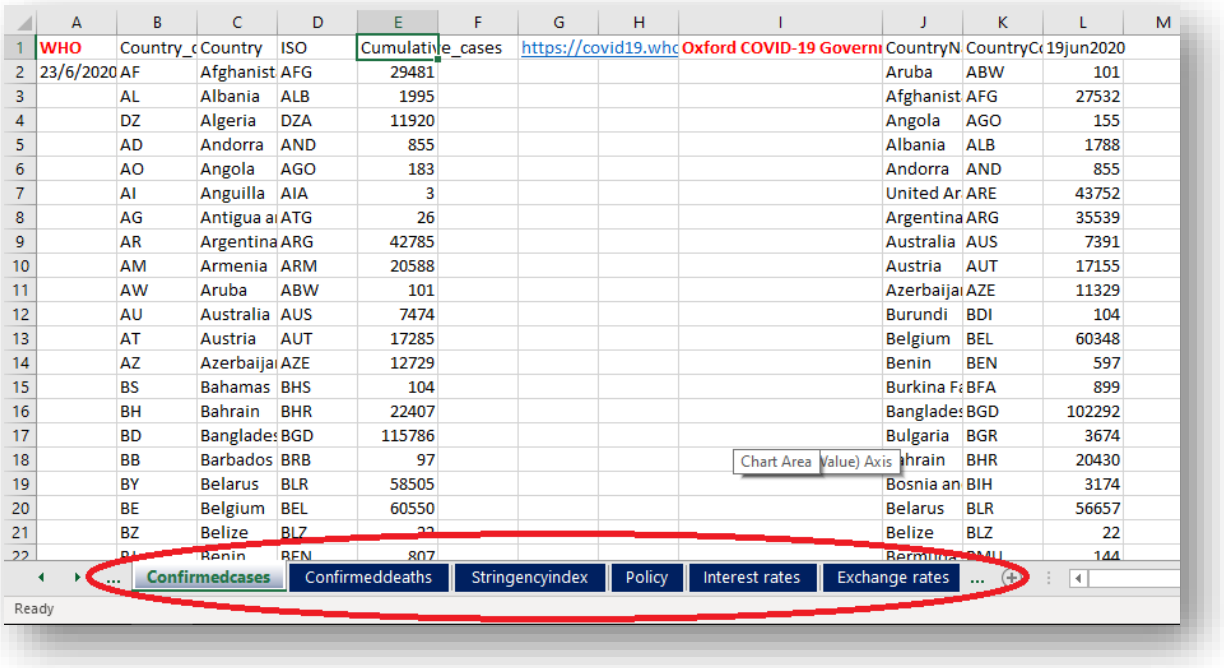
1. **"Country overview" page** provides a snapshot of the socio-economic situation facing the selected country in the time of COVID;
2. **"Scenarios" page** illustrates the performance of economic, social and environmental indicators and their estimates in a selected country under pre- and post-COVID-19 baseline scenarios; and allows users to modify the model to test policy impact;
3. **"Working overview" page** is a worksheet that pulls relevant data from across the workfile for the selected country, to create the figures illustrated on the "Country overview" page;
4. **"Working baseline" page** pulls relevant data from across the workfile for the selected country, and computes the model estimates for the Post-COVID-19 baseline estimates on the "Scenarios" page;
5. **"Working scenario" page** computes the model estimates for the Post-COVID-19 scenario estimates on the "Scenarios" page;
6. **"Confirmedcases" page** includes accumulative confirmed COVID-19 cases and daily new cases [Data source: WHO and Oxford COVID-19 Government Response Tracker];
7. **"Confirmeddeaths" page** includes accumulative deaths and new deaths due to COVID as of the last update [Data source: WHO and Oxford COVID-19 Government Response Tracker];
8. **"Stringencyindex" page** includes lockdown stringency index [Data source: Oxford COVID-19 Government Response Tracker, "index_stringency" page];
9. **"Interest rates" page** includes countries' policy rates and its change since the beginning of 2020 [Data source: Central Bank News];
10. **"Exchange rates" page** includes countries' exchange rates against the United States dollar since 1 June 2019 [Data source: UN Operational rates of exchange];
11. **"Pre-COVID baseline data" page** includes data and estimates during 2019 to 2021 that feed into the pre-COVID baseline scenario on the "Scenarios" page, including Real GDP growth, inflation, employment, general government net lending/borrowing, general government gross debt, Gini coefficient, poverty headcount ratio at $1.90 a day (2011 PPP), poverty headcount ratio at $5.50 a day (2011 PPP), CO_2 emissions, PM2.5 air pollution (mean annual exposure) and population [Data source: ESCAP, DESA's World Economic Forecasting Model, World Bank Open Data, ILOStat, IMF, UN Population, Global Carbon Atlas and World Development Indicators Database];
12. **"TradeMatrix" page** reports the estimated bilateral export patterns (goods and services) based on available data to 2018 from column country to row country. Used to identify the largest trading partners for each country. [Data source: derived from various sources, including UNCTAD bilateral goods trade, UNCTAD total services trade, OECD bilateral services trade, Eurostat bilateral services trade, and national statistics. Missing values are filled through an iterative process. The levels of data for the countries highlighted in

yellow are not strictly comparable to the rest of the table, where totals are adjusted to align with national accounts total goods and services trade.]

13. **"Data" page** includes the data to support the "Country overview" page and part of the baseline scenarios on the "Scenarios" page, including:
    - GDP (in 2018 and 2019) and its breakdown by private consumption (in 2018), government consumption (in 2018), investment (in 2018), and exports and imports (in 2018) [Data source: UNSD National Accounts Main Aggregates]; and GDP's breakdown by industries, including agriculture, mining and utilities, manufacturing, construction, wholesale/retail/restaurants/hotels, transport/ storage/communication, and others (in 2018) [Data source: UNSD National Accounts Main Aggregates];
    - Trade: total exports and its breakdown by fuel, machinery and transport, other goods, transport services, travel services and other services; fuel imports; vulnerable trade; and travel and transport trade [Data source: UNCTAD];
    - Fiscal: carbon subsidies as a share of GDP [Data source: IEA Energy Subsidies database], announced fiscal support package as a share of GDP and its breakdown by spending on healthcare, income support, employment retainment, liquidity support, and others [Data source: ESCAP COVID Policy Reponses tracker and IMF COVID policy tracker];
    - Columns for Fiscal 2020 and Fiscal 2021 include the final assumptions of total new fiscal measures (as % of GDP) that feed into the fiscal model for the post-Covid-19 baseline estimates. Total packages may be spread over 2 years (via Fiscal adjustment column) especially where they are very large;
    - Income support/Employment retainment/Loans/guarantees/Health/Other: estimates of the breakdown of announced policy packages, based on available information from the IMF's Policy Responses to Covid-19 Policy Tracker. Given the limited available information, this may not fully reflect the current situation for each country or territory. Users may modify these initial estimates via scenarios;
    - Foreign currency (FX) share of government debt [Data source: Benchmarked from World Bank database of fiscal space];
    - Government interest payments as a % of GDP [Data source: pre-Covid Baseline derived from IMF WEO database October 2019];
    - Sovereign debt average years to maturity [Data source: Benchmarked from World Bank database of fiscal space];
    - Remittances as a share of GDP and derived amount of remittances in 2019 [Data source: World Bank Remittances data April 2020];
    - Mean income (in 2019) [Data source: DESA's World Economic Forecasting Model. Missing series are filled with World Development Indicators database where available];
    - Social conditions:

- Lack of Coping Capacity, measured by World Risk Index [Data source: Institute of Regional Development Planning (IREUS), University of Stuttgart];
- Hospital beds per 1000 people, total hospital beds and population in countries with bed [Data source: World Development Indicators Database];
- Social protection, measured by social protection effective coverage (older persons) [Data source: ILO];
- Informal sector as a share of total employed and self-employment share of total employed [Data source: ILO].

Among all the worksheets, ESCAP will update "Confirmedcases", "Confirmeddeaths", "Stingencyindex", "Policy", "Interest rates" and "Exchange rates" (the tabs coloured in blue, see the figure below) on a regular basis to reflect the most recent socio-economic situation in countries. The last update is done on 10 November 2020.



If users wish to use their own data, they may find the related worksheet and replace the value of specific indicators. However, this should be done with care, to ensure that the changes feed correctly into the formulas embedded in the model. The worksheets are protected without password.

Technical notes

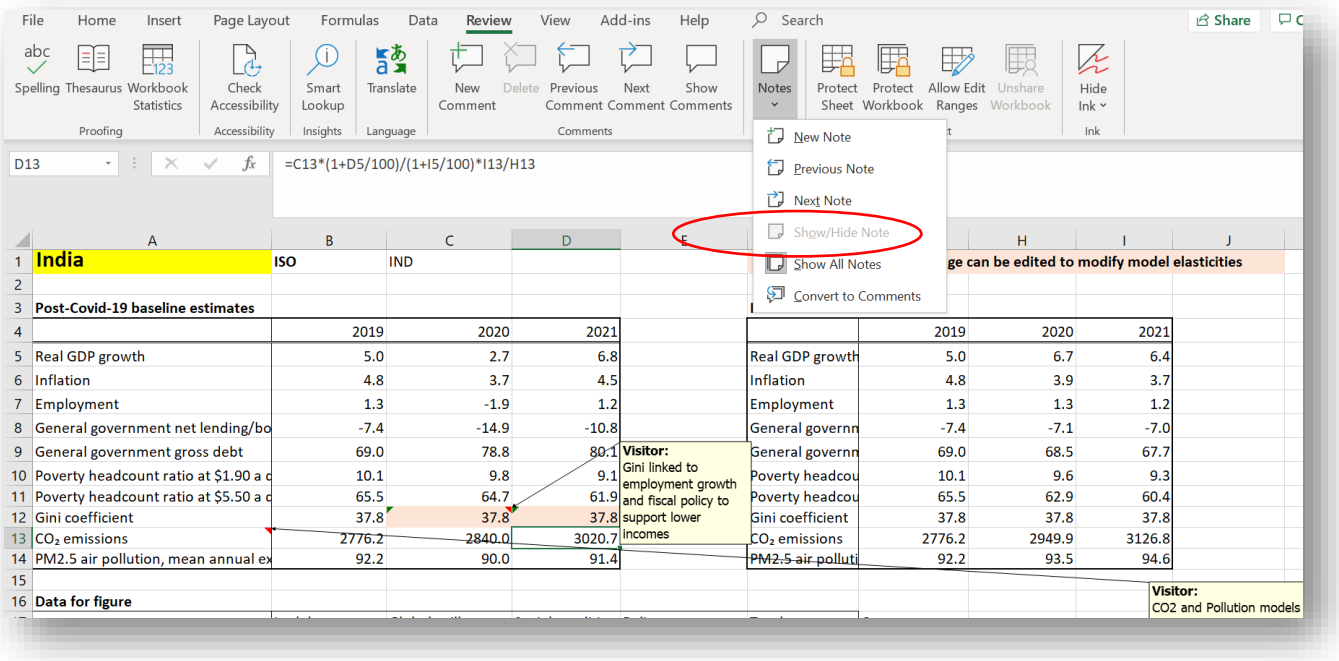
The post-COVID-19 baseline and scenario estimates are derived from an underpinning set of model equations. These equations incorporate a set of calibrated and estimated parameters and elasticities. All the data, elasticities and assumptions underlying the model are specified within the workfile for transparency.

Elasticities have been estimated and calibrated based on expert judgement and available information, which is scant in many cases. The full model was then recalibrated, with small adjustments to initial elasticity estimates, to minimize deviations from a set of "target" projections. The targets were based on forecast changes for GDP by ESCAP (April 2020), World Bank (June 2020) and Consensus (June 2020) since December 2019/January 2020.

A common set of elasticities is applied to all countries, although the impacts differ depending on the country-specific data that enters the model. Below is an overview of these elasticity estimates, with some notes on how they were derived. In many cases this relies heavily on expert judgement. A more elaborate model would finetune these elasticities for individual countries, although there is often little information on which to base country-specific values.

Advanced users may choose to modify some of the elasticities underpinning the model, in order to tailor them to an individual country. On the "Working baseline" and "Working scenario" worksheets, all cells highlighted in orange include editable values.

To review the elasticities underpinning the model, go to the "Working baseline" sheet and view all notes for information.



Below, all editable elasticities and parameters are highlighted in bold red font.

Baseline Post-Covid-19 Forecast Model

The impact on GDP growth is disaggregated into the shock to GDP from domestic lockdown measures; global spillovers to GDP from lockdown measures introduced in major trading partners; the impact of underlying social conditions; the impact of fiscal and monetary policy measures introduced since the beginning of 2020; and other exogenous factors that are not captured by the model.

Domestic lockdown impact on GDP

Domestic lockdown measures have impacted both consumption and investment decisions, and is modelled as follows:

For 2020:

$$\Delta GDP = \Delta Lock[\boldsymbol{\varepsilon^C} Cshare + \boldsymbol{\varepsilon^I} Ishare]Leak$$

Where:

ΔGDP is the percentage point impact on GDP growth;

ΔLock is the change in the lockdown stringency index;

$\boldsymbol{\varepsilon^C}$ is **-0.24** (the estimated private consumption elasticity with respect to lockdown stringency, calibrated from available retail sales and consumption data to May 2020. See Holland, 2020);

Cshare is the consumption share of GDP (benchmark 2018);

$\boldsymbol{\varepsilon^I}$ is the estimated investment elasticity with respect to lockdown stringency. This depends on the country's industrial structure. Investment in agriculture and mining/utilities sectors is assumed to be unaffected and the sectors are assigned an elasticity of **0**, as available evidence shows little impact on investment in these sectors; the wholesale, retail, restaurants and hotels sector is assigned an elasticity of **-0.26** in 2020, and **-0.06** in 2021, given the steep drop in spending in 2020 in the retail and tourism sectors; all other sectors are assigned an elasticity of **-0.06**. The elasticities were calibrated as part of the process to minimize deviations from a set of "target" projections as discussed above. Advanced model users can set revised investment elasticities for 7 different sectors.

Ishare is the investment share of GDP (benchmark 2018);

Leak is an estimate of import leakages – the share of domestic demand met by imported goods and services. This is approximated as: $\frac{1}{1+\mathbf{1.85}*Mshare}$, where **1.85** is an elasticity approximated on global data during crisis episodes, when traded goods and services fall more rapidly than GDP, and ***Mshare*** is the import share of GDP (benchmark 2018).

For 2021:

$$\Delta GDP = \{\Delta Lock[\varepsilon^C Cshare + \varepsilon^I Ishare] + \mathbf{0.29} * \Delta Lock_{2020}\varepsilon^C Cshare\}Leak$$

Defined as for 2020, with the exception that **29%** of the consumption shock in 2020 is carried over to 2021. This reflects the permanent loss of foregone consumption in 2020, with the elasticity of **0.29** calibrated from literature (Keogh-Brown et al., 2010).

Global spillovers impact on GDP

Global spillovers are modelled in terms of the impact on the country's exports from the drop in demand abroad, and the impact on consumption due to the drop in remittances:

For 2020

$$\Delta GDP = \Delta Lock^{F}[\boldsymbol{\varepsilon^{X}}_{\mathbf{2020}} Xshare + (\boldsymbol{\varepsilon^{Remit}}_{\mathbf{2020}} Remit)(\boldsymbol{\varepsilon^{SRCI}} Cshare)]Leak$$

Where:

ΔLock^{F} is the average change in the lockdown stringency index in the country's primary export partners. The 5 biggest export partners (determined as a share of total trade in goods in services over the period 2014-2018) are modelled independently, while the global average stringency is applied to the remaining share of trade;

ε^{x}_{2020} is the estimated elasticity for 2020 of exports with respect to lockdown stringency in the country's primary export partners. The export elasticity depends on the country's export structure. The total export elasticity is given by:

$$\boldsymbol{\varepsilon^{X}}_{\mathbf{2020}} = \mathbf{-0.24}(MachS + OthS) \mathbf{- 0.35}(FuelS) \mathbf{- 0.48}(TranS) \mathbf{- 0.78}(TravS)$$

Where MachS is the machinery and transport equipment share of exports; OthS is the other goods and services share; FuelS is the fuel share; TranS is the transport services share; and TravS is the travel services share. The elasticities were calibrated as part of the process to minimize deviations from a set of "target" projections and available information on the decline in tourism receipts. Tourism and transport trade have suffered the biggest losses, while fuel exports have been hit by the decline in fuel prices;

Xshare is the export share of GDP (benchmark 2018);

$\varepsilon^{Remit}_{2020}$ is the estimated elasticity of remittances with respect to lockdown stringency in primary trading partners in 2020. It is set to **-0.42**. The elasticity was calibrated as part of the process to minimize deviations from a set of "target" projections, as detailed above;

Remit is remittances as a share of GDP (2019 estimate);

ε^{SRCI} is the short-run elasticity of consumption with respect to income, estimated as **0.85**, which is based on global averages. 15% of the impact of remittances on consumption is carried over to 2021;

Cshare and ***Leak*** are as described above.

For 2021

$$\Delta GDP = \Delta Lock^{F}[\boldsymbol{\varepsilon^{X}}_{\mathbf{2021}} Xshare + (\boldsymbol{\varepsilon^{Remit}}_{\mathbf{2021}} Remit)(\boldsymbol{\varepsilon^{SRCI}} Cshare) + \Delta Lock^{F}{}_{2020}(\boldsymbol{\varepsilon^{Remit}}_{\mathbf{2020}} Remit)(\boldsymbol{\varepsilon^{LRCI}} - \boldsymbol{\varepsilon^{SRCI}})Cshare]Leak$$

$\boldsymbol{\varepsilon^{X}_{2021}}$ is the estimated elasticity for 2021 of exports with respect to lockdown stringency in the country's primary export partners. This adjusts all 2020 elasticities by a factor of **0.8**, with the exception of travel services which are adjusted by a factor of **0.5**, on the assumption that the rebound in trade will take more than 1 year:

$$\boldsymbol{\varepsilon^{X}}_{\mathbf{2021}} = \mathbf{0.8}\{\mathbf{-0.24}(MachS + OthS) \mathbf{- 0.35}(FuelS) \mathbf{- 0.48}(TranS)\} \mathbf{- 0.5}\{\mathbf{0.78}(TravS)\}$$

$\boldsymbol{\varepsilon^{Remit}_{2021}}$ is the estimated elasticity of remittances with respect to lockdown stringency in primary trading partners in 2021. It is set to **-0.04**, on the assumption that remittances flows may take time to rebuild, and much of returned income will be used to rebuild lost savings.

$\boldsymbol{\varepsilon^{LRCI}}$ is the long-run elasticity of consumption with respect to income, estimated as **1.0**, which keeps the savings ratio stable. The adjustment is added to 2021, so that 15% of the consumption losses associated with a decline in remittances in 2020 are carried over to 2021.

Social impact on GDP

Underlying social conditions will play an important role in determining the duration of the crisis and speed of recovery from the shock. The impact on GDP is modelled as follows:

$$\Delta GDP = \boldsymbol{\varepsilon^{S}}\{SEshare - SEshare^{F} + Cope - Cope^{F}\}Leak$$

where

$\boldsymbol{\varepsilon^{S}}$ is the estimated elasticity of GDP with respect to selected relative social indicators. This is set to **0.015** in 2020, and **0** in 2021. The elasticities were calibrated as part of the process to minimize deviations from a set of "target" projections;

SEshare is an estimate of the stable employment share, which is the average of the formal employment and secure employment (not self-employment) shares. There is limited data available, so years vary across countries. Where there is no data available for the formal or secure employment share, the other series is used independently. Where there is no data for either, the regional average is used.

$\boldsymbol{SEshare^{F}}$ is the regional average of the stable employment share, based on available data.

Cope is the "Capacity to cope" measure from the World Risk Index, which measures governance, medical capacities and insurance coverage.

$\boldsymbol{Cope^{F}}$ is the regional average of the "Capacity to cope" measure, based on available data.

Leak is an estimate of import leakages, as described above.

Fiscal policy impact on GDP

Many countries have introduced fiscal support measures to help households and firms weather the shock caused by the global pandemic. We disaggregate announced policy measures into income support measures that will accrue primarily to lower income households (which support consumption and alleviate poverty), employment retainment measures (which reduce the rise in unemployment and speed up the recovery), firm liquidity supports (which prevent bankruptcy and speed the recovery), healthcare spending (which improve health outcomes and stimulate the economy) and other measures. There are a wide range of estimates for fiscal multipliers, both across countries and across fiscal instruments (see, for example, Barrell et al., 2013). For the purposes of this simple model, fiscal multipliers are all set relatively low, at roughly half of what they might be in normal times, to reflect the fact that it is difficult to stimulate activity when lockdown measures prevent mobility and force firm closures. The fiscal elasticities below were initially calibrated by expert judgement, and finetuned as part of the process to minimize deviations from the set of "target" projections, as described above. Advanced model users can modify any of the initial fiscal elasticities if required. The impact on GDP is modelled as:

$$\Delta GDP = \left[\boldsymbol{\varepsilon}^{Tran} Tran + \boldsymbol{\varepsilon}^{Retain} Retain + \boldsymbol{\varepsilon}^{Liq} Liq_{t-1} + \boldsymbol{\varepsilon}^{Health} Health + \boldsymbol{\varepsilon}^{Goth} Goth\right] Leak$$

Where:

$\boldsymbol{\varepsilon}^{Tran}$ is the estimated elasticity of GDP (pre-import leakages) to a rise in government transfers targeting lower income households. Set to **0.5**.

Tran is the estimated rise in government transfers targeting lower income households, expressed as a share of GDP.

$\boldsymbol{\varepsilon}^{Retain}$ is the estimated elasticity of GDP (pre-import leakages) to a rise in employment retainment measures. Set to **0.3**.

Retain is the estimated rise in government spending on employment retainment measures, expressed as a share of GDP.

$\boldsymbol{\varepsilon}^{Liq}$ is the estimated elasticity of GDP (pre import leakages) to a rise government measures to support firm liquidity (e.g., loan guarantees or concessional lending). Set to **0.1** for a change in the previous year, as the measures are designed to prevent bankruptcy, so will not stimulate activity in the current year.

Liq is the estimated rise in government spending on firm liquidity support, expressed as a share of GDP.

$\boldsymbol{\varepsilon}^{Health}$ is the estimated elasticity of GDP (pre-import leakages) to a rise in government spending on healthcare. Set to **0.7**.

Health is the estimated rise in government spending on healthcare, expressed as a share of GDP.

$\boldsymbol{\varepsilon}^{Goth}$ is the estimated elasticity of GDP (pre-import leakages) to a rise in other government spending measures. Set to **0.5**.

Goth is the estimated rise in government spending on all other measures, expressed as a share of GDP.

Leak is an estimate of import leakages, as described above.

Monetary policy impact on GDP

Many countries have cut interest rates since the outbreak of the crisis to support economic activity. The impact of interest rate and exchange rate changes on GDP is modelled as:

For 2020:

$$\Delta GDP = \boldsymbol{\varepsilon^{int}} \left\{ \Delta int + \frac{1}{\mathbf{0.05}} (\Delta rx - \Delta rx^{e}) \right\} Leak$$

Where:

$\boldsymbol{\varepsilon^{int}}$ is the estimated elasticity of GDP (pre-import leakages) to a basis point change in interest rates. Set to **-0.0031**, calibrated from global average estimates;

Δint is the basis point change in interest rates since the beginning of 2020;

Δrx is the percentage change in the exchange rate against the US$ since the beginning of 2020;

$\boldsymbol{\Delta rx^{e}}$ is the expected percentage change in the exchange rate against the US$ since the beginning of 2020, based on a rule of thumb exchange rate to interest rate basis point elasticity of **-0.05**. The rule of thumb associates a 1 percentage point cut in interest rates with a 5 per cent depreciation of the exchange rate.

Leak is an estimate of import leakages, as described above.

For 2021:

A partial reversal of the impact of any stimulus in 2020 is assumed for 2021, with interest rates and exchange rates expected to remain stable at 2020 levels by default. A reversal of **50%** is set by default.

$$\Delta GDP = \mathbf{-0.5} \left[\boldsymbol{\varepsilon^{int}}_{\mathbf{2020}} \left\{ \Delta int_{2020} + \frac{1}{\mathbf{0.05}} (\Delta rx_{2020} - \Delta rx^{e}{}_{2020}) \right\} Leak \right]$$

Other impact on GDP

The **"other"** impact on GDP is a country-specific exogenous setting, designed to capture any factors that may impact GDP growth in that year that are not captured by the model. This includes any information available from quarterly or monthly data for 2020. The post-Covid-19 baseline projections for GDP are aligned with ESCAP forecasts as of 31 July 2020.

Inflation model

The inflation model includes impacts from the change in the output gap; the change in the oil price; the change in the exchange rate and an impact from risk or uncertainty relative to the rest of the world. To capture the impact of higher uncertainty and risk on inflation expectations, some inflationary pressure is allowed to build in countries with limited capacity to copy with the crisis. This impact is halved in 2021:

$$\Delta INF = \boldsymbol{\varepsilon^{infy}}(\Delta GDP^{Post} - \Delta GDP^{Pre}) + \boldsymbol{\varepsilon^{OilP}} Fuel \boldsymbol{\Delta OilP} + \boldsymbol{\varepsilon^{infrx}}(\Delta rx - \Delta rx^{e}) Mshare + \left(1 - \frac{Cope}{Cope^{F}}\right) INF^{Pre} + Oth$$

Where:

ΔINF is the estimated percentage point change in projection for the inflation rate;

$\boldsymbol{\varepsilon^{infy}}$ is the estimated elasticity of inflation with respect to a change in GDP growth. This is set at **0.19**, calibrated from global data;

$\boldsymbol{\Delta GDP^{Post}}$ is the post-Covid-19 baseline projection for GDP growth;

$\boldsymbol{\Delta GDP^{Pre}}$ is the pre-Covid-19 baseline projection for GDP growth;

$\boldsymbol{\varepsilon^{OilP}}$ is the estimated elasticity of inflation with respect to a change in the oil price. This is set at **0.3**, calibrated from global data;

Fuel is imports of fuel as a share of GDP (2018 benchmark);

ΔOilP is the estimated percentage change in the oil price, which is set to **-35** for 2020 and **+19** for 2021 for the post-Covid-19 baseline projection;

$\boldsymbol{\varepsilon^{infrx}}$ is the estimated elasticity of inflation with respect to an unexpected change in the exchange rate. This is set at **0.2**, calibrated from global data;

$\boldsymbol{INF^{Pre}}$ is the benchmark pre-Covid-19 inflation forecast;

Oth is and exogenous adjustment to align the post-Covid-19 baseline inflation estimates with ESCAP forecasts as of August 2020;

Cope, Cope^{F}, Δrx, Δrx^{e}, Mshare are as defined above.

Employment model

Employment growth depends on the change in GDP growth. This impact is allowed to vary with the dependence of the economy on the export of travel services, which have been particularly hard hit, and the "stable" employment share – those that are neither self-employed nor working informally. Informal workers and the self-employed are at high risk of unemployment, and are less likely to be covered by social protection measures. Employment growth is also impacted by the magnitude of any fiscal policy initiatives to support employment retainment. For 2021 the

impact of travel services is dropped from the equation, reflecting the assumption that the recovery in travel services is already embedded in the speed of GDP recovery.

For 2020

$$\Delta E = (\Delta GDP^{Post} - \Delta GDP^{Pre})\{1 + TravS - SEshare\} + Y^{Retain}$$

For 2021

$$\Delta E = (\Delta GDP^{Post} - \Delta GDP^{Pre})\{SEshare\} + Y^{Retain}$$

Where:

ΔE is the percentage point change in the projection for employment growth;

$\mathbf{Y^{Retain}}$ is the fiscal impulse from employment retainment measures;

$\boldsymbol{\Delta GDP^{Post}}$, $\boldsymbol{\Delta GDP^{Pre}}$, ***TravS, SEshare*** are as defined above.

Fiscal model

The fiscal model is disaggregated into the impact of the crisis on fiscal revenue; the impact on social spending to support the unemployed; the impact on government interest payments, and the impact of new policy measures:

Government revenue model

Non-commodity revenue is adjusted in line with nominal GDP, and commodity revenue is adjusted in line with the oil price.

$$\Delta Rev = Rev^{Pre} + (1 - CommodSh)Rev^{Pre}(\Delta GDP^{Post}INF^{Post} - \Delta GDP^{Pre}INF^{Pre}) + (CommodSh)Rev^{Pre}(\boldsymbol{\Delta OilP})$$

Where:

ΔRev is the impact on the level change in government revenue;

$\boldsymbol{Rev^{Pre}}$ is the pre-Covid estimate of Government revenue, which is approximated as **15%** of nominal GDP, in line with the regional average;

CommodSh is the commodity (generally oil related) share of government revenue, where applicable;

$\boldsymbol{\Delta GDP^{Post}INF^{Post}}$ is the Post-Covid-19 estimate of nominal GDP growth;

$\boldsymbol{\Delta GDP^{Pre}INF^{Pre}}$ is the Pre-Covid-19 estimate of nominal GDP growth;

ΔOilP is as defined above**.**

Government unemployment benefit model[4]

As unemployment is rising in most countries, the pre-Covid-19 estimate of spending on unemployment benefit will underestimate the actual spending requirement. Spending on unemployment benefit is modelled to rise with unemployment, adjusted for the share of the population with insurance coverage.

$$\Delta Soc = Soc^{Pre} + Cover * Exp^{Pre} * \boldsymbol{Ush} * (\Delta U - 1)$$

Where:

ΔSoc is the impact on the level change in social spending on unemployment benefit;

Soc^{Pre} is the Pre-Covid-19 estimate of government spending on unemployment benefit, estimated as **9%** (Ush) of government expenditure;

Cover is the share of the population covered by social protection;

Exp^{Pre} is the Pre-Covid-19 estimate of Government expenditure, which is approximated as *Rev^{Pre}* adjusted for the fiscal balance;

Ush is the estimate of the unemployment benefit share of government expenditure, of **9%**, based on a global benchmark share;

ΔU is an estimate of the growth rate of the level of unemployment, estimated from the modelled change in employment, under the assumption of a **5%** starting level of unemployment. The 5% started value is approximated from the regional average;

Government interest payment model

Government interest payments in 2020 are adjusted in line with the exchange rate for the share of debt held in foreign currency. In 2021, the baseline assumption is no change in the exchange rate. Relative to the pre-Covid-19 baseline, interest payments rise by the 2020 increase, plus the additional interest paid on new debt issued in 2020 and debt rolled over from 2019.

For 2020:

$$\Delta GIP = GIP^{Pre}\left\{\frac{(1 - FXsh) + FXsh\Delta RX}{(1 - FXsh) + FXsh}\right\}$$

For 2021:

[4] This part of the social spending model excludes all new measures that have been introduced to combat the crisis. These are included in the net policy spending model below.

$$\Delta GIP = GIP^{Pre} + (GIP^{Post}{}_{2020} - GIP^{Pre}{}_{2020}) + \Delta DEBT^{Post}{}_{t-1} * GINT^{Post}{}_{t-1} - \Delta DEBT^{Pre}{}_{t-1} * GINT^{Pre}{}_{t-1} + \frac{DEBT^{Post}{}_{t-2}}{Maturity} GINT^{Post}{}_{t-1} - \frac{DEBT^{Pre}{}_{t-2}}{Maturity} GINT^{Pre}{}_{t-1}$$

Where:

ΔGIP is the impact on the level change in government interest payments;

GIP^{Pre} is the Pre-Covid-19 estimate of government interest payments;

FXsh is the foreign currency share of government debt;

ΔRX is the percentage change in the exchange rate;

GIP^{Post} is the Post-Covid-19 baseline estimate of government interest payments;

ΔDebt is the change in the level of government debt;

GINT is the average interest rate on government debt;

Maturity is the average years to maturity of the government debt stock;

Net policy spending model

The impact on the fiscal balance of all new fiscal policy measures introduced since the beginning of the crisis are captured here. This is modelled as:

$$\Delta Pol = (1 - Multiplier) Fiscal$$

Where

ΔPol is the change in net policy spending;

Multiplier is the modelled percentage point impact of total fiscal measures on GDP (as described above) divided by the estimated cost of total fiscal measures as a per cent of GDP. For example, if total policy spending increases by 1 per cent of GDP and GDP is expected to rise by 0.8 per cent as a result, this would give a multiplier of 0.8/1 = 0.8;

Fiscal is the modelled estimate (in value terms) of the new fiscal measures.

Fiscal balance model

The change in the government budget balance is given by the change in revenue, less the change in spending on unemployment benefit, less the change in interest payments, less the change in net policy spending:

$$\Delta Gbal = \Delta Rev - \Delta Soc - \Delta GIP - \Delta Pol$$

Government debt model

The fiscal deficit flows onto the government debt stock, with an adjustment to allow for any discrepancy between debt and deficit projections in the pre-Covid-19 baseline.

$$DEBT = DEBT_{-1} - GBal + (\Delta DEBT^{Pre} + GBal^{Pre})$$

Where:

GBal is the fiscal balance.

Poverty model

The poverty model is based on the assumption that income approximately follows a lognormal distribution. We calculate the cumulative density function of log income, evaluated at the poverty benchmarks of $1.90/day and $5.50/day. This requires an estimate of inequality (standard deviation of log income) and mean income (approximated to grow in line with GDP per capita, with an adjustment of **0.87**; this captures the average historical discrepancy between mean income growth and GDP per capita growth, and is in line with the approach adopted by the World Bank to estimate poverty in non-survey years).

The standard deviation of log income is approximated from the estimate of the Gini coefficient. Under a lognormal distribution, the relationship between the two can be approximated as:

$$SDLI = 2\left\{GAMMA.INV\left(\frac{Gini}{100}, Alpha\right)\right\}^{0.5}$$

Where:

SDLI is the standard deviation of log income;

GAMMA.INV returns the inverse of the gamma cumulative distribution associated with the probability of the given Gini coefficient;

Alpha is a distribution parameter of the standard Gamma distribution, set to **0.5**;

Poverty is then approximated as the cumulative distribution function of the lognormal distribution, evaluated at the appropriate poverty benchmark:

$$Headcount = Lognorm.dist\{Benchmark, MeanLI, SDLI\} * 100$$

Where

Headcount is the poverty headcount ratio at the specified benchmark;

Lognorm.dist returns the cumulative distribution function evaluated at the specified benchmark, for the specified mean log income and standard deviation of log income;

Benchmark is the poverty threshold, set to either $1.90/day or $5.50/day;

MeanLI is an estimate of the mean of log income. Under the lognormal distribution, this is given as:

$$MeanLI = ln(MeanI) - 0.5\sqrt{SDLI}$$

Where

MeanI is mean income.

Gini coefficient model

The Gini coefficient tends to be a very slow-moving variable. It is modelled as a function of employment growth and fiscal policy measures to support lower incomes, with a low elasticity of **1%**:

$$Gini = Gini_{-1} - \mathbf{0.01}(\Delta E + Y^{Tran})$$

Where:

ΔE is the percentage point change in employment;

$\boldsymbol{Y^{Tran}}$ is the estimated fiscal impulse from new measures targeting lower income households, aligned with the model of the fiscal policy impact on GDP.

CO_2 emissions and PM2.5 models

For the baseline Post-Covid-19 forecasts, CO_2 and Pollution models are linked to the change in GDP growth, assuming carbon/pollution per unit of output remains as in pre-COVID projections:

$$Emissions = Emissions_{-1}\frac{\Delta GDP^{Post}}{\Delta GDP^{Pre}}$$

Post-COVID-19 Scenario Model

The scenario model follows the same structure as the forecast model described above, with a few small additions/modifications.

Fiscal policy impact on GDP

The fiscal policy impact on GDP model is expanded to include a role for carbon subsidies. Carbon subsidies remain in place in many countries. Reducing these subsidies can create fiscal space for other measures and accelerate the transition towards cleaner energy use. Applying a "negative" carbon subsidy within the scenario model will also act as the introduction of a carbon tax, which can create more fiscal space and encourage a more rapid transition towards cleaner energy use.

The withdrawal of carbon subsidies, or introduction of a carbon tax, acts as a fiscal tightening, with a negative short-term impact on GDP.

$$\Delta GDP = \left[\boldsymbol{\varepsilon}^{Tran} Tran + \boldsymbol{\varepsilon}^{Retain} Retain + \boldsymbol{\varepsilon}^{Liq} Liq_{t-1} + \boldsymbol{\varepsilon}^{Health} Health + \boldsymbol{\varepsilon}^{Goth} Goth + \boldsymbol{\varepsilon}^{Carbon} Carbon\right] Leak$$

Where

$\boldsymbol{\varepsilon}^{Carbon}$ is the estimated elasticity of GDP (pre-import leakages) to a rise in carbon subsidies. Set to **0.5**, based on expert judgement.

Carbon is the estimated change in carbon subsidies, expressed as a share of GDP.

CO_2 emissions and PM2.5 models

$$Emissions = Emissions_{-1} \frac{\Delta GDP^{Post}}{\Delta GDP^{Pre}} (\boldsymbol{\varepsilon}^{CO_2})^{Sub_t - Sub_{t-1}}$$

Where

$\boldsymbol{\varepsilon}^{CO2}$ is an estimate of the elasticity of carbon emissions with respect to a change in subsidies per metric ton of CO_2. This is set to **0.999**, calibrated from literature (see Carbon Tax 7-sector model: http://www.komanoff.net/fossil/CTC_Carbon_Tax_Model.xlsx);

Sub is an estimate of the level of carbon subsidies per metric ton of CO_2.

PM2.5 is modelled to move in line with carbon emissions.