Accelerating Sustainable Development in Viet Nam: Policy Options

Macroeconomic Modelling (Augmented Public Debt Sustainability Analysis) Study

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Acknowledgements

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1. Introduction

Viet Nam has achieved remarkable successes in promoting economic development, raising living standards and lifting millions of people out of poverty. Building on these achievements, the country is strongly committed to the implementation of the 2030 Agenda for Sustainable Development. Viet Nam aspires to become a high-income country by 2045 and achieve net-zero carbon emissions by 2050. Whereas the Voluntary National Review 2023 (VNR 2023) revealed that Viet Nam has made significant progress in various Sustainable Development Goals (SDGs), the country needs to expedite the implementation to bring all Goals back on track in order to achieve the 2030 targets. In the current context of rising geopolitical tensions and economic uncertainty, the country faces critical development challenges, including building economic resilience, eradicating poverty and tackling climate risks.

To attain development aspirations and overcome the challenges, the Government of Viet Nam has launched various policy packages and it plans to increase investments in key development sectors. To inform the Government's decisions on the policies, it is critical to answer questions about how the Government's investments in Sustainable Development Goals and other national priorities, such as investment in renewable energy, might affect economic activities and other socioeconomic and environmental indicators such as the poverty rate and carbon dioxide emissions.

In this context, ESCAP and the United Nations in Viet Nam in collaboration with the Ministry of Planning and Investment (MPI) have carried out a study based on the region-wide ESCAP Macroeconomic Model.[1] The objectives of the study are to assess the impact of selected policy scenarios on economic, social and environmental outcomes, including public debt sustainability, and further integrate sustainable development into macroeconomic modelling in Viet Nam.

ESCAP has developed a macroeconomic model to assist in the design of economic recovery policy packages for countries in the Asia-Pacific region in the post-COVID-19 period to contribute to sustainable economic, social and environmental development. [2]

The policy scenarios selected for model simulations in this study include: (a) towards a greener economy; (b) poverty and inequality reduction and social protection; and (c) towards innovation-based growth. The selection of the specific model scenarios was conducted together with local experts by prioritizing the most relevant policy packages for Viet Nam's efforts to achieve national development goals and realize the Sustainable Development Agenda.

[1] The model takes an augmented approach to assess public debt sustainability in the long term, which supplements the short- to medium-term approaches currently adopted by international financial institutions and credit rating agencies.

[2] It is worth mentioning that this is a macroeconomic model designed primarily to measure the effects of substantial government spending on environmental, social and economic variables. It utilizes parametrizations derived from cross-country and historical data to provide rough estimates for specific policy packages and to determine the expected magnitude of effects through various interacting channels. While it can illustrate consistent channels in accordance with economic theory, it may be beneficial to employ a different modelling approach when assessing the effects of micro policies. For example, due to rather general parametrization, proper measurement of some specific micro-policies of the Government might require further analysis, as the model parametrization does not distinguish between different policies in a given sector.

2. Development challenges

Viet Nam introduced the Socio-Economic Development Strategy (SEDS) 2021-2030 to guide the implementation of development policies and programmes to realize national development goals, such as becoming a high-income country by 2045 and achieving net-zero emissions by 2050. The principle of "leave no one behind" is the central, transformative promise of the 2030 Agenda for Sustainable Development and its Sustainable Development Goals; it is also integrated into the SEDS 2021-2030, which is operationalized through five-year Socio-Economic Development Plans (SEDP).

In past decades, Viet Nam has made great strides in various dimensions of its sustainable development agenda, propelling the country up the development ladder. With rapid economic growth, the country graduated from low-income to lower middle-income status in 2011, and it aims to achieve upper-middle-income status by 2030. Viet Nam's economy sustained high growth rates from 1991 to 2020, with an average rate of 6.8 per cent per annum. GDP per capita rose more than 10 times from US$ 402 in 2000 to US$ 4,284.50 in 2023.[3] Viet Nam's GDP per capita jumped 56 places to 117 in the world and became the sixth-highest in South-East Asia.

Along with economic progress, social development outcomes have also improved significantly. The incidence of multidimensional poverty decreased from 9.2 per cent in 2016 to an estimated 3.2 per cent in 2023.[4] The multidimensional poverty rate among children declined from 19.1 per cent in 2016 to 11.7 per cent in 2020.[5] The Human Development Index (HDI) increased from 0.689 in 2016 to 0.726 in 2022, which categorized Viet Nam as a High Human Development country since 2019.[6] Viet Nam has also achieved notable progress in education. Despite some adverse effects of the COVID-19 pandemic, the proportion of students completing primary school reached 98 per cent in the academic year 2020-2021.[7] The proportion of students completing lower secondary school was 87 per cent in the same academic year.[8] The number of people registered in social insurance programmes increased from 13 million in 2016 to 18.26 million in 2023, accounting for 39.25 per cent of the working-age population.[9] Health insurance coverage increased to 93.35 per cent in 2023.[10] The national average rate of malnutrition (stunting) among children aged under five years decreased from 24.3 per cent in 2018 to 19.2 per cent in 2021, although in ethnic minority regions it remains high at 31.4 per cent among children under five years of age.[11]

However, Viet Nam faces many critical development challenges, including addressing economic vulnerability, eradicating poverty and inequality, and tackling climate risks. The

[3] GSO (2023), "Socio-economic situation in the fourth quarter and 2023," General Statistics Office (GSO).
[4] GSO (2023), "Socio-economic situation in the fourth quarter and 2023," General Statistics Office (GSO).
[5] MPI (2023), "Voluntary National Review 2023".
[6] UNDP (2024), "Human Development Report 2023/2024", available at https://hdr.undp.org/data-center/human-development-index#/indicies/HDI.
[7] UNICEF (2022), "Viet Nam Education Fact Sheets 2022".
[8] Ibid.
[9] Viet Nam Social Security (21 January 2024), "Top 10 outstanding achievements made by Viet Nam Social Security in 2023".
[10] Viet Nam Social Security (23 February 2024), "Proposed amendment to health insurance law to ensure maximum benefits for health insurance card holders".
[11] MPI (2023), "Voluntary National Review 2023".

COVID-19 pandemic resulted in a sharp deceleration in economic growth. Nevertheless, Viet Nam achieved positive growth rates of 2.9 per cent in 2020 and 2.6 per cent in 2021, which was among the fastest in the region. Growth rebounded to 8 per cent in 2022, before decelerating to a slower rate of 5.05 per cent in 2023 due to a drop in demand for Viet Nam's exports.[12] Many workers, especially those in the textile and electronic sectors, the majority of whom are women, lost their jobs or experienced a reduction in their working hours.

Despite notable progress, there are still gaps in social development outcomes, such as poverty and inequality eradication, gender equality and women's empowerment, health care, and social protection. Although all measures of poverty, including multidimensional and income poverty indicators, show that the incidence and depth of poverty has fallen, there remain pockets of poverty in various population groups and regions, especially among ethnic minorities in mountainous and remote areas. Inequalities, including income and wealth gaps and gender inequality, continue to be a challenge. Violence against women and children remains persistent, and women continue to shoulder disproportionately unpaid care and domestic work.

Viet Nam's rapid economic development in past decades has also put tremendous pressure on the environment. Carbon dioxide emissions per capita doubled from 1.6 metric tons in 2012 to 3.5 metric tons in 2022.[13] Viet Nam is one of the countries that is most vulnerable to climate change, with an estimated loss of 3.2 per cent of GDP in 2020.[14] During the past three decades, Viet Nam has suffered an average annual loss of 1-1.5 per cent of GDP and an average of 430 deaths due to climate-related disasters.[15] It has also been estimated that climate change could reduce national income by up to 3.5 per cent by 2050.[16] As reported in the 2023 VNR, the impact of climate change has been more severe. The impact includes: rising sea levels and saline intrusion affecting such plain areas as the Mekong Delta; extreme climatic conditions eroding agriculture, tourism and infrastructure; rising heat affecting labour productivity across economic sectors; and more severe and frequent floods and droughts. As such, addressing climate change through mitigation and adaptation, especially reducing greenhouse gas (GHG) emissions, is a major national priority.

Financing, which is a means for Viet Nam to address development challenges and fulfil national development goals, is of paramount importance, especially in the context of the global economic slowdown, tightened global financial conditions and rising geopolitical tensions. Official development assistance (ODA) is on a declining trend, especially after Viet Nam became a lower middle-income country in 2011. ODA decreased dramatically from 3.84 per cent of GDP in 2001 to only 0.14 per cent of GDP in 2021 while remittances as a share of GDP were recorded at a stable and average level of 3.3 per cent.[17] Between 2011 and 2021, foreign direct investment (FDI) inflows into Viet Nam were stable at an average of 5.9 per cent

[12] GSO (2023), "Socio-economic situation in the fourth quarter and 2023," General Statistics Office (GSO).
[13] Our World in Data, 2023, "Viet Nam: CO_2 Country Profile".
[14] World Bank (2022), "*Viet Nam: Country Climate and Development Report"*.
[15] United Nations Office for Disaster Risk Reduction (UNDRR) and Asian Disaster Preparedness Center (ADPC) (2020), *Disaster Risk Reduction in Viet Nam*, available at https://www.undrr.org/media/48541/download?startDownload=true.
[16] World Bank and Asian Development Bank (2021), "*Viet Nam: Climate Risk Country Profile*".
[17] World Development Indicators (WDI).

of GDP.[18] Top sources of FDI inflows include Singapore; the Republic of Korea; Japan; China; and Hong Kong, China. Viet Nam remains a top destination for foreign investors, given its cost competitiveness, comparatively low taxation, comprehensive free trade agreements and special economic zones. Domestic private investment grew gradually from 15.5 per cent of GDP in 2011 to 20.4 per cent of GDP in 2019 before dropping slightly to 20 per cent in 2020 and 20.1 per cent in 2021, respectively, due to the economic fallout of the pandemic.[19] Nevertheless, Viet Nam's domestic private investments remain low. The experience of newly developed economies, such as the Republic of Korea, China and Taiwan Province of China, shows that high levels of domestic investments are essential for sustaining high growth and advancing to higher development levels. Despite sustained and high GDP growth, government revenue fluctuated widely between 2011 and 2022, with an average share of 18.9 per cent of GDP. During this period, however, tax revenue decreased steadily from 16.7 per cent of GDP in 2011 to 12.9 per cent of GDP in 2022.[20] The negative trend in tax revenue must be reversed to expand government revenue to invest in development priorities. Meanwhile, with strong fiscal discipline in the past decades, Viet Nam has maintained public debt well below the threshold of 60 per cent of GDP. In 2022, public debt was estimated at 37.1 per cent of GDP, leaving ample room for further investments in tackling development challenges and meeting national development goals.[21]

3. Policy scenarios and key assumptions

To achieve its national development goals and the Sustainable Development Goals by 2030, Viet Nam has developed and implemented various policies and strategies, such as the National Master Plan for the period of 2021-2030, with Vision to 2050, Socio-Economic Development Plan (SEDP) 2021-2025, National Target Programmes (NTPs) for 2021-2025 and Power Development Plan VIII (PDP8).

Based on various government policies and objectives for the 2021-2030 period, a few policy scenarios have been selected to assess ex ante their potential impact on economic, social and environmental outcomes, including the public debt trajectory, through the application of the ESCAP Macroeconomic Model. Three areas of policies and policy objectives that are particularly relevant to Viet Nam's commitments to net-zero emissions and attainment of Sustainable Development Goals, which were selected for assessment, include the development of renewable energy and introduction of a carbon tax; poverty reduction and expansion of social protection, especially for poor and vulnerable groups; and investment in ICT infrastructure for an innovation-based economy.

These policy areas are developed into three different policy scenarios with specific assumptions for simulations using the ESCAP Macroeconomic Model. The Model generated alternative sets of results that compare trajectories of economic, social and environmental indicators to the baseline forecast, providing insights into how they would differ from business-as-usual scenario.

[18] World Development Indicators (WDI).

[19] https://www.gso.gov.vn/en/px-web/?pxid=E0401&theme=Investment

[20] IMF's World Economic Outlook Database April 2023 and CEIC.

[21] IMF's World Economic Outlook Database April 2023.

Scenario 1. Towards a greener economy

Viet Nam adopted the National Green Growth Strategy (NGGS) 2021-2030 with a vision to 2050 to transform its economic growth model towards a more resilient and carbon neutral economy. To realize green growth objectives, the strategy sets out targets for reducing greenhouse gas emissions, greening economic sectors, greening the people's lifestyle and promoting sustainable consumption based on the principles of equality, inclusivity and resilience.

Moreover, Viet Nam made a strong commitment to net-zero emissions at the Twenty-sixth session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP26) in 2021. To follow a net-zero pathway, the Government of Viet Nam has already started to revamp its plans and legal frameworks. Viet Nam will also need to make substantial investments in a green economy. Viet Nam is participating in the Just Energy Transition Partnership (JETP), under which Viet Nam is supported to implement the energy transition from a fossil fuel system to a renewable energy system that is inclusive and equitable. Viet Nam announced its Resource Mobilization Plan to implement the JETP at the COP28 held from 30 November to 12 December 2023 in Dubai.

Scenario 1.1. Development of renewable energy

Transitioning from fossil fuels to renewable energy is one of the priorities for Viet Nam to achieve its net-zero emission target by 2050. The total energy mix will be powered mainly by clean and renewable energy sources. By the end of 2022, the installed capacity of renewable energy (RE) reached 36,582 MW. Viet Nam has abundant potential for developing renewable energy, such as hydropower, wind and solar power, to realize the goal of a renewables-based energy mix and net-zero emissions.

The NGGS aims to improve energy efficiency and effectiveness, promoting effective exploitation, and increasing the proportion of renewable energy in the country's energy production and consumption. These objectives were also included in the PDP8 for the period 2021-2030, with a vision to 2050 (approved in Decision No. 500/QD-TTg dated 15 May 2023). The PDP8 aims to create an overall energy industrial ecosystem based on renewable and clean energy. Specifically, renewable energy is expected to achieve a power generation capacity of 72,332 MW by 2030, an increase of 136.6 per cent compared with the level of 2020, and further reach 370,275 MW by 2050, an increase of 411.9 per cent. Thus, it is expected that renewable energy sources for electricity production will reach 30.9-39.2 per cent in 2030 and progress towards the goal of reaching 67.5-71.5 per cent in 2050.

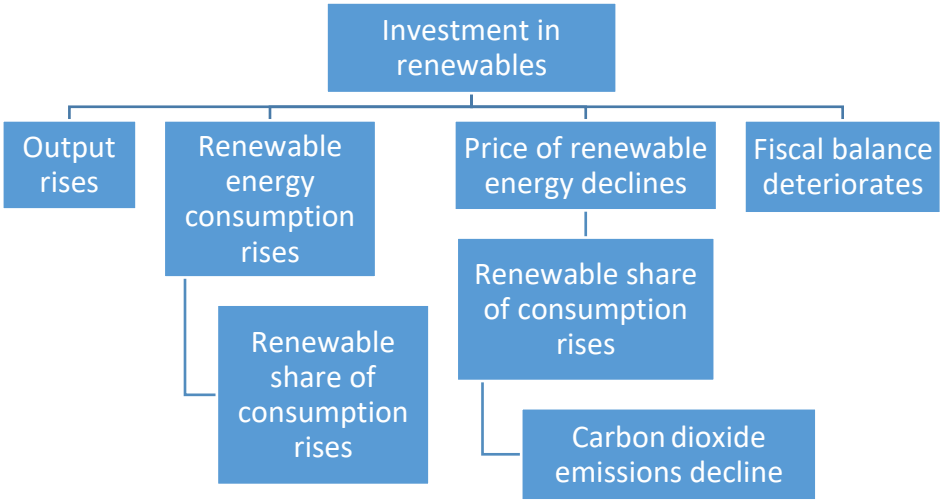
Table 1. Renewable capacity targets

Type of renewable energy (Megawatts)	2020	2030	2050
Hydropower	20,859	29,346	36,016
Solar	8,852	12,836	168,594-189,294
Wind	538	27,880	130,050-168,550
Biomass	325	2,270	6,015
Total	30,574	72,332	370,275
Renewable capacity increase (percentage)		**136.6**	**411.9**

Source: VNR 2023, Decision No. 500/QĐ-TTg.

Figure 1 illustrates how investments in renewables are transmitted in the ESCAP Macroeconomic Model. These investments initially serve as a short-term stimulation to economic activity. As renewable capacity expands, the consumption of renewable energy gradually rises, offsetting declines in fossil fuel consumption. The increased renewable capacity also reduces the average production costs of renewables relative to fossil fuels, leading to a further shift in the energy mix towards renewables. This shift in the energy mix results in a decrease in carbon dioxide emissions and air pollution. However, if the Government finances the investment in renewables entirely, it may put pressure on the fiscal balance.

Figure 1. Transmission channels of renewable energy investment in the ESCAP Macroeconomic Model



Source: ESCAP Macroeconomic Model.

The investment required to meet the targets set in Decision No. 500/QD-TTg will be substantial. How the investment is financed is a crucial policy challenge because it would cause distinguished socioeconomic and environmental impacts. Whereas such state-owned enterprises as Viet Nam Electricity (EVN) and PetroVietnam (PVN) play an important role, the private sector is also key to contributing to renewable energy development. Based on the current regulation, the private sector is allowed to participate in investments in power generation. The private sector's contribution to renewable power generation increased from 14.4 per cent in 2010 to 27.3 per cent in 2019[22] and to 42 per cent in 2022.[23]

In this scenario, it is assumed that the Government will increase investment in renewable energy with an estimated amount of about US$ 13.5 billion per year from 2021 to 2030, and US$ 23 billion per year from 2031 to 2050 (which was stated under Decision No.500/QD-TTg).[24] Of the total investments, 75 per cent will be needed for developing generation capacity and 25 per cent for upgrading power grids. In Viet Nam, the investment in renewable energy is mainly from State-owned enterprises (SOEs) such as EVN, which generated 55 per cent of

[22] https://congthuong.vn/dau-tu-vao-nang-luong-khuyen-khich-khu-vuc-tu-nhan-143937.html

[23] https://e.vnexpress.net/news/business/economy/vietnam-electricity-and-the-conundrum-of-establishing-a-competitive-market-4652366.html

[24] Note that the investment amount in this scenario follows the initial government plan. The actual realization of the policy package, which occurred in the period 2021-2023, might differ from the initial plan.

total renewable sources in 2022.[25] Because there is no classification between public investment and SOE investments in the ESCAP model, it is assumed that the SOE investment is treated as public investment. In this scenario, we develop and simulate two scenarios based on assumptions about the source of capital for investments in renewable energy.

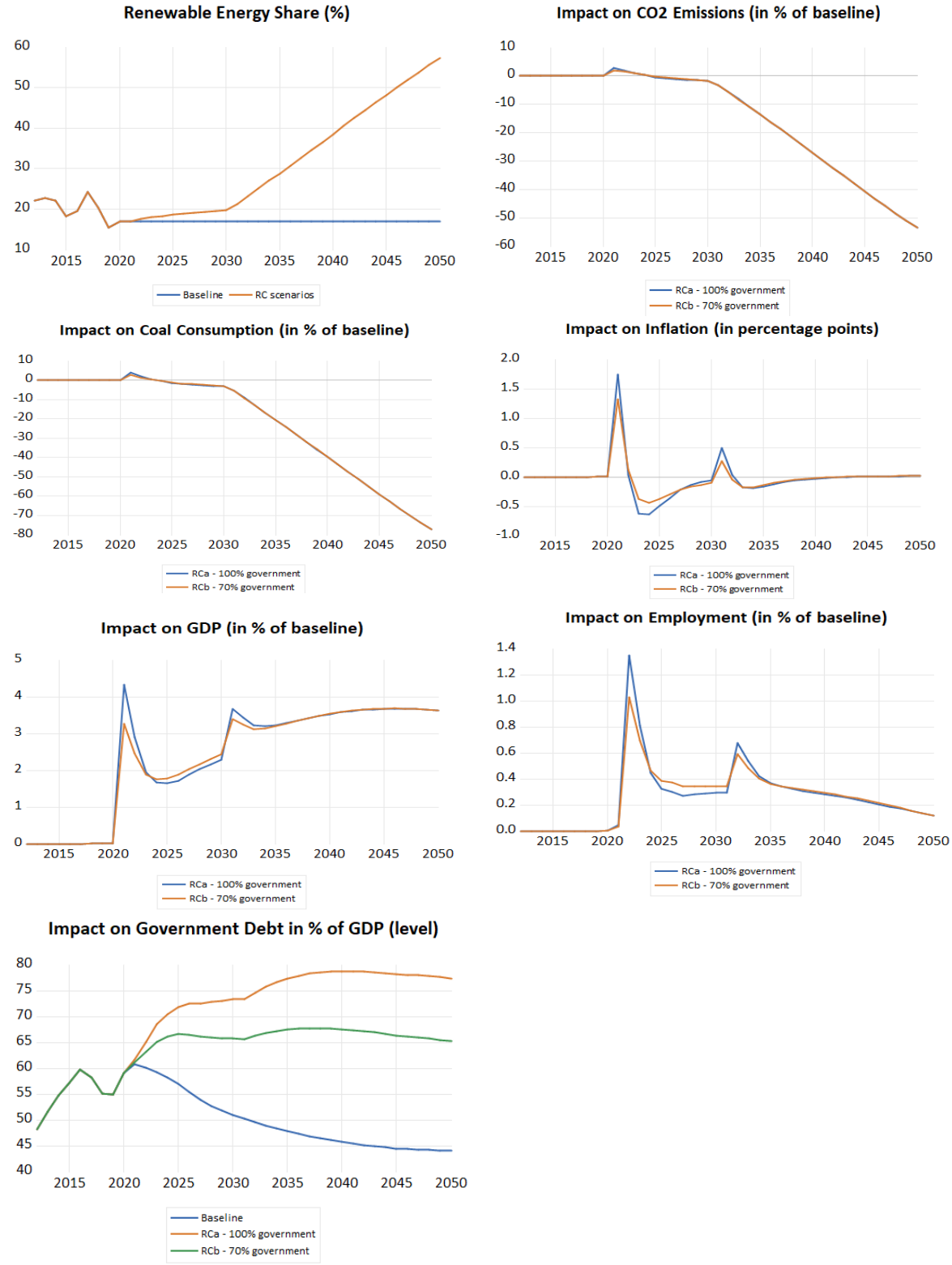
Scenario 1.1.1: Total investment is financed by the Government, including SOE investments.

Scenario 1.1.2: Total investment is financed 70 per cent by the Government and 30 per cent by the private sector. According to the current regulation, the private sector can invest only in power generation. It is assumed that the private sector's contribution to total power generation capacity using renewable sources is 40 per cent, which is approximately the 2022 level. Hence, the private sector is assumed to account for 30 per cent of the total investments required for overall renewable energy development, including both power production and transmission.

Figure 2 shows the results of the simulations. The results show that investing in renewable energy will help to increase its share in the energy mix. The proportion of renewable energy will account for about 20 per cent of the total national energy by 2030. In the first phase, the proportion increases slowly because the demand for traditional energy sources is still large, but after 2030 there is an accelerated increase in renewable energy, which outweighs the growth in energy consumption in the long term.

[25] https://www.erav.vn/tin-tuc/t47/buc-tranh-toan-canh-nganh-dien-luc-viet-nam-nam-2022.html#:~:text=S%E1%BA%A3n%20l%C6%B0%E1%BB%A3ng%20%C4%91i%E1%BB%87n%20s%E1%BA%A3n%20xu%E1%BA%A5t,so%20v%E1%BB%9Bi%20n%C4%83m%202021.%2F.

Figure 2. Impact of renewable energy investment



Source: ESCAP Macroeconomic Model.

Increasing renewable energy sources helps reduce carbon dioxide emissions as well as the use of fossil fuels such as coal. In the period from now to 2030, the increase in renewable energy consumption cannot fully compensate for the rising energy consumption associated with additional energy needs due to the substantial investment. Consequently, there is no reduction in coal consumption or a significant increase in the share of renewable energy as a

percentage of overall energy consumption until 2030. However, after 2030, there would be a substantial and gradual reduction in coal consumption, resulting in positive and significant climate effect marked by a reduction in air pollution and carbon dioxide emissions. Notably, carbon dioxide emissions are expected to decrease by 53 per cent from the baseline in 2050.

The extra spending on energy-related investments results in short-term economic stimulus, pushing up inflation, real GDP and employment during the investment period. Model results also show that GDP will grow higher by 3 per cent to 4 per cent compared with the baseline scenario in the first years of investment before declining to a positive extra gain of around 2 per cent of baseline GDP until 2030. After 2030, the impact on GDP will increase again with an average gain of around 3.5 per cent given the new and larger investments between 2031 and 2050. The increased investment in renewable energy will increase the demand for labour, thus creating more employment. In the first phase, the investment will increase employment by a peak rate of 1 per cent to 1.4 per cent compared with the baseline. The employment effect will decrease gradually starting from 2035 because of the decreasing demand for labour and the improvement in labour productivity (due to better health of the labour force resulting from reduced emissions and pollution).

It is important to note that, to achieve a positive employment effect, the labour force should be flexible enough to adjust and adapt to the energy transition. Reducing coal production and increasing renewable energy production will entail some movements of labour across sectors. As such, skills development, social protection measures and other supporting policies are vitally important to ensuring a smooth, inclusive and sustainable transition.

There is a short-term, positive surge in inflation due to the extra investment, but it dissipates quickly because the decline in the prices of renewable energy drives a reduction in the overall prices of goods and services. The effect on poverty is insignificant. In the initial period, poverty is likely to increase slightly up to 0.2 per cent due to the rising inflation in this period. After that, it decreases slightly throughout the period until 2050.

However, debt pressure will increase when this investment is assumed to be financed fully 100 per cent by the State budget. Government debt will increase from the baseline of around 60 per cent of GDP[26] to hover at around 77 per cent of GDP until 2050 because the investment package is relatively substantial, accounting for approximately 3-4 per cent of GDP per year. However, in scenario 1.1.2 where only 70 per cent of the investment is financed by the Government and the remainder comes from the private sector, fiscal deterioration is less pronounced. Government debt will remain below 70 per cent of GDP throughout the period until 2050.

Scenario 1.2. Introduction of a carbon tax

The phenomenon of global warming, primarily due to the accumulation of greenhouse gas emissions (mainly CO_2), also known as the greenhouse effect, causes climate change globally. In May 2021, the European Commission (EC) presented a proposal for a regulation establishing the European Union Carbon Border Adjustment Mechanism (CBAM) as one of the initiatives to promote the reduction of greenhouse gas emissions and achieve carbon neutrality by 2050. CBAM is scheduled to take effect from 2026 and be fully operational by 2034. Accordingly, the European Union imposes a carbon tax on all goods entering the European Union market based

[26] It is important to note that the baseline public debt used in the model is around 60 per cent of GDP because the model database uses the IMF World Economic Outlook and United Nations Statistics Division databases with the data ending in 2019 before Viet Nam's GDP was revised upwardly by 25.4 per cent.

on the intensity of GHG emissions in the production process in the host country. A carbon tax is defined as a tax levied on the carbon emissions required to produce goods and services. A carbon tax is a form of carbon pricing and, as a market-based approach, it is generally seen as a cost-effective policy instrument to reduce greenhouse gas emissions based on the polluters-pay principle.[27] CBAM will initially apply to imported goods such as steel, cement, fertilizer, aluminium, electricity and hydrogen. These are sectors with a high risk of "carbon leakage" and high carbon emissions, accounting for 94 per cent of the European Union's industrial emissions. Importers will have to report the emissions contained in imported goods. If these emissions exceed European Union standards, they will have to buy “emission certificates” according to the European Union's current carbon price. If a non-European Union exporting country fails to account for the environmental cost of carbon emissions, this regulation will effectively increase the import prices.

Consequently, for Viet Nam, unless the country implements a stricter carbon price by 2026, the country’s competitiveness and exports to the European Union might be negatively impacted by the new European Union carbon pricing system. Viet Nam is currently applying the Law on Environmental Protection No. 72/2020/QH14, dated 17 November 2020, that subjects some carbon-emitting products, including petroleum, oil and coal, to environmental tax. The law aims to enhance social responsibility and awareness towards the environment and encourage production and consumption of environmentally-friendly goods.[28] However, many products whose usages have the potential to cause environmental pollution are yet to be regulated under this law. Those products that are not covered include: (a) industrial emissions, cigarettes, radioactive waste; (b) chemicals (including inorganic acids, caustic soda, plant protection chemicals etc.); (c) electronics (generating electronic waste); (d) rubber (tubes, tyres etc.); (e) polymers; and (f) other items related to carbon emissions.

Viet Nam has yet to adopt the implementation of carbon tax policy. Although the application of carbon tax may bring benefits in reducing carbon emissions and developing green industries, it also poses socioeconomic challenges such as a potential rise in inflation and erosion of economic competitiveness. Thus, a thorough analysis on the potential impacts of the carbon tax policy is needed before this policy instrument is enacted for implementation.

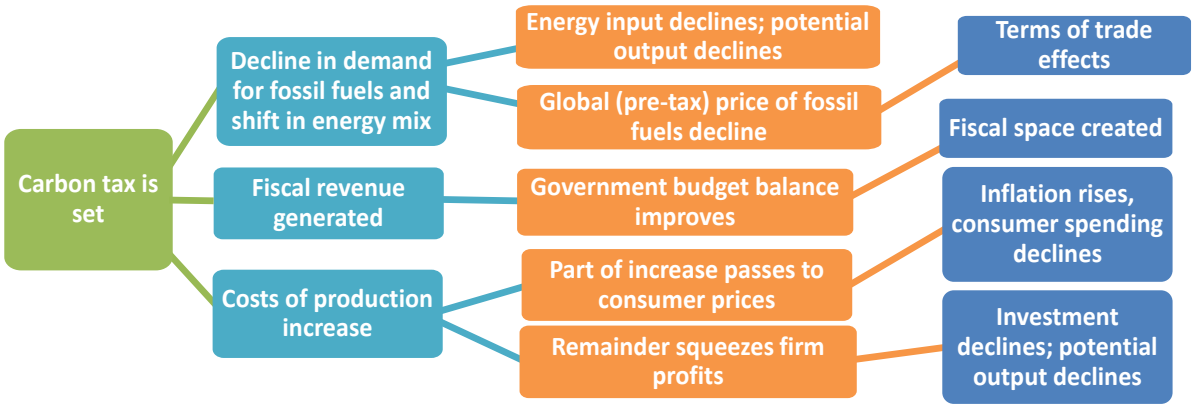
The ESCAP Macroeconomic Model can be used to assess the macroeconomic implications of: (a) a carbon tax and the impact on inflation and production costs, (b) study the appropriate speed of subsidy withdrawal and introduction of a carbon price, and (c) understand the economic, social and environmental trade-offs and benefits.

Figure 3 depicts the impact transmission channels of the implementation of a carbon tax in the ESCAP Macroeconomic Model for Viet Nam. Carbon-linked subsidies, such as energy subsidies, follow a similar transmission path, although with the opposite sign. For example, rather than a decline in demand for fossil fuels, a subsidy would encourage a rise in demand for fossil fuels. If a carbon tax is set, the costs of production will increase, and part of this cost will pass through to consumers and increase inflation. Higher costs also affect firm profits as well as lead to lower investment for production and decrease potential output. In contrast to the negative impact, the application of this tax will increase State budget revenue and expand fiscal space to achieve other goals while encouraging energy transition in consumption and production.

[27] https://taxfoundation.org/topics/carbon-taxes/#:~:text=A%20carbon%20tax%20is%20a,gas%20emissions%2C%20such%20as%20methane

[28] https://mof.gov.vn/webcenter/portal/btcvn/pages_r/l/tin-bo-tai-chinh?dDocName=MOFUCM172895

Figure 3. Transmission channels of a carbon tax in the ESCAP Macroeconomic Model



Source: ESCAP Macroeconomic Model.

By using the ESCAP Macroeconomic Model, we establish a carbon tax scenario to assess the potential impacts of the carbon tax to provide empirical evidence for Viet Nam in considering the implementation of a carbon tax. According to the World Bank's *Country Climate Development Report 2022* for Viet Nam,[29] the existing carbon tax – the Environmental Protection Tax is about US$ 0.05 per tCO2e on coal, US$ 77.60 per tCO2e on petroleum and US$ 32.90 per tCO2 on diesel – is lower than in most other countries and too low to incentivize large-scale decarbonization. The carbon tax is estimated to have been US$ 12 per tCO2e in 2022, which is the weighted average of the Environmental Protection Tax rate on coal, diesel and gasoline. We use this average carbon tax as our starting point. In this carbon tax scenario, there are three main assumptions:

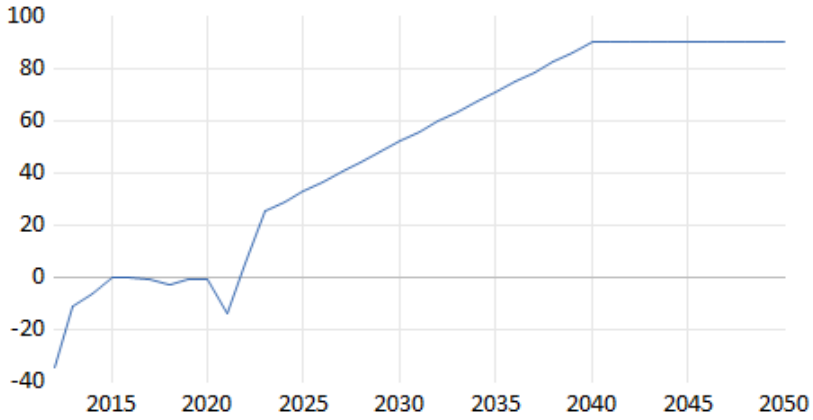
- Carbon tax (figure 4). In 2023, we expected the prosed carbon tax to increase in line with the Government's regulation[30] to around US$ 25 per tCO2e from the starting rate of US$ 12 per tCO2e. In the long term, we expect it to increase to US$ 90 per tCO2e by 2040, which is in line with the World Bank study.[31]
- Carbon subsidy: According to the IEA, the carbon subsidy increased to US$ 13.9 per tCO2e in 2021 from US$ 1.2 per tCO2e in 2020. We expect this subsidy to have eased completely by 2023.
- Extra revenue from the carbon tax will be used to finance budget deficits and pay back debt, with no increase in government spending.

[29] https://openknowledge.worldbank.org/server/api/core/bitstreams/a27f1b05-910d-59ab-ba2c-84206bf107c2/content

[30] https://thuvienphapluat.vn/van-ban/Thue-Phi-Le-Phi/Nghi-quyet-30-2022-UBTVQH15-muc-thue-bao-ve-moi-truong-xang-dau-mo-nhon-548478.aspx

[31] https://openknowledge.worldbank.org/server/api/core/bitstreams/a27f1b05-910d-59ab-ba2c-84206bf107c2/content

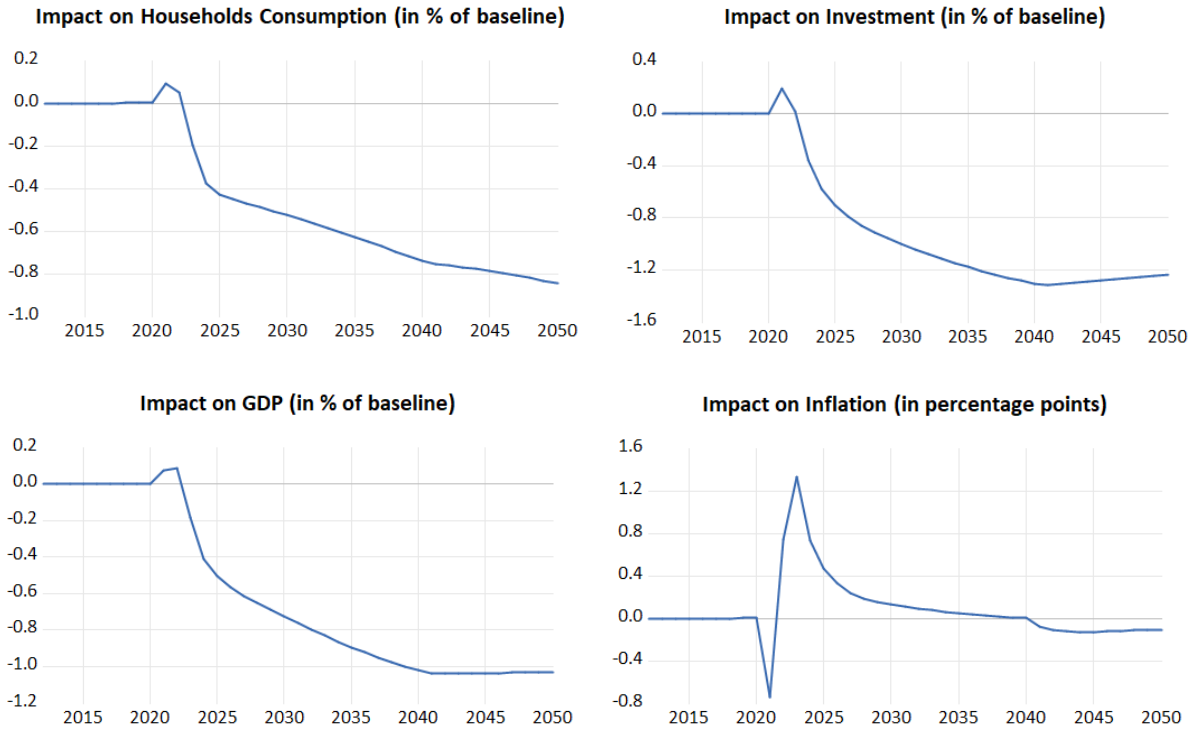
Figure 4. Effective carbon tax rate in Scenario 1.2 (US$ per metric ton of CO_2)

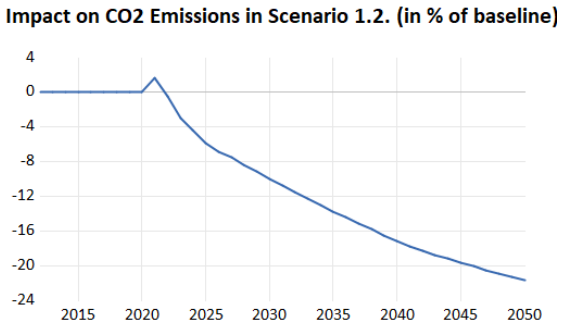


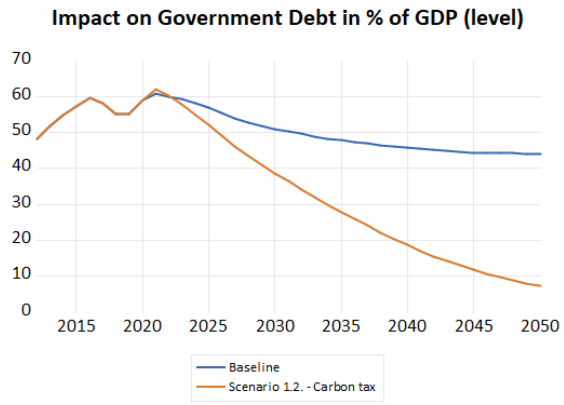
Source: ESCAP Macroeconomic Model.

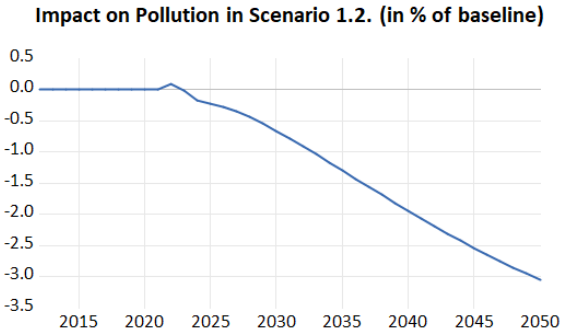
Scenario 1.2 shows that the carbon tax is a useful tool in reducing emissions. An increase in carbon tax and a reduction in carbon subsidies would raise the price of fossil fuel, thereby reducing energy consumption, shifting consumption towards renewable energy sources, and expediting the decarbonization process. Consequently, carbon dioxide emission and pollution levels will decrease. Carbon dioxide emissions are projected to decrease by about 10 per cent by 2030, leading to improved air quality and associated health benefits that will contribute to overall productivity growth (figure 5). Over the long term, the high carbon tax will continue to lead to a decline in carbon dioxide emissions and pollution.

Figure 5. Impact of introducing a carbon tax in Viet Nam









Source: ESCAP Macroeconomic Model.

The revenue generated from the carbon tax and the savings from eliminating carbon-linked subsidies creates significant fiscal space. This enables the government debt as a percentage of GDP to decline from the baseline of 60 per cent to 38.8 per cent in 2030 and to experience a significant reduction over the long term. In practice, a portion of the "new" government revenue can be reinvested into the economy, prioritizing areas such as energy infrastructure, transportation improvements or enhancing energy efficiency, as will be discussed in the subsequent scenarios. Furthermore, the revenue can also be directed towards investments in crucial sectors, especially supporting the population groups and workers who are adversely affected by the transition towards green or carbon-neutral industries through social protection, reskilling, upskilling and education. In this respect, the declining debt-to-GDP ratio should be seen as a starting point for a discussion on scenarios which combine government expenditure programmes with the introduction of the carbon tax.

The increase in costs contributes to inflationary pressures. In this scenario, where the Government does not counterbalance the negative effects by allocating a portion of carbon tax revenue to social spending, inflation is projected to increase in the initial period by approximately 1.5 percentage points above the baseline. However, the inflation effect is temporary and dissolves quickly. The policy has a negative net impact on GDP and the demand side, especially on household consumption and investment. With the rise in production costs, GDP is expected to experience a slight decline, although the impact remains moderate. The decrease in GDP stabilizes over the long term, indicating a modest approximately 1 per cent decline in long-term GDP. If the Government does not utilize the extra revenue to boost social, health or education spending, the impact of the carbon tax on social indicators will remain relatively minimal.

Scenario 2. Poverty, inequality reduction and social protection

Scenario 2.1. Implementation of National Target Programmes

With sustained high economic growth in past decades, Viet Nam has achieved notable success in promoting social progress, improving people's living standards and reducing poverty. However, there remain some shortcomings. According to Resolution 42-NQ/TW dated 24 November 2023 on continuing to innovate and improve the quality of social policies, the outcomes of poverty reduction are unstable, the risk of falling back into poverty remains high, and the wealth and income gaps tend to increase. The lives of some people are still difficult, especially in remote areas, ethnic minority areas and areas frequently affected by natural disasters. The development gaps between localities, provinces and regions are still significant. Therefore, Resolution 42-NQ/TW has set a goal to develop a social policy system in a sustainable, progressive and equitable direction up to 2030 to create opportunities for people. This is especially to help the poor, people in difficult circumstances and people residing in areas with extremely difficult socioeconomic conditions and lack of access to basic social services, such as health care, education, housing and information.

In addition, the Government has implemented National Target Programmes (NTPs) since the start of the 2000s to improve the people's living conditions, especially for the most vulnerable groups. In the 2021-2030 period, Viet Nam will continue to implement three NTPs: – the NTP for Sustainable Poverty Reduction, the NTP for Building New Rural Areas and the NTP for Improving Living Standards for Minorities and Mountainous Areas. The three NTPs are aimed at: (a) gradually narrowing the gaps in living standards and average incomes of the region, compared with the national average; (b) supporting poor and vulnerable households to rise above the minimum standard of living; (c) provide access to basic social services according to

the national multidimensional poverty line; and (d) improve the overall quality of life. Additional support is to be provided to poorer districts and communes with special difficulties, such as in the lowlands, coastal areas and islands, with the aim of reducing poverty. These programmes are designed to achieve the goal of "leaving no one behind" in Viet Nam's sustainable development process.

These NTPs comprise many investment projects, which are allocated to several sectors, focusing mainly on improving infrastructure in poor, remote and disadvantaged areas, training and creating sustainable jobs for the poor and replicating poverty reduction models. Different forms of investments may yield differentiated social, economic and environmental outcomes.

The investment projects in the NTPs cannot be easily translated to be input parameters for modelling. Hence, those investment projects are grouped, based on expert opinions, into four main categories, including infrastructure, health, social protection and education, for simulating their impacts in the model. It is assumed that the majority of the infrastructure spending is focused on improving energy efficiency. This assumption is rather optimistic, but crucial, because without it, infrastructure investment would have a negligible impact on environmental outcomes, such as carbon dioxide emissions and energy efficiency. The investment period begins from 2021 up to 2025. It is worth noting that the impacts of the NTP simulations are at macro level, with the assumptions of efficient disbursement of investment funds and effective project implementation.

Table 2. Investment categories of the National Target Programmes

Category	Total investment	State budget	Non-state financing
Infrastructure	258,783	255,983	2,800
Health	7,500	5,500	2,000
Social protection	2,134,495	71,202	2,063,293
Education	43,018	39,308	3,710
Total	2,443,796	371,993	2,071,803

Source: Decision No. 1719/QD-TTg, No. 90/QD-TTg, 263/QD-TTg, in billions of VND.

We first build a scenario, namely scenario 2.1.1, to assess the impacts of the NTPs whose total investments of VND 2,443,796 billion are financed by the State budget of VND 371,993 billion and by the non-State sources valued at VND 2,071,803 billion. For the model simulation, the investments are allocated into four main sectors: infrastructure; health; social protection; and education, as presented in table 2.

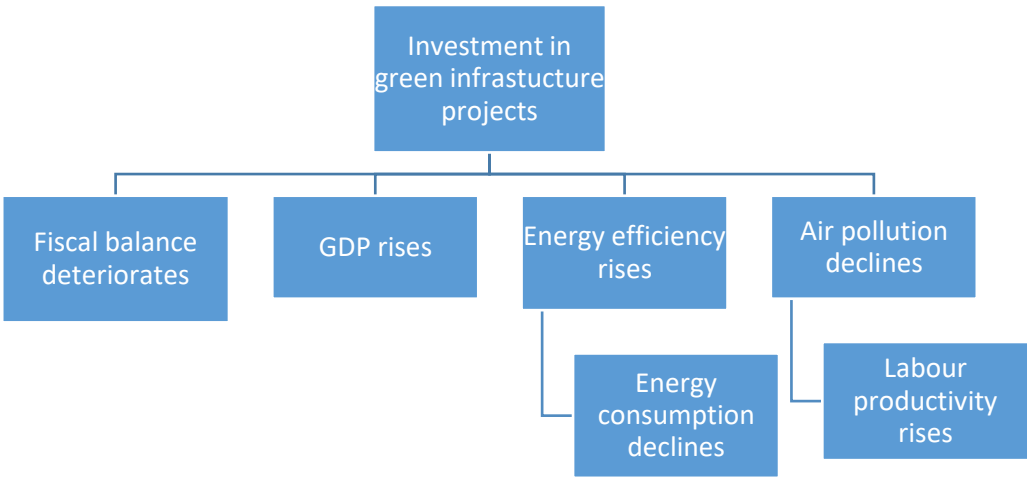
Scenario 2.1.2 is developed for simulation to further assess the impacts of different spending categories and facilitate a comparison of their impacts. In that scenario, we assume that the total investments of VND 2,443,796 billion are allocated entirely for each investment category. To simplify model simulations, it is further assumed that the NTPs investments are efficiently and fully disbursed according to the plan, and the total investments of each category are financed entirely by the State budget. As scenario 2.1.1 aims to show the combined impacts

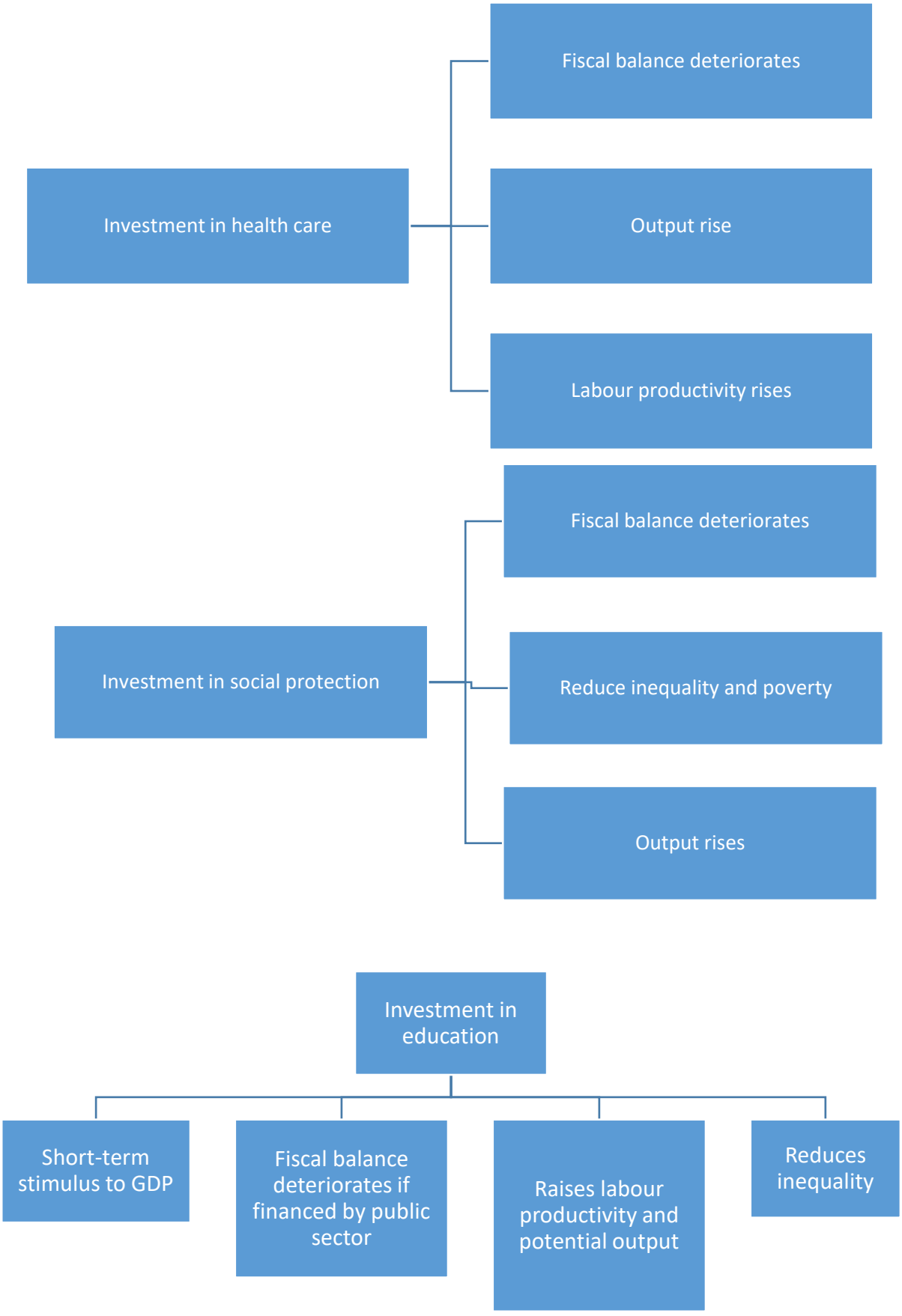
of the total investments in the four sectors, the impacts of the four sectors on socioeconomic and environmental developments may not be as clearly visible and comparable. As such, scenario 2.1.2 comprises four sub-scenarios for separately assessing the impacts of the investments in the four sectors: infrastructure, health, social protection and education. Hence, the hypothetical sub-scenarios shown in scenario 2.1.2 are for illustrative purposes to demonstrate how the same amounts of investments in different sectors yield different socioeconomic and environmental impacts. The results of simulations intend to inform policy trade-offs.

In summary, this section has five scenarios as follows:

- Scenario 2.1.1: The investment package is allocated based on table 2. It is financed by the State budget of 15.22 per cent and the non-State sources of 84.78 per cent;
- Scenario 2.1.2a: It is assumed that the total investment package is allocated for infrastructure projects and financed by the Government;
- Scenario 2.1.2b: it is assumed that the total investment package is allocated for the health sector and financed by the Government;
- Scenario 2.1.2c: it is assumed that the total investment package is allocated for social protection programmes and financed by the Government;
- Scenario 2.1.2d: it is assumed that the total investment package is allocated for education sector and financed by the Government.

Figure 6. Impact transmission channels of investment in infrastructure, health care, social protection and education in the ESCAP Macroeconomic Model





Source: ESCAP Macroeconomic Model.

The impact transmission channels of investments in infrastructure, health care, social protection and education are shown in figure 6. This Macroeconomic Model embeds a direct inequality variable, although there is no distinction between poor and non-poor households or between urban and rural areas. The investment is assumed to flow into specific sectors, including education, health, social protection and infrastructure, without making a distinction whether rural areas or lower-income households receive more investments than urban areas or high-income households. Hence, poverty and inequality are measured at aggregate national levels.

It is assumed that the majority of the infrastructure investment is focused on the projects that improve energy efficiency. Increasing investment in infrastructure is expected to result in a positive shock to the economy, resulting in increased capital accumulation and productivity improvement, thus increasing economic growth. Since the investment is assumed to be financed by the Government's budget, it will cause a deterioration in the Government's fiscal space. Meanwhile, the investments that focus on energy-efficiency and green projects will enhance the efficiency of energy usage, resulting in a lower energy consumption in the long term. This will reduce carbon dioxide emissions and improve environmental and air quality – thereby improving the quality of life and labour productivity.

Investment in health care acts as a short-term stimulus to the economy, expanding aggregate demand and economic output. An enhanced health-care system and services will lead to improvement in well-being of the labour force, which helps improve labour productivity and increase potential economic output in the long term. If the investment in health is financed by the Government's budget, it will create pressures on the Government's fiscal space.

Investment in social protection is assumed to directly aid the intended beneficiaries of the designated social protection programmes. Social protection spending includes cash transfers, social insurance, extra unemployment benefits or pension payments. The beneficiaries can use the social protection support to serve the needs of their families and improve their livelihoods, resulting in a reduction of poverty and inequality. The investment in social protection programmes also props up the aggregate demand in the economy, thereby driving increased output and economic growth. However, introducing such social protection programmes increases general government expenditure on social benefits. If the social protection investment is entirely financed by the Government, there is increased pressure on the Government's budget.

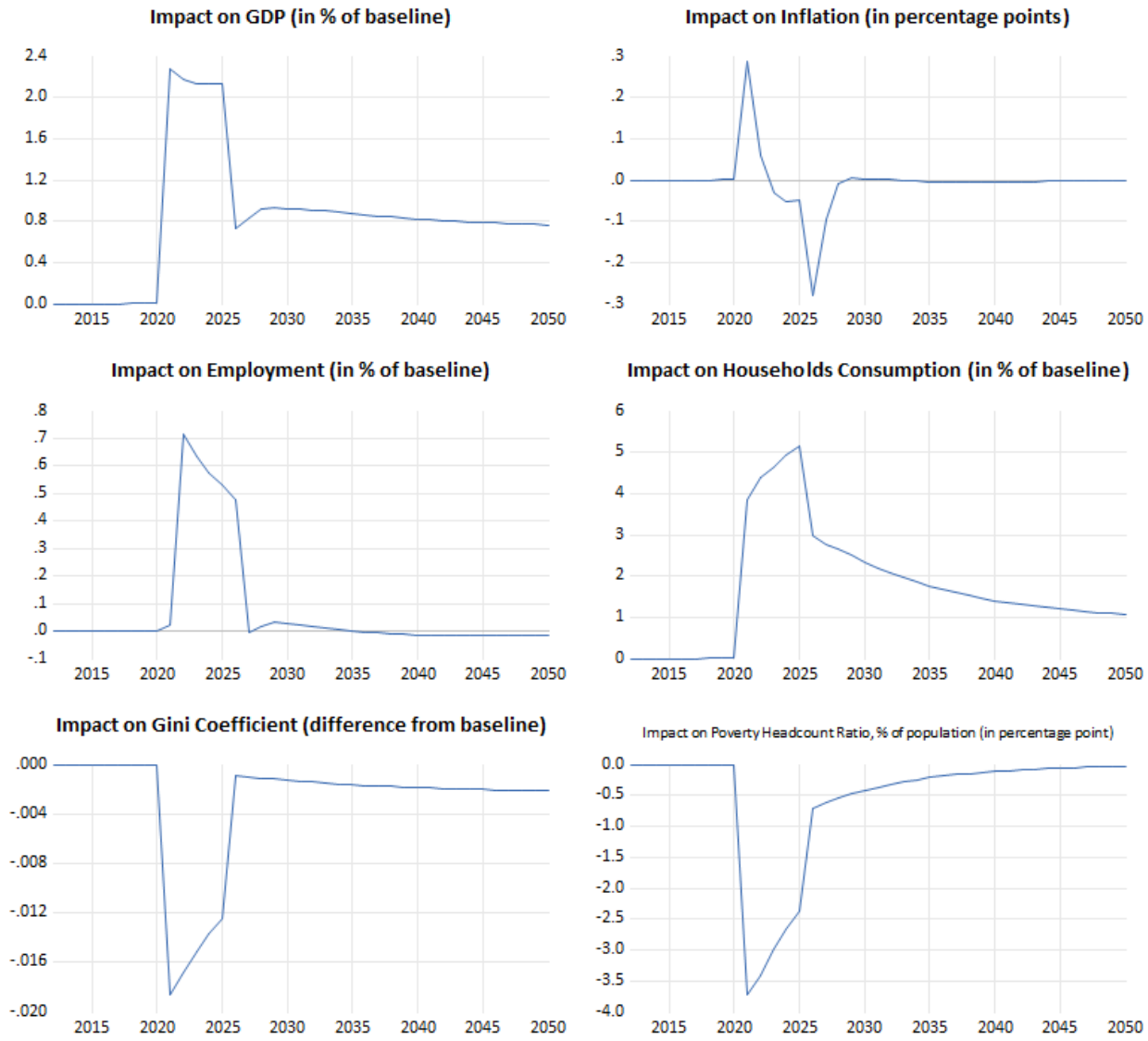
Investment in education provides a short-term stimulus to the economy; thereby promoting GDP growth. The return to education has been widely studied in the academic literature. We assume a benchmark estimate that a 1 per cent of GDP rise in spending on education adds about 0.1 percentage points compared with the baseline in productivity growth per year, according to the social returns to education reported by Botev and others (2019). Broader access to education is also expected to improve human capital and labour productivity. With improved labour productivity and associated higher income, income inequality is likely to be reduced in the long term. In this macroeconomic modelling, it is assumed that a 1 per cent of GDP rise in spending on education will drive a 1 per cent decline in the Gini coefficient in the long term, which in turn raises labour productivity.

The results of scenario 2.1.1 – the combined impact of the three NTPs – are shown in figure 7. The results indicate that economic output is likely to increase by 2 percentage points compared with the baseline scenario during the years of the programme implementation during 2021-2025. The positive growth effect subsides to about 0.8 per cent higher than the

baseline from 2025 onwards. While the largest proportion of the investments goes to social protection – supporting households in poverty and vulnerability – there are insignificant effects on inflation and employment. In the first few years of investment, inflation is likely to increase slightly by 0.3 percentage points higher than the baseline. As the investments improve and household consumption rises significantly, especially during the programme implementation period, it can reduce poverty by a peak level of about 3.5 percentage points compared with the baseline. However, there is a minuscule effect on income inequality during the implementation period as the GINI coefficient decreases between 0.012 and 0.018 during the 2021-2025 period. Meanwhile, the fiscal impact is insignificant, as only 15.22 per cent of the total spending package is funded by the State budget, with the remainder expected to be covered by non-State actors. Therefore, the increase in GDP more than offsets the small increase in government spending, causing the public debt to decrease to marginally lower than the baseline.

In summary, the NTP investments with a large proportion directed towards social protection are expected to: (a) generate significant and positive effects on poverty reduction during the implementation period and economic growth during and after the implementation period, but (b) have only negligible effects on the cost of living.

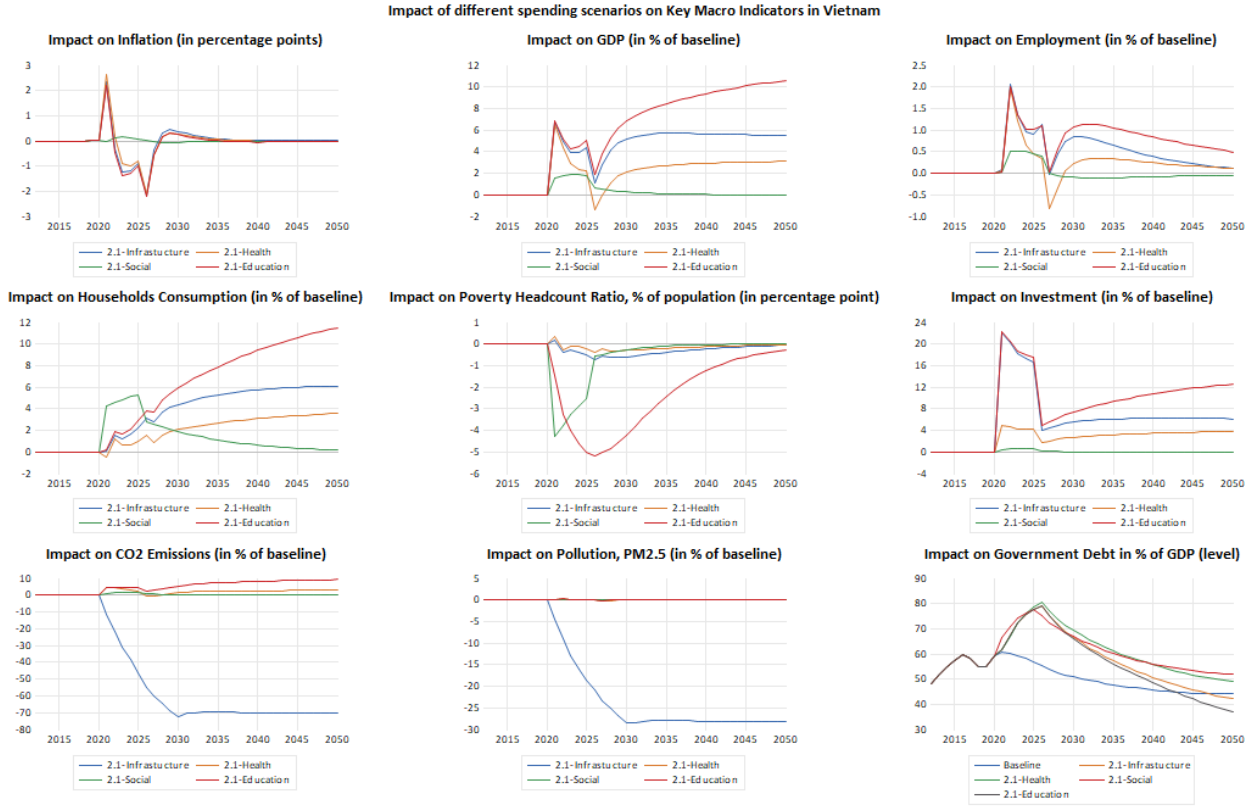
Figure 7. Impact of investment in National Target Programmes in Scenario 2.1.1



Source: ESCAP Macroeconomic Model.

The results of scenario 2.1.2 (scenarios 2.1.2a, 2.1.2b, 2.1.2c and 2.1.2d) are reported in figure 8. The difference between scenario 2.1.2 and scenario 2.1.1 is that the total investments are assumed to be financed entirely from the State budget and invested in a single sector, whether infrastructure, health, social protection or education.

Figure 8. Impact of investment in different categories



Source: ESCAP Macroeconomic Model.

Scenario 2.1.2a (infrastructure): By investing in green infrastructure that enhances energy efficiency, such climate indicators as carbon dioxide emissions and air pollution will see significant improvement. This type of investment will also lead to a long-term boost in labour productivity. In this scenario, GDP is likely to grow 4-6 per cent higher than the baseline scenario in the first few years until 2025. After that, this positive growth effect decelerates slightly but starts to revert to its average rate of 6 per cent higher than the baseline in the remaining period. The carbon dioxide emissions will decrease by about 50 per cent compared with the baseline level, and the level of fine particulate matter ($PM_{2.5}$) will drop by 25 per cent compared with the baseline. Notably, investing in green infrastructure with a focus on enhancement of energy efficiency will create a positive impact in reducing carbon emissions and fine dust in the air – thus positively improving the living environment and people's health. Since this infrastructure investment boosts economic productivity, it helps to expand economic output, offset the investment costs and create less impact on government debt compared with other scenarios (i.e., scenarios 2.1.2b on health and scenario 2.1.2c on social protection).

Scenario 2.1.2b (health): Investment in health care has a primary positive impact on labour productivity. At first, this investment increases GDP by about 6 per cent higher than the baseline scenario, but this impact disappears quickly and is maintained at about 3 per cent from 2030 onwards. The impact on other indicators is small or insignificant. However, it still creates a burden on the fiscal stance as much as other scenarios.

Scenario 2.1.2c (social protection): Given significant spending in the social sector targeting vulnerable groups, rural populations and people in poverty, household consumption increases and poverty decreases in the short term. However, if the investment is limited to a five-year time frame, the effects are only temporary. The economic impact is about 2 per cent different

from the baseline scenario and quickly disappears after 2025. The positive growth effect of the investment in social protection is also detected in a recent study by ILO (2023) showing that an investment of VND 1 million in social policies can lead to an expansion of GDP by VND 3.2 million at peak level.

Compared with other scenarios, this investment shock has a smaller impact on economic growth. As social protection spendings are aimed largely at supporting the people's livelihoods, it may help people to improve their consumption, which can drive short-term growth; however, it may make a limited contribution to investment in productive capacity that is needed to boost long-term growth. Nevertheless, this policy plays a crucial role in improving people's living standards and eradicating poverty. In this scenario, it helps to reduce the poverty headcount ratio by 4 percentage points compared with the baseline, although the impact dissolves rather quickly after 2025.

Scenario 2.1.2d (education): Investment in education is likely to improve productivity, resulting in a substantial increase in potential output as well as other social outcomes, such as poverty and inequality reduction. GDP is projected to grow by 4-6 per cent higher than the baseline scenario in the first few years until 2025. After a slight deceleration around 2025-2026, GDP growth is projected to pick up again to an average rate of 8 per cent until 2050 (see figure 8). With the same investment amount in the four sub-scenarios (infrastructure, health, social protection and education), the investment in education is anticipated to have the highest growth effect. As such, the investment in education is likely to generate a positive impact on GDP growth in the long term. Along with the economic growth effect, the investment is projected to create a greater number of employment opportunities via education for those belonging to a lower socioeconomic status. Poverty is likely to fall by about 5 percentage points lower than the baseline in 2025-2026 and continue to decrease, albeit at a lower rate, until 2050. Hence, this simulation results demonstrate that the investment in education generates the highest positive impact on poverty eradication.

Scenario 2.2. More education for a better future

Viet Nam has continued to improve the systems and policies for education and training development, especially the policy of free tuition for primary schools nationwide and preschools in ethnic minority areas, mountainous areas, islands and areas with extremely difficult socioeconomic conditions. As a result, Viet Nam has achieved positive results in the implementation of Sustainable Development Goal 4 (quality education).

However, the percentage of teachers who meet the minimum training standards as stated in the Education Law in 2019 was 75 per cent for primary schools and 87 per cent for lower secondary schools – a significant decrease from 99.5 per cent and 99.6 per cent, respectively, in the 2018-2019 academic year. The number of schools with basic conditions and services to serve the learning needs of all children, including children with disabilities, is still limited. Furthermore, the proportion of trained workers in Viet Nam was only 26.2 per cent in 2022, causing a shortage of skilled workers for jobs requiring trained labour; thus, affecting the process of industrialization and international integration.[32]

The proportion of the State budget spent on education in 2022 did not reach the minimum level of 20 per cent of total state budget expenditure as instituted in Resolution No. 37/2004/NQ-QH11. The Government's report on educational activities and implementation of the 2022 education budget shows that the estimated current expenditure on education and

[32] MPI, 2023, "Voluntary National Review 2023".

training is VND 275,709 billion out of the total budget of VND 1,784,600 billion, accounting for approximately 15.45 per cent of the total budget.[33]

In this scenario, the model is simulated to evaluate the impact of an extra 4.55 per cent of the total State budget (approximately VND 81,199.3 billion) to meet the minimum level of 20 per cent of the State budget needed to invest in the education sector per year in the period 2023-2030. There are two options for financing this extra investment. The first option is that it is financed by government borrowing (scenario 2.2.1). The other option is through a reallocation of other government expenditure, apart from health, social protection and infrastructure spending (scenario 2.2.2).

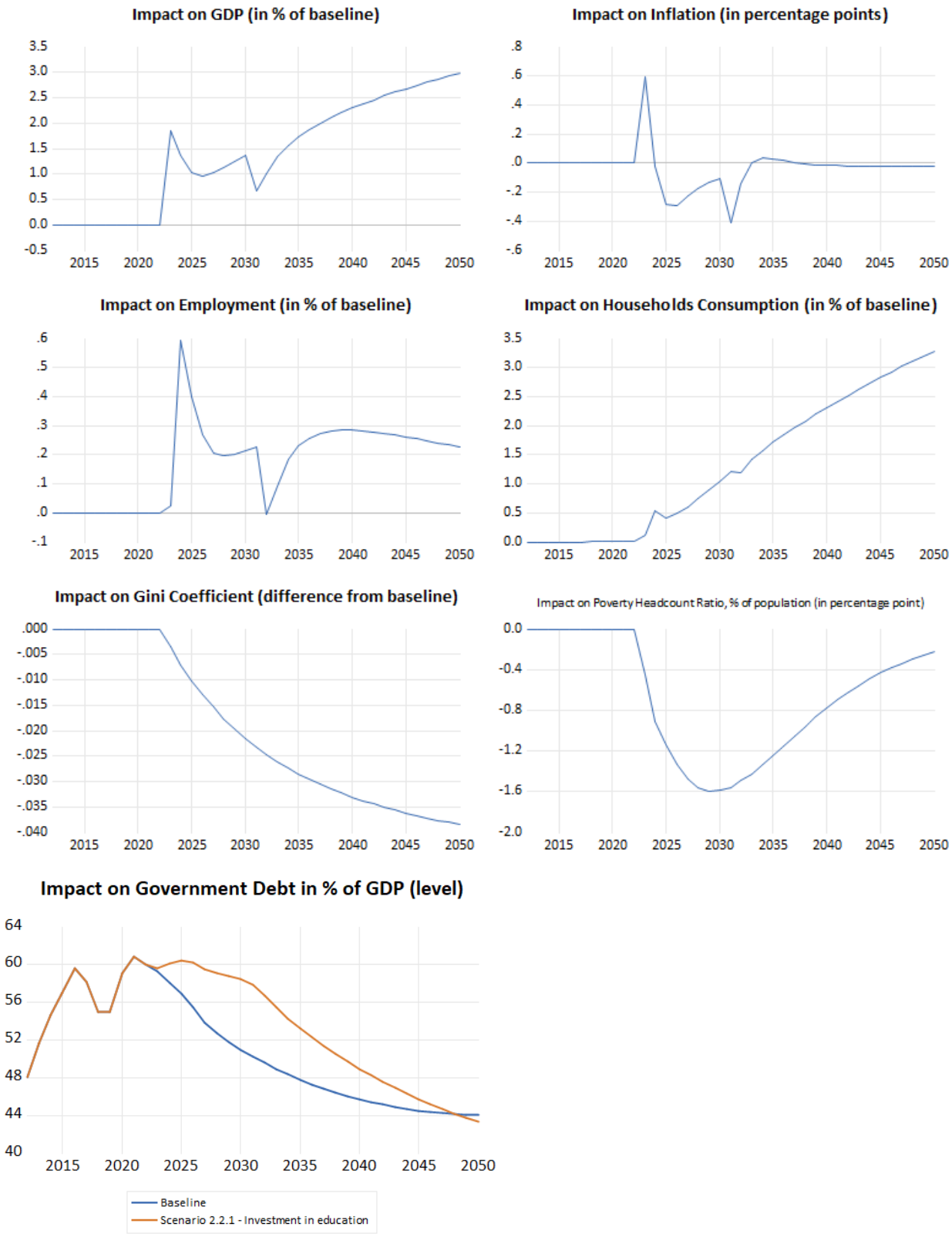
The simulation results show that, in the first option (scenario 2.2.1), the increased investment in education will act as an economic stimulus that generates a positive short-term effect on both GDP and employment. GDP will increase to a peak of nearly 2 per cent and employment might increase up to 0.6 per cent compared with the baseline scenario during the initial period of the stimulus. In the long term, GDP will continue to expand gradually up to 3 per cent higher than the baseline by 2050, due mainly to the improvements in productivity resulting from better education and training. The employment effect continues to be positive throughout the period until 2050 although the size of the effect is marginal. The impact on inflation is limited. From the beginning of the investment shock, the inflation rate is 0.6 percentage points higher than the level of the baseline, and the effect is gradually disappearing. The positive effect of this scenario is smaller than in Scenario 2.1.2a, because the size of the additional investment is smaller (i.e. 4.55 per cent in scenario 2.2 compared with 20 per cent in scenario 2.1.2d). Moreover, the investment package in scenario 2.1.2d is more frontloaded, which results in faster positive effects.

The positive impact of investment in education can be seen quite clearly with a reduction in poverty compared with the baseline scenario. From the first year of the investment, poverty will decrease subsequently to the highest rate of 1.6 percentage points by around 2030, compared with the baseline. Poverty reduction is attributable mainly to the fact that the extra education investment helps the population in gaining higher skills and know-how alongside improved productivity, resulting in higher income and living standards. This positive effect, however, will gradually moderate after 2030. As the poverty rate declines, there is a corresponding improvement in income equality. The GINI coefficient in this case is 0.035-0.04 lower than the baseline scenario to 2050 and has a lasting impact. Income increases and household spending also tend to increase compared with the baseline scenario in the long term.

However, additional government spending on education, without a reduction in other areas, would lead to a fiscal deficit that needs to be financed by government borrowing. Given the additional education investment, the government debt as a share of GDP will increase higher, up to 7 percentage points, around 2030 compared with the baseline scenario. In the long term, the productivity improvements will contribute to higher GDP growth, which is expected to offset the impact of higher government spending, thereby pushing government debt to the same level in the baseline scenario.

[33] https://vaefa.edu.vn/images/2023/23.08.03_VIETNAM_spotlight_2023--04_rev.pdf

Figure 9. Impact of investment in education in Scenario 2.2.1



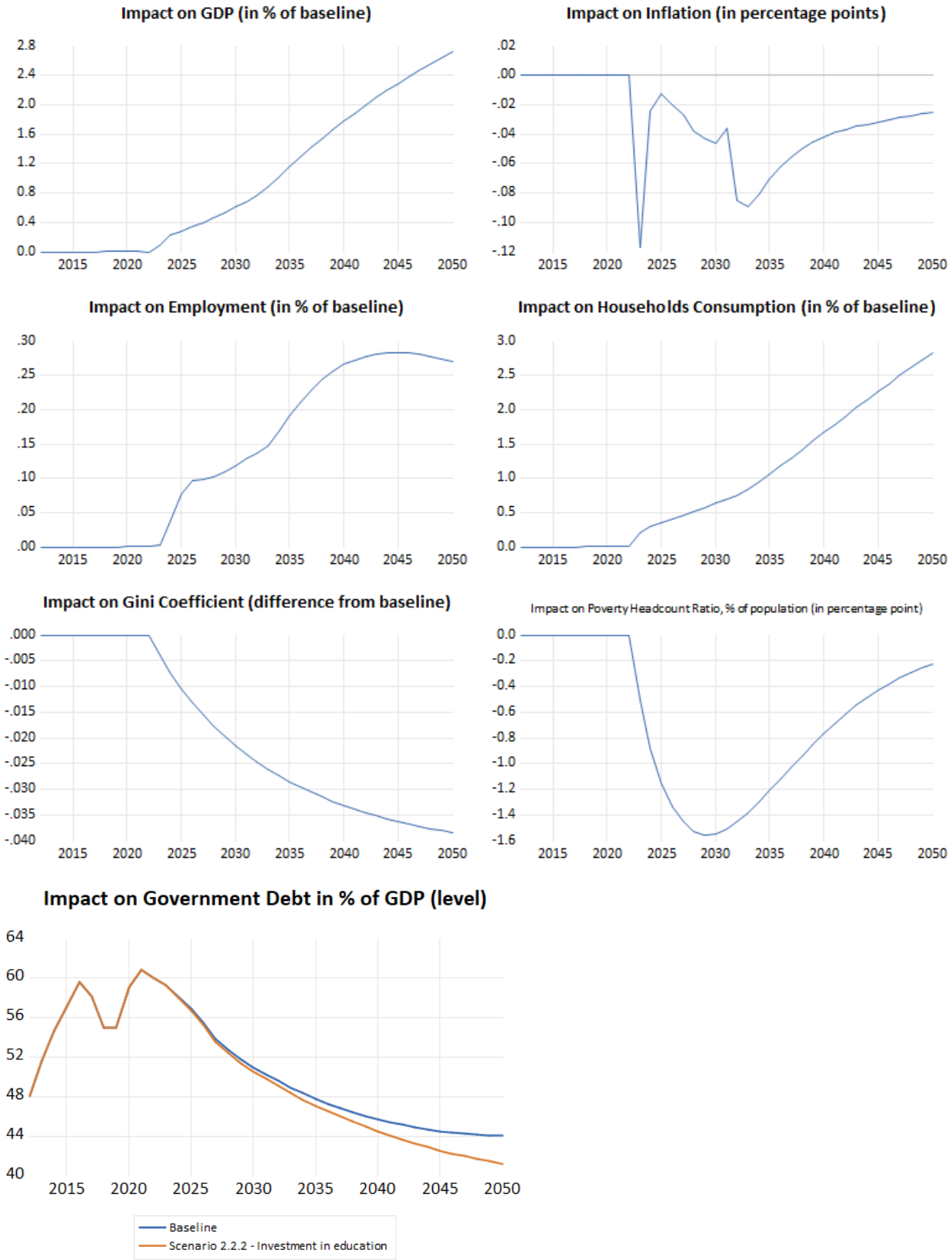
Source: ESCAP Macroeconomic Model.

For scenario 2.2.2, there is no increase in total budget expenditures. The additional education investment comes from the reallocation of the budget from other investment areas. In other words, the increase in education investment comes from a cut to the budget for other sectors. The increased investment in education in this case still creates a positive impact on economic

growth and employment, but the level of impact is lower than scenario 2.2.1 because there is no fiscal stimulus to the economy and the investment in other sectors is reduced. The impact on GDP growth is long term. By 2030, GDP will increase by 0.6 per cent higher than the baseline scenario, but by 2050, the impact will expand to 2.6 per cent higher than the baseline. Given the economic output expansion, the number of employed workers will increase by about 0.12 per cent higher than the baseline scenario in 2030 and continue to increase by about 0.27 per cent until 2045. As there is no stimulus to the economy in this scenario, there is no inflationary pressure. Hence, inflation appears relatively stable.

Social outcomes such as poverty and income are likely to see significant improvement, which is similar to scenario 2.2.1. The positive effect on poverty reduction is largely due to the improvements in skills and productivity, which translates into higher income and GDP growth. The poverty headcount ratio is nearly 1.6 percentage points lower than the baseline scenario around the year 2030. Meanwhile, since no additional government borrowing is required for scenario 2.2.2, the public debt-to-GDP ratio will decline compared with the baseline scenario as a result of GDP expansion.

Figure 10. Impact of investment in education by reallocation in Scenario 2.2.2



Source: ESCAP Macroeconomic Model.

Scenario 3. Towards innovation-based growth

Innovating the growth model and restructuring the economy are a major policy aspiration of Viet Nam. In guiding the country's development trajectory for the period 2021-2030, the Resolution of the CPVN's 13th National Congress affirmed "continuing to strongly innovate the growth model and the basis for restructuring the economy" with the important strategy of "strongly shifting the economy to a growth model based on increased productivity, scientific and technological progress and innovation." In this spirit, the Government issued Resolution No. 54/NQ-CP declaring the Government's Action Programme to implement the National Assembly's Resolution on Economic Restructuring Plan for the period 2021-2025. This includes: Decision No. 36/QD-TTg of the Prime Minister on promulgating the General Plan to improve productivity based on science, technology and innovation for 2021-2030, and Decision No. 1305/QD-TTg on national programme for increasing labour productivity to 2030 in order to promote economic restructuring associated with innovating growth models based on science, technology, knowledge and innovation as well as many other policy documents.

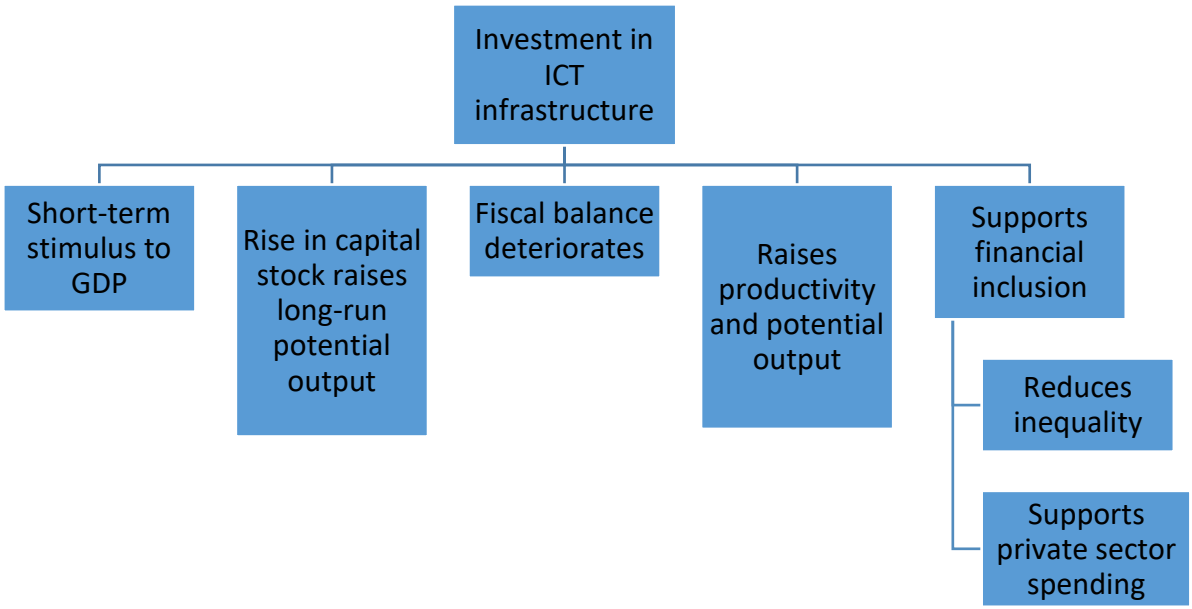
One of these policy actions is the Information and Communications Infrastructure Plan (ICIP) for 2021-2030, with a vision for 2050. The ICIP is aimed at developing infrastructure for national digital transformation, opening up new development space for the economy and society, linking development in the digital space with traditional physical development spaces, and creating a favourable environment for innovation to improve national competitiveness. By 2030, the ICIP target is to complete the basic telecommunications infrastructure, moving to infrastructure with large capacity, high speed and reliability, ultra-low latency, guaranteed mobility, network information security and numerous services of the so-called fourth industrial revolution, thereby contributing to the successful implementation of the national digital transformation and maintaining national sovereignty in cyberspace.

Given the far-reaching potential of this plan to promote Viet Nam's innovation-based economy, it is vitally important to assess ex ante the plan's effects on social, economic and environmental outcomes through the application of the ESCAP Macroeconomic Model. It is estimated that the investment needed for this plan will be VND 266 trillion (US$ 10.64 billion) for the entire 2021-2030 period, of which the capital from the State budget is VND 11.8 trillion (US$ 472 million) and the capital from other sources is VND 254.9 trillion (US$ 10.19 billion).[34] How this policy is financed may pose a challenge and has significant socioeconomic implications, including the Government's fiscal space, which needs to be duly considered.

Figure 11 depicts the impact transmission channels of the investment in ICT infrastructure. Increasing investment in ICT infrastructure will provide a boost to economic growth. Additional new investments create more demands for production goods and services in the economy alongside increased capital accumulation and productivity in the long term, thereby boosting potential GDP growth. The ICT infrastructure investment may also enhance financial inclusion (e.g. financial technology), which can help people and businesses, especially those in rural and remote areas, in gaining access to credit and other financial services. This would lead to higher private sector spending and improve economic activities and living conditions, especially for those in rural areas – thereby contributing to reducing inequality. However, the investments will put pressure on the fiscal balance if they are largely financed by the Government.

[34] Demand and divergence of investment capital, at IV.6.3 of the draft report for ICIP of Ministry of Information and Communications, 2021.

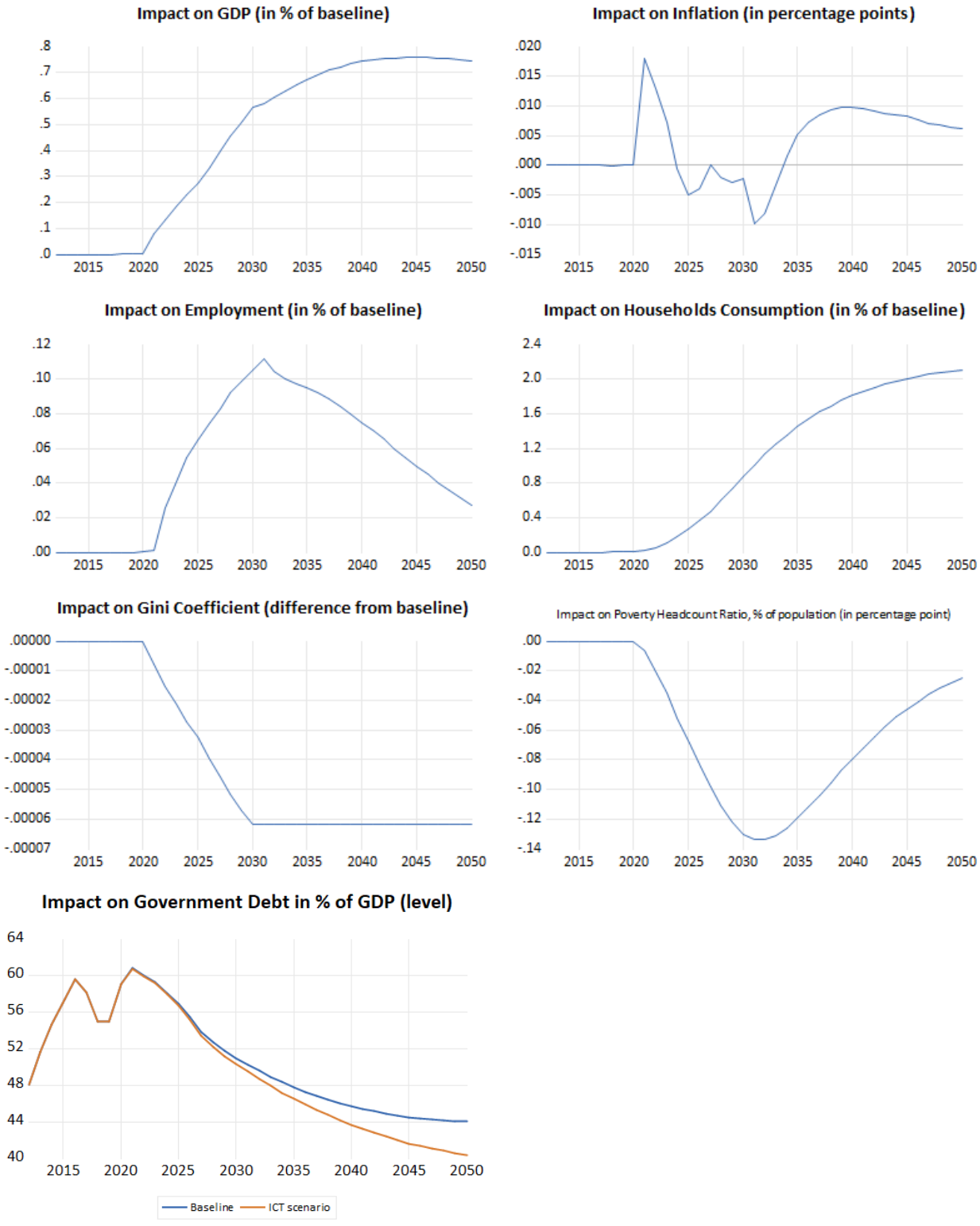
Figure 11. Impact transmission channels of investment in ICT infrastructure



Source: ESCAP Macroeconomic Model.

The simulation results show that the investment in ICT generates a positive effect on economic growth. The initial investment has created a small growth effect, but from 2025 onward the effect becomes more pronounced and will reach just over 0.7 per cent higher than the baseline. However, because the size of this investment package is relatively moderate (approximately 2 per cent of GDP) when compared with other scenarios, the impact is correspondingly smaller. With a small size of the investment shock, the effect on inflation is negligible. The impact on employment is relatively low, peaking in 2031 with an increase of about 0.11 per cent compared with the baseline scenario, but the impact gradually disappears. However, the impact on household consumption is relatively positive, with an increase of more than 2 per cent compared with the base scenario, and continues over the long term.

Figure 12. Impact of investment in ICT infrastructure (percentage difference from baseline)



Source: ESCAP Macroeconomic Model.

The enhancement of ICT infrastructure will yield beneficial effects on social outcomes, including inequality and poverty reduction. As the investment is expected to promote financial inclusion, the GINI coefficient tends to decrease in the 2021-2030 period and stabilize at a low level compared with the baseline scenario after 2030. The poverty rate compared with the baseline scenario tends to be 0.14 percentage points lower by 2031, but the impact then gradually decreases as the investment effect dies out.

As the size of the investment is relatively small and the private sector contributes significantly (96 per cent) to the financing, there is an insignificant effect on the government fiscal balance. In the first few years, the government debt as a share of GDP will increase slightly by less than 1 percentage point. However, in the long term, public debt as a percentage of GDP decreases gradually due to the higher GDP. In this scenario, debt-to-GDP is expected to decrease from the baseline of about 60 per cent of GDP in 2020 to 40 per cent of GDP by 2050.

4. Limitations of the Model

Similar to other macroeconomic models that are used for policy simulations, the ESCAP Macroeconomic Model faces certain limitations. These arise from the fact that, while macroeconomic models are developed to deal with certain research topics, they are often used for other analytical purposes too. In this regard, the ESCAP Macroeconomic Model was primarily designed with the idea of analysing the socioeconomic and environmental impacts of policies at a regional level. Hence, its multi-country framework and other aspects have to be simplified in order to reduce complexity in analysing a country case. As such, there are two key limitations as follows.

First, a clear limitation of the model that often emerges in discussion with local authorities is its one single aggregated production function. Indeed, the model is not suited for answering questions that are aimed at the heterogeneous impact of economic shocks and government policies on different economic sectors, such as agriculture, manufacturing and service industries. However, the model is enriched with macroeconomic behavioural relationships that can capture macroeconomic effects of economic shocks, despite the fact that the model is composed of only a single aggregated production function.

Second, being derived from a family of large-scale econometric models, the model lacks a precise micro-foundation of its structural equations as well as a proper handling of forward-looking expectations.[35] This means that some of the transmission channels of government policies may be suppressed compared with general equilibrium models fully incorporating rational expectations. Nevertheless, these may not be numerically significant in countries where the majority of the population has limited resources to create savings and limited access to financial markets that would enable active substitution between current and future consumption and investment.

Despite these limitations, the ESCAP Macroeconomic Model still provides useful insights into synergies and trade-offs associated with key policy decisions that need to be taken in order to shift the economy towards sustainable development.

5. Policy implications

With the application of the ESCAP Macroeconomic Model for Viet Nam, this study aims to assess economic, social and environmental impacts of the selected policies, and shed light on synergies and trade-offs of the said policies. The study analyses the impacts of certain selected policy priorities that are being implemented or are in the pipeline, including renewable energy transition, introduction of a carbon tax, investment in poverty reduction and social development, and moving towards innovation-based growth.

[35] The model is derived based on a more complex United Nations DESA World Economy Forecasting Model (WEFM) and belongs to the same family of models as is the NiGEM, for example.

The analysis shows that investment in renewable energy would likely help Viet Nam to achieve its targets of renewable energy development, emissions reduction and air quality improvement. It would also drive expansion of the economy. However, it would likely result in a surge in public debt if the investment were financed mainly by the Government.

The investment in green infrastructure, health, social protection and education as allocated in the three NTPs is likely to have significantly positive effects on poverty reduction and economic output, especially during the programme implementation period from 2021-2025. Because a major proportion of the investment is expected to come from non-State sources (such as charity, voluntary contributions from people and communities, and corporate capital), the Government's fiscal space would likely improve in the long term compared with the baseline. It is worth noting that the model assumes most of the infrastructure investment is focused on energy efficiency.

The investment in ICT infrastructure would likely result in a positive effect on economic output in the long term due to the improvement of productivity. However, due to the relatively small size of the planned investment package financed by the Government, it has limited impacts on such social indicators as poverty and inequality, whereas public debt would decrease relative to the baseline.

The simulation results offer some policy implications for Viet Nam in considering the investments to accelerate achievement of the Sustainable Development Goal and net-zero emission targets.

First, the modelling results highlight the importance of inclusive fiscal policy in support of the achievement of the Sustainable Development Goals. The most fundamental one is to maintain adequate public spending on three major development areas – health, education and social protection. Enhancing the access to, and the quality of, these public services will directly benefit vulnerable populations, including people living in remote areas, ethnic minority areas, and areas frequently affected by natural disasters, and thus promote socioeconomic equality in the long term.

Second, the study demonstrates how environmental benefits can be realized through investment in key transition areas, such as renewable energy and energy efficiency, and economic growth can be boosted through a healthy population and increasing labour productivity.

Third, the simulations shed light on the trade-offs between different policy choices and illustrate how different size, composition and pace of the investments will yield differentiated impacts. For example, the same amount of investment in education creates longer-term benefits in employment, investment and poverty reduction, but creates less short-term stimulus of household consumption compared with investment in social protection programmes. Yet, investment in social protection alone leads to more emissions compared with investment in energy efficiency enhancement infrastructure due to higher economic production while emissions per unit of production remain unchanged. Moreover, introduction of a carbon tax offers enormous environmental benefits, but creates short-term inflationary pressure, which tends to disproportionally affect the poor and other vulnerable groups. To mitigate the negative impacts, the Government must spend the additional carbon tax revenues wisely to offset some of the short-term costs to people, especially vulnerable groups.

Fourth, it is critical to ensure public spending efficiency. As emphasized in the report, the illustrated socioeconomic and environmental benefits are based on the assumptions of timely budget disbursement and effective project implementation. To this end, the Vietnamese Government can seek to deploy digital technologies to further improve project management, monitoring and evaluation.

Fifth, beyond fiscal revenue and spending policies, navigating a balance between prudent public debt management and achievement of long-term development goals is essential. How the investments in the select policy priorities are financed will have a direct impact on government debts. Scenarios 1.1.1 and 1.1.2 compare the impacts of the same amounts of investments in renewable energy on public debt trajectory when funded entirely by the Government versus partially by the private sector. When private investment is assumed to account for 30 per cent of total investments in renewable energy, the public debt-to-GDP ratio goes up by 28.8 percentage points compared with 43.8 percentage points without private investments.

6. Policy recommendations and ways forward

To meet large fiscal needs, the Government needs to step up its efforts in exploring untapped public financial resources, lower its costs of borrowing and mobilizing private capital.

The Government of Viet Nam can implement several strategies to increase its tax revenues effectively. New estimates by ESCAP show that Viet Nam could potentially increase its government tax revenues by 2.5 per cent of GDP if benchmarked against its best-performing peers.[36] First, enhancing tax administration and enforcement mechanisms can help to reduce tax evasion and increase compliance among taxpayers. This may involve leveraging technology for more efficient tax collection processes and improving monitoring systems to detect non-compliance. Second, broadening the tax base while ensuring progressive taxation can help to capture more revenue from a wider spectrum of economic activities and individuals. The introduction of a carbon tax, as illustrated in the modelling results, is a good example of how to broaden the tax base and increase government revenue. In addition, periodically reviewing and adjusting tax rates to reflect economic growth and changing circumstances can optimize revenue generation while maintaining competitiveness. Moreover, investing in initiatives to boost economic productivity and formalize the informal economic sectors can expand the base of taxpayers. Last, fostering a conducive business environment and promoting investment can stimulate economic activity, leading to higher taxable incomes and ultimately increased tax revenues for sustainable fiscal development.

When introducing a carbon tax, the Government of Viet Nam should carefully plan, consider its potential negative impacts and implement measures to mitigate them effectively. Introducing a carbon tax in Viet Nam involves careful planning and consideration of various factors, such as its legislative framework, setting the carbon prices, taxation mechanism, exemption and rebates, implementation and enforcement, revenue allocation and so on. Conducting thorough socioeconomic and environmental assessments will be the first step to help anticipate and address any adverse effects on vulnerable groups or industries. Ensuring transparency and stakeholder engagement throughout the policy development and

[36] ESCAP (2024), "Boosting affordable and longer-term financing for Governments. *Economic and Social Survey of Asia and the Pacific 2024".*

implementation process can build public trust and support for the carbon tax, facilitating its successful adoption and long-term effectiveness in combating climate change.

The Government of Viet Nam has a prime opportunity to explore non-conventional public bond financing mechanisms, notably sustainability bonds, to complement traditional fiscal borrowings and address financing gaps for achieving the Sustainable Development Goals. By issuing sustainability bonds, the Government can attract a new pool of investors who prioritize environmental, social and governance (ESG) considerations, thereby expanding its funding sources. These bonds, specifically earmarked for sustainability-related projects, would not only provide crucial capital for sustainable initiatives but also signal Viet Nam's commitment to sustainable development of both domestic and international stakeholders. Moreover, leveraging sustainability bonds can enhance the Government's credibility in the global financial markets and bolster its reputation on the international stage as a responsible and forward-thinking actor. Through strategic issuance and transparent allocation of proceeds, Viet Nam can harness the power of sustainable finance to accelerate progress towards achieving its own sustainable development goals while diversifying its funding base for long-term economic prosperity.

Viet Nam can lower the cost of government borrowing by focusing on capital market development and channelling domestic savings into sovereign bonds through several strategic measures. First, enhancing market infrastructure and regulatory frameworks can deepen liquidity and increase investor confidence in the bond market, attracting a broader investor base and lowering borrowing costs. This may involve improving trading platforms, implementing transparent pricing mechanisms and strengthening legal protection for bondholders. Second, fostering financial innovation, such as introducing new bond products and facilitating access to bond markets for retail investors, can broaden the investor pool and create more competitive pricing dynamics. In addition, promoting financial literacy and investor education initiatives can raise awareness about the benefits of investing in sovereign bonds, encouraging households and institutional investors to allocate more of their savings to government securities. Furthermore, enhancing fiscal discipline and transparency in government finances can instil confidence among investors, reducing risk premiums associated with sovereign borrowing.

Viet Nam should seek to enhance public debt management to cope with potential debt distress while increasing investments in long-term development priorities. Some of the good practices, which help lower fiscal risks and borrowing costs, include: (a) having clear debt management objectives and a transparent legal framework; (b) taking an overall portfolio point of view when making government borrowing decisions; and (c) developing a more comprehensive debt management strategy which not only focuses on the size of the debt, but also the structures and sources, along with various other factors.

The development and implementation of the green taxonomy holds the potential to create a highly conducive business environment for green investments by providing clear and standardized criteria for defining environmentally sustainable economic activities. By establishing a common language and classification system for what constitutes "green", investors gain greater clarity and confidence in identifying and assessing green investment opportunities. This transparency not only reduces information asymmetry, but also facilitates

better risk assessment and pricing, ultimately lowering the cost of capital for green projects. Moreover, a green taxonomy fosters market integrity and credibility by preventing "greenwashing" and ensuring that investments genuinely contribute to environmental objectives. Furthermore, it encourages innovation and the development of new green technologies and solutions by signalling market demands for sustainable products and services. Overall, the adoption of a green taxonomy can catalyse a virtuous cycle of investment, innovation and sustainability, driving the transition to a greener and more resilient economy.

Viet Nam also possesses a significant opportunity to leverage FDI in sustainability-focused sectors, particularly in renewable energy and climate-resilient infrastructure, which often require substantial capital investments. By creating an attractive investment environment through streamlined regulations, fiscal incentives and investment guarantees, Viet Nam can attract international investors seeking opportunities in sustainable development. Partnering with foreign investors not only brings in much-needed capital, but also facilitates the transfer of advanced technologies and expertise – thereby accelerating the deployment of renewable energy projects and climate-resilient infrastructure across the country. By harnessing FDI in these critical sectors, Viet Nam can not only meet its climate goals but also drive inclusive economic growth, create job opportunities and enhance resilience to climate change impacts, positioning the country as a leader in sustainable development within the Asia-Pacific region and beyond.

The State Bank of Vietnam (SBV) can play a pivotal role in promoting green development and mobilizing private capital into green investments through various strategic initiatives. SBV should establish clear guidelines for green lending operations, incorporating environmental and social risk assessments and incentivizing banks to prioritize green projects. Robust risk management and reporting mechanisms are essential, along with standardized monitoring and evaluation frameworks to track performance and compliance. SBV should also invest in capacity-building for banks, offering training programmes and technical assistance to support effective implementation of green lending strategies. In addition, SBV should strengthen its supervisory capacity to oversee green lending activities effectively and fostering of information-sharing to ensure compliance with environmental standards and regulatory requirements. These measures will enable SBV to promote sustainable finance and contribute to the transition to a low-carbon economy in Viet Nam.

7. Concluding remarks

This macroeconomic modelling study for Viet Nam provides valuable insights into the complex interplay of economic, social and environmental factors shaping the country's sustainable development trajectory. By employing macroeconomic modelling techniques and incorporating national data, this study has elucidated key trends, challenges and opportunities for policymakers and stakeholders. The findings underscore the importance of proactive and targeted policy interventions to promote inclusive growth and sustainable development. As Viet Nam continues on its path of economic development and integration, the insights gleaned from this study serve as a robust foundation for evidence-based decision-making and strategic planning.

Table 3. Summary table of the scenarios

Scenario	Sub-scenario		Scenario setup					Difference from the baseline (percentage, if not indicated otherwise)							Interpretation of the results
			Size of the investment package (percent-age of 2020 GDP)	Investment time frame	Percentage of investment from budget	Re-allocation of gov. spending	Extra spending in which sectors:	Real GDP change in 2030 (percentage)	GDP public debt change in 2030 (percentage)	Poverty reduction in 2030 (percentage)	CO_2 reduction in 2030 (percentage)	CO_2 reduction in 2050 (percentage)	Renewable energy share in 2030	Renewable energy share in 2050	
1. Towards a greener economy	***1.1.1.***	***Renewable energy investment from budget***	*220%*	2021-2050	*100%*	No	Renewable energy (100%)	*2.28*	*43.8*	*-3.5*	*-1.7*	*-53.5*	*19.8*	*57.3*	The climate effect is significant, marked by a reduction in pollution and CO_2 emissions. Also, there is an accelerated increase in renewable energy, which outweighs the growth in energy consumption in the long run. The growth effect is positive and is driven by the substantial investment shock and supports poverty reduction. Negligible on social impact. Highest pressure on public debt because the investment package is relatively substantial.
	1.1.2.	***Renewable energy investment partly from budget***	*220%*	2021-2050	*70%*	No	Renewable energy (100%)	*2.43*	*28.8*	*-3.1*	*-1.6*	*-53.5*	*19.8*	*57.3*	The same size of impact on the environment with the scenario above. Because the investment is partially financed by the private sector, there is less pressure on fiscal and more stimulus to the economy.
	1.2.	***Introduction of carbon tax***	-	2021-2050	-	Yes, from carbon tax revenue	Debt reduction (100%)	*-0.73*	*-24.2*	*2.2*	*-9.9*	*-21.6*	*19.0*	*25.4*	No new investment. With the rise in production costs, GDP is expected to experience a slight decline, although the impact remains moderate. If the Government does not utilize the extra revenue to boost social, health or education spending, the impact of the carbon tax on social indicators remains negligible. Over the long term, the high carbon tax would continue to lead to a decline in CO_2 emissions and pollution but smaller effects than under Scenario 1.1. However, there is significant fiscal space.
2: Poverty and inequality reduction and social protection	***2.1.1.***	***Implementation of NTP***	*39%*	2021-2025	*15%*	No	Infrastructure (10.6%), Health (0.3%), Social (87.3%),	*0.93*	*-1.0*	*-8.2*	*-7.0*	*-7.0*	*17.1*	*17.1*	There is significant poverty reduction. The impact on economic growth is positive, driven by the additional investments in various sectors and the creation of more fiscal space. The effect on the climate is moderate, but somewhat larger than in Scenario 1 in 2030, due to our assumption that infrastructure investments will enhance

Scenario	Sub-scenario		Scenario setup					Difference from the baseline (percentage, if not indicated otherwise)							Interpretation of the results
			Size of the investment package (percent-age of 2020 GDP)	Investment time frame	Percentage of investment from budget	Re-allocation of gov. spending	Extra spending in which sectors:	Real GDP change in 2030 (percentage)	GDP public debt change in 2030 (percentage)	Poverty reduction in 2030 (percentage)	CO_2 reduction in 2030 (percentage)	CO_2 reduction in 2050 (percentage)	Renewable energy share in 2030	Renewable energy share in 2050	
							Education (1.8%)								energy efficiency, leading to an expected decline in CO_2 emissions even in the short term.
	2.1.2.a	***Implementation of NTP - spending on infrastructure***	*39%*	2021-2025	*100%*	No	Infrastructure (100%)	*5.20*	*30.5*	*-11.3*	*-51.4*	*-50.5*	*17.2*	*16.9*	By investing in green infrastructure that enhances energy efficiency, climate indicators such as CO_2 emissions and pollution will see significant improvement. This type of investment will also lead to a long-term boost in productivity. However, this could lead to high pressure on fiscal space.
	2.1.2.b	***Implementation of NTP - spending on health care***	*39%*	2021-2025	*100%*	No	Healthcare (100%)	*2.09*	*36.1*	*-5.7*	*1.6*	*2.9*	*16.9*	*17.1*	Investment in health care has a primary impact on productivity because it enhances the labour productivity of the workforce. However, extra investment leads to high fiscal pressure because the positive impact of this investment type on the real economy is limited to offset the additional public spending. Negligible effects on environmental variables.
	2.1.2.c	***Implementation of NTP - spending in the social sector***	*39%*	2021-2025	*100%*	No	Social (100%)	*0.26*	*31.1*	*-5.2*	*0.3*	*0.0*	*17.1*	*17.1*	Given significant spending in the social sector, targeting vulnerable groups, rural populations, and people in poverty, household consumption will increase, and poverty decrease in the short term. However, if the investment is limited to a 5-year time frame, the effects are only temporary. To systematically improve social conditions, it is preferable to invest in sectors with long-term effects, such as education or health.
	2.1.2.d	***Implementation of NTP - spending on education***	*39%*	2021-2025	*100%*	No	Education (100%)	*6.83*	*29.8*	*-81.6*	*5.8*	*9.7*	*16.9*	*17.1*	Investment in education makes a positive contribution to social indicators, such as reducing poverty. Additionally, it improves productivity and results in a substantial increase in potential output in the long run.

Scenario	Sub-scenario		Scenario setup					Difference from the baseline (percentage, if not indicated otherwise)							Interpretation of the results
			Size of the investment package (percent-age of 2020 GDP)	Investment time frame	Percentage of investment from budget	Re-allocation of gov. spending	Extra spending in which sectors:	Real GDP change in 2030 (percentage)	GDP public debt change in 2030 (percentage)	Poverty reduction in 2030 (percentage)	CO_2 reduction in 2030 (percentage)	CO_2 reduction in 2050 (percentage)	Renewable energy share in 2030	Renewable energy share in 2050	
	2.2.1.	***Education investment from budget***	*20%*	2023-2030	*100%*	No	Education (100%)	*1.37*	*14.6*	*-30.9*	*1.2*	*2.7*	*17.0*	*17.1*	Increased investment in education will have a positive short-term effect on both GDP and employment due to the additional government stimulus. The positive effects of educational investment gradually become manifest. Additional government spending, without reductions in other areas of investment, would lead to an increase in the fiscal deficit, resulting in a higher debt-to-GDP ratio in the coming years. Education spending does not yield a positive impact on climate indicators. Extra government spending pushes up CO_2 emissions.
	2.2.2.	***Education investment from reallocation***	*20%*	2023-2030	*100%*	Yes, from other gov. Investment	Education (100%)	*0.61*	*-0.8*	*-30.1*	*0.5*	*2.4*	*17.0*	*17.1*	Additional government spending in education with reductions in other areas of investment would lead to a very similar fiscal balance and public debt path in the coming years than in the baseline scenario. However, as education spending is financed by reallocation, other investment of the government budget in the meantime declines. Growth will continue to outpace the baseline in the long run, primarily due to the expected productivity improvements resulting from education spending. Poverty will continue to decline in the long term, although the positive impact moderates over time
3: Towards innovation-based growth	***3***		*4%*	2021-2030	*5%*	No	Infrastructure (100%)	*0.57*	*-1.3*	*-2.5*	*0.5*	*0.8*	*17.0*	*17.1*	There is a positive effect on growth stemming from the additional investment. However, given that the size of this investment package is relatively moderate when compared with other scenarios, the impact is correspondingly smaller. As the size of the investment is relatively small and mostly financed by the private sector (95%), this scenario's influence on fiscal balance and debt in the coming years is a small positive.

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Annex

Technical description of the ESCAP Macroeconomic Model

The ESCAP Macroeconomic Model is a global model and comprises 46 individual full-country models for the Asia-Pacific region, including a model of Viet Nam, smaller models of nine key trading partners outside of the region, plus aggregate models for the remaining world's economies grouped into four regions. The individual country models are linked via trade, remittances, financial markets and global energy markets. A full description of the model equations follows.

The country models are characterized by a short-run Keynesian demand side and a long-run neo-classical supply side. In the model, households consume, save and supply labour, while firms produce output, hire labour and invest. Governments pursue fiscal policy by spending and taxing, while monetary authorities conduct monetary policy by setting the short-term interest rate and exchange rate policy. The balance of demand and supply, together with tax policy, global commodity prices and other imported prices, determine inflation. Higher prices constrain consumption and dampen the net trade balance. Most of the key behavioural relationships are specified in an error-correction framework, which allows us to distinguish short- and long-term relationships between variables.

In the short run, GDP is driven by aggregate demand, which comprises private and public consumption, private and public investment and net foreign trade. Household consumption depends on real personal disposable income, financial inclusion (proxied by the share of population with a bank account) and the gap between actual and expected inflation rates. Private investment is determined by potential output, user cost of capital, financial inclusion and gross domestic income (which captures terms-of-trade shocks). Financial inclusion depends on government investment in connectivity.

Public consumption and investment and policy variables are disaggregated into spending on health, environmental protection and other areas. Exports depend on external demand and relative non-commodity export prices, both of which are derived from a global bilateral trade matrix. Finally, imports depend on domestic demand, the output gap, the relative price of imported goods and oil imports.

In the long term, each country's potential output level is driven by its aggregate supply, which is determined by the labour force, capital stock, energy use, energy efficiency, trend productivity growth and damage from climate shocks. The labour force depends on demographic factors and the labour force participation rate. The capital stock is driven by the accumulation of investment, after allowing for depreciation. The capital depreciation rate depends on global carbon emissions to capture the impact of climate change on the erosion of capital. Total energy demand depends on output, energy prices and energy efficiency. The energy mix depends on relative prices of oil, gas, coal and renewables. Trend productivity growth is modelled as a function of the global productivity frontier (which is related to global trade), inequality, air pollution and government expenditure on health, education and connectivity. Finally, damage from climate shocks depends on government expenditure on environmental protection.

Deviations of actual output from potential output will activate adjustment processes that bring the economy back to potential in the long run. Among other channels, the gap between demand and supply, or output gap, feeds through prices. For example, a positive output gap will put upward pressure on prices, resulting in slower consumption growth and a deterioration of the trade balance, so that demand falls towards available supply.

In the fiscal module, government spending is disaggregated into spending on social protection, spending on health, spending on environmental protection, fossil fuel subsidies, other government consumption, other

government investment and interest payments. Spending on education is modelled through a rise in spending on other government consumption and other government investment. Government revenue is disaggregated into income tax revenue, corporate tax revenue, indirect tax revenue, taxes on international transactions, carbon tax revenue, commodity revenue and other net revenue. The fiscal deficit is financed by an increase in government debt, and debt service payments flow back onto the fiscal balance. In the model, an increase in the government debt-to-GDP ratio leads to a higher risk premium for that country. In this way, running a large fiscal deficit for an extended period of time can cause government debt to spiral and become unsustainable. The risk premium is also sensitive to above target inflation. Countries with a higher initial level of risk premium are more sensitive to any rise in public debt. A rise in the risk premium pushes up inflation and increases borrowing costs, which results in lower investment.

In addition to economic relationships, the model has additional channels to capture interactions with key social and environmental variables, such as poverty, income inequality, GHG emissions and air quality. Relationships between variables are econometrically estimated where appropriate or guided by the academic literature. For example, losses associated with climate shocks are underpinned by benchmarks contained in World Bank (2019), in which an investment in resilience valued at 1 per cent of GDP reduces annual damage by 5 percent. Other major studies that are used for developing relationships among the variables include Botev, Egert and Jawadi (2019), Briceño-Garmendia, Estache and Shafik (2004), ECB (2017), Griscom and others (2017), IEA (2019, 2020), OECD (2019) and Wang (2015).

The poverty model assumes that income follows approximately a log-normal distribution. The cumulative density function of log income is calculated based on estimates of mean income and income inequality, and evaluated at the poverty benchmarks of USUS$1.90/day and $5.50/day. Income inequality is measured according to the after-tax Gini coefficient. It declines in response to a rise in government spending on social protection and education, or a rise in financial inclusion.

Carbon emissions depend on the composition of energy consumption, which in turn depends on the relative (after carbon tax) price of coal, gas, oil and renewables. Air pollution (PM2.5) also depends on the composition of energy consumption, especially the consumption of coal and oil. Emissions and air pollution also both depend on the number of tourists. Air pollution feeds into trend productivity growth to reflect the relationship between pollution, health and productivity.

ESCAP Macroeconomic Model equation listing

Consumer Price Index, Period Average, 2015 = 100 (HIC)

$$\Delta \, ln \, ln \, (HIC\square_t) = \beta_1 \Delta \, ln \, ln \, (HIC_{t-1}) \, + \beta_2 \Delta \, ln \, ln \, (MTD_t) \, + (1 - \beta_1 - \beta_2)\left(\frac{INFT_t}{100}\right) + \beta_3 \left(\frac{YER_t}{YFT_t} - \frac{YER_{t-1}}{YFT_{t-1}}\right) + \Delta \, ln \, ln \, (1 + ITAXR_t) \, + 0.5 * \Delta \, ln \, ln \left(1 + \frac{GCARB_t}{0.6 * YEN_{t-1}}\right) + \beta_4 \frac{PREM_t - PREM_{t-1}}{100}$$

MTD	Deflator for Imports of Goods and Services, National currency, 2015 = 100
INFT	Inflation target (not necessarily explicit)
YER	Gross Domestic Product (GDP), Constant 2015 prices, Billions National Currency
YFT	Trend output, Constant 2015 prices, Billions National Currency
ITAXR	Tax rate on goods and services
GCARB	General government net (after subsidies) carbon tax revenue, Billions National Currency
YEN	Gross Domestic Product (GDP), Current prices, Billions National Currency
PREM	Country-specific risk premium, basis points.

Deflator for GDP, National Currency, 2015 =100 (YED)

$$YED_t = YED_{t-1} * \frac{HIC_t}{HIC_{t-1}}$$

HIC	Consumer Price Index, Period Average, 2015 = 100

Monetary policy-related interest rate, percent per annum (INT)

$$INT_t \equiv INT_{t-1} + [INT_t^{USA} - INT_{t-1}^{USA}]$$

INT^{USA}	Monetary policy-related interest rate, percent per annum, USA

Long-term bond yield, per cent (LTI)

$$LTI_t \equiv LTI_{t-1} + \beta_1 * (INT_t - INT_{t-1}) + \frac{PREM_t - PREM_{t-1}}{100}$$

INT	Monetary percent per annum
PREM	Country-specific risk premium, basis points.

Country-specific risk premium, basis points. (PREM)

$$PREM_t = PREM_{t-1} * \left(1 + \beta_1 * \frac{GDNRATIO_{t-1} - GDNRATIO_{t-2}}{100}\right)$$

GDNRATIO	Gross government debt, % of GDP

Employment, 1000s (LNN)

$$\Delta\, ln\, ln\, (LNN_t) = \beta_1 \Delta\, ln\, ln\, (LFN_t) - \beta_2 * (ln\, ln\, (LNN_{t-1}) - ln\, ln\, (LFN_{t-1})) + \beta_3 * \Delta\, ln\, ln\, (YER_{t-1}) + \beta_4 * \Delta\, ln\, ln\, (ARRIVALS_t)$$

LFN	Labour Force, 1000s
YER	Gross Domestic Product (GDP), Constant 2015 prices, Billions National Currency
ARRIVALS	Inbound tourist arrivals, 1000s

Female employment, 1000s (LNNF)

$$\Delta\, ln\, ln\, (LNNF_t) = \Delta ln\, (LNN_t)$$

LNN	Employment, 1000s

Income tax rate (TAXR)

$$TAXR_t = TAXR_{t-1} + \beta_1 * \frac{GLNT_{t-1} - GLNRATIO_{t-1}}{100} * \frac{YEN_{t-1}}{RPDI_{t-1} * HIC_{t-1}} * SOLV_t$$

GLNT	General government fiscal balance target, % GDP
GLNRATIO	General government net lending (fiscal balance), % GDP
YEN	Gross Domestic Product (GDP), current prices, Billions National Currency

RPDI	Real personal disposable income, constant 2015 prices, Billions National Currency
HIC	Consumer Price Index, period average, 2015 = 100
SOLV	Solvency rule switch

Corporate tax rate (CTAXR)

$$CTAXR_t = CTAXR_{t-1} + \beta_1 * \frac{GLNT_{t-1} - GLNRATIO_{t-1}}{100} * \frac{YEN_{t-1}}{PROF_{t-1}} * SOLV_t$$

GLNT	General government fiscal balance target, % GDP
GLNRATIO	General government net lending (fiscal balance), % GDP
YEN	Gross Domestic Product (GDP), current prices, Billions National Currency
PROF	Profits, Billions National Currency
SOLV	Solvency rule switch

Other general government consumption expenditure, Billions National Currency (OGC)

$$OGC_t = OGC_{t-1} * \left(\frac{YFT_t}{YFT_{t-1}} * \frac{YED_t}{YED_{t-1}}\right)$$

YFT	Trend output, Constant 2015 prices, Billions National Currency
YED	Deflator for GDP, National Currency, 2015 =100

User cost of capital, per cent (USER)

$$USER_t = \frac{LTI_t - INFT_t + DEP_t * 100}{1 - CTAXR_t} + \beta_1 * \left(\frac{GCARB_t}{YEN_{t-1}}\right) * 100$$

LTI	Long-term bond yield, per cent
INFT	Inflation target (not necessarily explicit)
DEP	Depreciation rate of capital stock
CTAXR	Corporate tax rate

GCARB	General government net (after subsidies) carbon tax revenue, Billions National Currency
YEN	Gross Domestic Product (GDP), Current prices, Billions National Currency

Exports of goods and services, current prices, Billions National Currency (XTN)

$$XTN_t \equiv XTD\$_t * \frac{EXR_t}{EXR_{2015}} * XTR_t$$

XTD$	Deflator for Export of Goods and Services, US$, 2015 =100
EXR	Exchange rate (national currency / US$)
XTR	Exports of goods and services, constant 2015 prices, Billions National Currency

Gross Domestic Product (GDP), current prices, Billions National Currency (YEN)

$$YEN_t \equiv YER_t * YED_t$$

YER	Gross Domestic Product (GDP), Constant 2015 prices, Billions National Currency
YED	Deflator for GDP, National Currency, 2015 =100

Imports of goods and services, current prices, Billions National Currency (MTN)

$$MTN_t \equiv MTD_t * MTR_t$$

MTD	Deflator for Imports of Goods and Services, National currency, 2015 = 100
MTR	Imports of goods and services, Constant 2015 prices, Billions National Currency

Exports of goods and services, current prices, Billion US$ (XTN$)

$$XTN\$_t \equiv \frac{XTN_t}{EXR_t}$$

XTN	Exports of goods and services, current prices, Billions National Currency

EXR Exchange rate (national currency / US$)

Tourist arrivals (ARRIVALS)

$$ARRIVALS_t = ARRIVALS_{t-1} * 1.01$$

Gross Domestic Product (GDP), current prices, US$ billion (YEN$)

$$YEN\$_t \equiv \frac{YEN_t}{EXR_t}$$

YEN Gross Domestic Product (GDP), current prices, Billions National Currency

EXR Exchange rate (national currency / US$)

Imports of goods and services, current prices, US$ (MTN$)

$$MTN\$_t \equiv \frac{MTN_t}{EXR_t}$$

MTN Imports of goods and services, current prices, Billions National Currency

EXR Exchange rate (national currency / US$)

Imports of goods and services, constant 2015 prices, Billions (MTR$)

$$MTR\$_t \equiv MTR\$_{t-1} * \frac{MTR_t}{MTR_{t-1}}$$

MTR Imports of goods and services, constant 2015 prices, Billions National Currency

Exports of goods and services, constant 2015 prices, Billions US$ (XTR$)

$$XTR\$_t \equiv XTR\$_{t-1} * \frac{XTR_t}{XTR_{t-1}}$$

XTR Exports of goods and services, constant 2015 prices, Billions National Currency

Gross Domestic Product (GDP), constant 2015 prices, Billions US$ (YER$)

$$YER\$_t \equiv YER\$_{t-1} * \frac{YER_t}{YER_{t-1}}$$

YER Gross Domestic Product (GDP), constant 2015 prices, Billions National Currency

Trend output, constant 2015 prices, Billions US$ (YFT$)

$$YFT\$_t \equiv YFT\$_{t-1} * \frac{YFT_t}{YFT_{t-1}}$$

YFT Trend output, constant 2015 prices, Billions National Currency

Total population, 1000s (POPT)

$$POPT_t = POPT_{t-1} - LIVES_t$$

LIVES Lives lost from climate shocks

Population aged 15-64, 1000s (POPWA)

$$POPWA_t = POPWA_{t-1} * \frac{POPT_t}{POPT_{t-1}}$$

POPT Total population, 1000s

Accumulation of inventories, constant 2015 prices, Billions National Currency (SCR)

$$SCR_t = SCR_{t-1} + |SCR_{t-1}| * \left(\frac{YFT_{t-1}}{YER_{t-1}} - \frac{YFT_{t-2}}{YER_{t-2}}\right)$$

YFT Trend output, constant 2015 prices, Billions National Currency

YER	Gross Domestic Product (GDP), constant 2015 prices, Billions National Currency

Gross fixed capital formation (including acquisitions, less disposals of valuables), constant 2015 prices, Billions National Currency (ITR)

$$ITR_t \equiv IGR_t + IPR_t$$

IGR	Public gross fixed capital formation, constant 2015 prices, Billions National Currency
IPR	Private gross fixed capital formation, constant 2015 prices, Billions National Currency

Gross Domestic Product (GDP), constant 2015 prices, Billions National Currency (YER)

$$YER_t \equiv PCR_t + GCR_t + ITR_t + SCR_t + XTR_t - MTR_t$$

PCR	Household consumption expenditure (including non-profit institutions serving households), constant 2015 prices, Billions National Currency
GCR	General government final consumption expenditure, constant 2015 prices, Billions National Currency
ITR	Gross fixed capital formation (including acquisitions less disposals of valuables),constant 2015 prices, Billions National Currency
SCR	Accumulation of inventories, constant 2015 prices, Billions National Currency
XTR	Exports of goods and services, constant 2015 prices, Billions National Currency
MTR	Imports of goods and services, constant 2015 prices, Billions National Currency

Profits, Billions National Currency (PROF)

$$PROF_t \equiv (YEN_t - ITAX_t) * (1 - LABSH_t)$$

YEN	Gross Domestic Product (GDP), current prices, Billions National Currency
ITAX	General government taxes on goods and services, Billions National Currency
LABSH	Share of labour compensation in GDP at current national prices

Gross domestic income (terms of trade adjusted), constant 2015 prices, Billions National Currency (GDI)

$$GDI_t \equiv YER_t - XTR_t + MTR_t + \frac{XTN_t}{\frac{YEN_t - XTN_t + MTN_t}{YER_t - XTR_t + MTR_t}} - \frac{MTN_t}{\frac{YEN_t - XTN_t + MTN_t}{YER_t - XTR_t + MTR_t}}$$

YER	Gross Domestic Product (GDP), constant 2015 prices, Billions National Currency
XTR	Exports of goods and services, constant 2015 prices, Billions National Currency
MTR	Imports of goods and services, constant 2015 prices, Billions National Currency
YEN	Gross Domestic Product (GDP), current prices, Billions National Currency
XTN	Exports of goods and services, current prices, Billions National Currency
MTN	Imports of goods and services, current prices, Billions National Currency

Real personal disposable income, constant 2015 prices, Billions National Currency (RPDI)

$$RPDI_t \equiv LABSH_t * \beta_1 * (YER_{t-1} + GDI_{t-1}) * \frac{YED_{t-1}}{HIC_{t-1}} * \left(\frac{LNN_t}{LNN_{t-1}} + TECHL_t - TECHL_{t-1}\right) + \frac{REMIT_t}{HIC_t} + \frac{EXPSP_t}{HIC_t} - \frac{TAX_t}{HIC_t}$$

LABSH	Share of labour compensation in GDP at current national prices
YER	Gross Domestic Product (GDP), constant 2015 prices, Billions National Currency
GDI	Gross domestic income (terms of trade adjusted), constant 2015 prices, Billions National Currency
YED	Deflator for GDP, National Currency, 2015 =100
HIC	Consumer Price Index, period average, 2015 = 100
LNN	Employment, 1000s
TECHL	Labour augmenting technical progress trend, indexed to GDP per employee in 2015
REMIT	Inflow of personal remittances, Billions National Currency
EXPSP	General government expense on social benefits, Billions National Currency
TAX	General government taxes on income, profits, and capital gains, payable by individuals, plus social contributions, Billions National Currency

Trend output, constant 2015 prices, Billions National Currency (YFT)

$$\Delta\, ln\, ln\,(YFT_t) = (1 - ALPHA_t - LABSH_t) * \Delta\, ln\, ln\left(\frac{K_{t-1}}{LFN_{t-1}}\right) + (1 - ALPHA_t) * \Delta\, ln\, ln\,(LFN_t) + LABSH_t * \Delta(TECHL_t) + ALPHA_t * \left(\Delta\, ln\, ln\,(EC_t) + \Delta(EFF_t)\right) - \left(\frac{CLIMLOSS_t}{CLIMLOSS_{t-1}} - 1\right) * \left(\frac{DAMAGE_t}{100}\right)$$

ALPHA	Energy share of production costs
LABSH	Share of labour compensation in GDP at current national prices
K	Capital stock, constant 2015 prices, Billions National Currency
LFN	Labour Force, 1000s
TECHL	Labour augmenting technical progress trend, indexed to GDP per employee in 2015
EC	Primary energy consumption, Exojoules
EFF	Energy efficiency index
CLIMLOSS	Financial losses from climate shocks, constant prices, Billions National Currency
DAMAGE	Average annual damages from weather-related shocks, % GDP

Capital stock, constant 2015 prices, Billions National Currency (K)

$$K_t \equiv K_{t-1} * (1 - DEP_t) + ITR_t$$

DEP	Depreciation rate of capital stock
ITR	Gross fixed capital formation (including acquisitions less disposals of valuables),constant 2015 prices, Billions National Currency

Deflator for Imports of goods and services, National Currency, 2015 = 100 (MTD)

$$\Delta\, ln\, ln\,(MTD_t) = (1 - OMS_t) * (\Delta\, ln\, ln\,(CMUD_t) + \Delta\, ln\, ln\,(EXR_t)) + OMS_t * (\Delta\, ln\, ln\,(POIL_t^{WLD}) + \Delta\, ln\, ln\,(EXR_t))$$

OMS	Imports of petroleum, petroleum products and related materials as a share of Total Merchandise imports plus Total Services imports
CMUD	Non-oil import price, US$, 2015 = 1
EXR	Exchange rate (national currency / US$)
$POIL^{WLD}$	World oil price (US$ per barrel)

Deflator for export of good and services, US$, 2015 =100 (XTD$)

$$XTD\$_t = (1 - OXS_t) * \Delta\ ln\ ln\ (XTDNO\$_t)\ + OXS_t * \Delta\ ln\ ln\ (POIL_t^{WLD})\ +\ \beta_1 * \Delta\ ln\ ln\ (ARRIVALS_t)$$

OXS	Exports of petroleum, petroleum products and related materials as a share of Total Merchandise exports plus Total Services exports
XTDNO$	Non-oil export price deflator, US$, 2015 =100
$POIL^{WLD}$	World oil price ($ per barrel)
ARRIVALS	Inbound tourist arrivals, 1000s

Inflation target (not necessarily explicit) (INFT)

$$INFT_t = \beta_1 * INFT_{t-1} + (1 - \beta_1) * 2$$

Exports of petroleum, petroleum products and related materials as a share of Total Merchandise exports plus Total Services exports (OXS)

$$OXS_t = OXS_{t-1}$$

Imports of petroleum, petroleum products and related materials as a share of Total Merchandise imports plus Total Services imports (OMS)

$$OMS_t = OMS_{t-1} * \left(\frac{OILC_{t-1} * POIL_{t-1}^{WLD} * \frac{EXR_{t-1}}{MTN_{t-1}}}{OILC_{t-2} * POIL_{t-2}^{WLD} * \frac{EXR_{t-2}}{MTN_{t-2}}} \right)^{\beta_1}$$

OILC	Oil consumption, Exojoules
$POIL^{WLD}$	World oil price (US$ per barrel)
EXR	Exchange rate (national currency/US$)
MTN	Imports of goods and services, current prices, Billions National Currency

Exports of primary commodities, precious stones and non-monetary gold as a share of Total Merchandise exports plus Total Services exports (CXS)

$$CXS_t = CXS_{t-1}$$

Benchmark index for financial inclusion. (FINC)

$$FINC_t = FINC_{t-1}$$

Current Account Balance, US$ (CAN)

$$CAN_t \equiv \frac{XTN_t}{EXR_t} - \frac{MTN_t}{EXR_t} + \frac{REMIT_t}{EXR_t} + CANOTH_t$$

XTN	Exports of goods and services, current prices, Billions National Currency
MTN	Imports of goods and services, current prices, Billions National Currency
REMIT	Inflow of personal remittances, Billions National Currency
EXR	Exchange rate (national currency / US$)
CANOTH	Other items for current account, including net ODI and other grants, US$ billion

Derived as ratio of current account balance to nominal GDP in US$ (CANRATIO)

$$CANRATIO_t \equiv \frac{CAN_t}{YEN\$_t} * 100$$

CAN	Current Account balance, US$ billion
YEN$	Gross Domestic Product (GDP), Current prices, US$ billion

Other items for current account, including net ODI and other grants, US$ billion (CANOTH)

$$CANOTH_t = CANOTH_{t-1} + |CANOTH_{t-1}| * \left(\frac{YEN\$_t}{YEN\$_{t-1}} - 1\right) + \frac{REVG_t}{EXR_t} - \frac{REVG_{t-1}}{EXR_{t-1}}$$

YEN$	Gross Domestic Product (GDP), current prices, US$ billion
REVG	General government revenue, grants, Billions National Currency
EXR	Exchange rate (national currency/US$)

Effective exchange rate, 2015 = 1 (EFEX)

$$ln\ ln\ (EFEX_t) \equiv - ln\ ln \left(\frac{EXR_t}{EXR_{2015}}\right) + \sum_{i \in \{AFG, ARM \ldots\}} \beta_i * ln\ ln \left(\frac{EXR_t^i}{EXR_{2015}^i}\right)$$

EXR	Exchange rate (national currency /US$)
EXR^i	Exchange rate (national currency /US$), for country *i*

Real effective exchange rate, 2015 = 1 (REFEX)

$$ln\ ln\ (REFEX_t) \equiv - ln\ ln \left(\frac{\frac{EXR_t}{EXR_{2015}}}{\frac{HIC_t}{HIC_{2015}}}\right) + \sum_{i \in \{AFG, ARM \ldots\}} \beta_i * ln\ ln \left(\frac{\frac{EXR_t^i}{EXR_{2015}^i}}{\frac{HIC_t^i}{HIC_{2015}^i}}\right)$$

EXR	Exchange rate (national currency /US$)
EXR^i	Exchange rate (national currency /US$), for country *i*
HIC	Consumer Price Index, period average, 2015 = 100
HIC^i	Consumer Price Index, period average, 2015 = 100, for country *i*

Inflow of personal remittances, Billions National Currency (REMIT)

$$REMIT_t = \frac{REMIT_{t-1}}{EXR_{t-1}} * \left(\sum_{i \in \{AFG, ARM \ldots\}} \beta_i * \frac{YEN\$_t^i}{YEN\$_{t-1}^i}\right) * EXR_t$$

EXR	Exchange rate (national currency / US$)
YEN^i	Gross Domestic Product (GDP), current prices, US$ billion, for country *i*

General government average interest rate on outstanding debt (GINT)

$$GINT_t = GINT_{t-1} + \beta_1 * (LTI_t - LTI_{t-1})$$

LTI	Long-term bond yield, per cent

General government gross debt, Billions National Currency (GDN)

$$GDN_t = GDN_{t-1} * \left(GDFXSH_t * \left(\frac{EXR_t}{EXR_{t-1}} \right) + (1 - GDFXSH_t) \right) - GLN_t$$

GDFXSH	Foreign currency share of general government gross debt
EXR	Exchange rate (national currency / US$)
GLN	General government net lending (fiscal balance), Billions National Currency

Gross government debt, % of GDP (GDNRATIO)

$$GDNRATIO_t \equiv \frac{GDN_t}{YEN_t} * 100$$

GDN	General government gross debt, Billions National Currency
YEN	Gross Domestic Product (GDP), current prices, Billions National Currency

Foreign currency share of general government gross debt (GDFXSH)

$$GDFXSH_t = \frac{GDFXSH_{t-1} * \left(\frac{EXR_t}{EXR_{t-1}} \right)}{GDFXSH_{t-1} * \left(\frac{EXR_t}{EXR_{t-1}} \right) + 1 - GDFXSH_{t-1}}$$

EXR	Exchange rate (national currency / US$)

Change in stringency of measures introduced to contain the pandemic (LOCK)

$$LOCK_t = 0$$

General government net (after subsidies) carbon tax rate, expressed as US$ per tonne of CO_2 (GCARBR)

$$GCARBR_t = GCARBR_{t-1}$$

Tax rate on international trade and transactions (GTRADER)

$$GTRADER_t = GTRADER_{t-1}$$

Tax rate on goods and services (ITAXR)

$$ITAXR_t = ITAXR_{t-1}$$

General government revenue, Billions National Currency (REV)

$$REV_t \equiv TAX_t + CTAX_t + ITAX_t + GTRADE_t + REVG_t + GCARB_t + GCOM_t + GOTH_t$$

TAX	General government taxes on income, profits, and capital gains, payable by individuals, plus social contributions, Billions National Currency
CTAX	General government taxes on income, profits, and capital gains, payable by corporations, Billions National Currency
ITAX	General government taxes on goods and services, Billions National Currency
GTRADE	General government taxes on international trade and transactions, Billions National Currency
REVG	General government revenue, grants, Billions National Currency
GCARB	General government net (after subsidies) carbon tax revenue, Billions National Currency
GCOM	General government resource-related revenue, Billions National Currency
GOTH	Government other net revenue, Billions National Currency

General government taxes on income, profits, and capital gains, payable by individuals, plus social contributions, Billions National Currency (TAX)

$$TAX_t \equiv TAXR_t * \left(LABSH_t * \beta_1 * (YER_{t-1} + GDI_{t-1}) * YED_{t-1} * \left(\frac{LNN_t}{LNN_{t-1}} + TECHL_t - TECHL_{t-1}\right) + REMIT_t + EXPSP_t\right)$$

TAXR	Income tax rate
LABSH	Share of labour compensation in GDP at current national prices
YER	Gross Domestic Product (GDP), constant 2015 prices, Billions National Currency
GDI	Gross domestic income (terms of trade adjusted), constant 2015 prices, Billions National Currency
YED	Deflator for GDP, National Currency, 2015 =100
LNN	Employment, 1000s

TECHL	Labour augmenting technical progress trend, indexed to GDP per employee in 2015
REMIT	Inflow of personal remittances, Billions National Currency
EXPSP	General government expense on social benefits, Billions National Currency

General government taxes on income, profits, and capital gains, payable by corporations, Billions National Currency (CTAX)

$$CTAX_t \equiv CTAXR_t * PROF_t$$

CTAXR	Corporate tax rate
PROF	Profits, Billions National Currency

General government taxes on goods and services, Billions National Currency (ITAX)

$$ITAX_t \equiv ITAXR_t * \left(PCR_t * \frac{HIC_t}{HIC_{2015}}\right)$$

PCR	Household consumption expenditure (including Non-profit institutions serving households), Constant 2015 prices, Billions National Currency
HIC	Consumer Price Index, period average, 2015 = 100

General government taxes on international trade and transactions, Billions National Currency (GTRADE)

$$GTRADE_t \equiv GTRADER_t * XTN_t$$

GTRADER	Tax rate on international trade and transactions
XTN	Exports of goods and services, current prices, Billions National Currency

General government revenue, grants, Billions National Currency (REVG)

$$REVG_t = REVG_{t-1} * \left(\left(\sum_{i \in \{USA, DEU \ldots TWN\}} \beta_i * \frac{YEN\$_t^i}{YEN\$_{t-1}^i} \right) - \beta_1 * \left(\frac{\frac{YER\$_t}{POPT_t}}{\frac{YER\$_t^{WLD}}{POPT_t^{WLD}}} - \frac{\frac{YER\$_{t-1}}{POPT_{t-1}}}{\frac{YER\$_{t-1}^{WLD}}{POPT_{t-1}^{WLD}}} \right) \right) * \frac{EXR_t}{EXR_{t-1}}$$

YEN^{i}	Gross Domestic Product (GDP), current prices, US$ billion, for country *i*
YER$	Gross Domestic Product (GDP), constant 2015 prices, US$ billion
POPT	Total population, 1000s
YER^{WLD}	Gross Domestic Product (GDP), constant 2015 prices, US$ billion, World
POPT^{WLD}	Total population, 1000s, World

General government net (after subsidies) carbon tax revenue, Billions National Currency (GCARB)

$$GCARB_t \equiv GCARBR_t * CO2_t * \frac{EXR_t}{1000}$$

GCARBR	General government net (after subsidies) carbon tax rate, expressed as US$ per tonne of CO_2.
CO2	Territorial carbon dioxide remissions, $MtCO_2$
EXR	Exchange rate (national currency/US$)

General government resource-related revenue, Billions National Currency (GCOM)

$$GCOM_t = GCOM_{t-1} * \left(\frac{OILC_t}{OILC_t + GASC_t + COALC_t} * \frac{OILC_t^{WLD} * POIL_t^{WLD}}{OILC_{t-1}^{WLD} * POIL_{t-1}^{WLD}} + \frac{GASC_t}{OILC_t + GASC_t + COALC_t} * \frac{GASC_t^{WLD} * PG_t^{WLD}}{GASC_{t-1}^{WLD} * PG_{t-1}^{WLD}} + \frac{COALC_t}{OILC_t + GASC_t + COALC_t} * \frac{COALC_t^{WLD} * PC_t^{WLD}}{COALC_{t-1}^{WLD} * PC_{t-1}^{WLD}} \right)$$

OILC	Oil consumption, Exojoules
GASC	Natural gas consumption, Exojoules
COALC	Coal consumption, Exojoules
OILC^{WLD}	Oil consumption, Exojoules, World
POIL^{WLD}	World price of oil, inclusive of net carbon tax, US$ per Mn kJ
GASC^{WLD}	Natural gas consumption, Exojoules, World
PG^{WLD}	World price of natural gas, inclusive of net carbon tax, US$ per Mn kJ
COALC^{WLD}	Coal consumption, Exojoules, World
PC^{WLD}	World price of coal, inclusive of net carbon tax, US$ per Mn kJ

Government other net revenue, Billions National Currency (GOTH)

$$GOTH_t = GOTH_{t-1}$$

General government expenditure, Billions National Currency (EXP)

$$EXP_t \equiv EXPE_t + EXPH_t + EXPSP_t + OGC_t + OGI_t + GIP_t$$

EXPE	General government expenditure on environmental protection, Billions National Currency
EXPH	General government expenditure on health, Billions National Currency
EXPSP	General government expense on social benefits, Billions National Currency
OGC	Other general government consumption expenditure, Billions National Currency
OGI	Other general government investment expenditure, Billions National Currency
GIP	Gross government interest payments, Billions National Currency

General government expenditure on environmental protection, Billions National Currency (EXPE)

$$EXPE_t = EXPE_{t-1} * \left(\frac{YED_t}{YED_{t-1}}\right)$$

YED	Deflator for GDP, National Currency, 2015 =100

General government expenditure on health, Billions National Currency (EXPH)

$$EXPH_t = EXPH_{t-1} * \left(\frac{YED_t}{YED_{t-1}}\right)$$

YED	Deflator for GDP, National Currency, 2015 =100

General government expense on social benefits, Billions National Currency (EXPSP)

$$EXPSP_t = EXPSP_{t-1} * \left(\frac{YED_t}{YED_{t-1}}\right) * \frac{POPT_t - LNN_t}{POPT_{t-1} - LNN_{t-1}}$$

YED	Deflator for GDP, National Currency, 2015 =100
POPT	Total population, 1000s
LNN	Employment, 1000s

Other general government investment expenditure, Billions National Currency (OGI)

$$\Delta\, ln\, ln\, (OGI_t) = \Delta ln\, (YED_t)$$

YED	Deflator for GDP, National Currency, 2015 =100

General government final consumption expenditure, constant 2015 prices, Billions National Currency (GCR)

$$GCR_t = GCR_{t-1} + \left(\frac{OGC_t}{YED_t} - \frac{OGC_{t-1}}{YED_{t-1}}\right) + 0.5 * \left(\frac{EXPH_t}{YED_t} - \frac{EXPH_{t-1}}{YED_{t-1}}\right) + 0.5 * \left(\frac{EXPE_t}{YED_t} - \frac{EXPE_{t-1}}{YED_{t-1}}\right)$$

OGC	Other general government consumption expenditure, Billions National Currency
YED	Deflator for GDP, National Currency, 2015 =100
EXPH	General government expenditure on health, Billions National Currency
EXPE	General government expenditure on environmental protection, Billions National Currency

Public gross fixed capital formation, constant 2015 prices, Billions National Currency (IGR)

$$IGR_t = IGR_{t-1} + \left(\frac{OGI_t}{YED_t} - \frac{OGI_{t-1}}{YED_{t-1}}\right) + 0.5 * \left(\frac{EXPH_t}{YED_t} - \frac{EXPH_{t-1}}{YED_{t-1}}\right) + 0.5 * \left(\frac{EXPE_t}{YED_t} - \frac{EXPE_{t-1}}{YED_{t-1}}\right)$$

OGI	Other general government investment expenditure, Billions National Currency
YED	Deflator for GDP, National Currency, 2015 =100
EXPH	General government expenditure on health, Billions National Currency
EXPE	General government expenditure on environmental protection, Billions National Currency

Gross government interest payments, Billions National Currency (GIP)

$$GIP_t = \left(GIP_{t-1} + (GDN_{t-1} - GDN_{t-2}) * \frac{GINT_{t-1}}{100} + \frac{GDN_{t-6}}{5} * \left(\frac{GINT_{t-1}}{100} - \frac{GINT_{t-6}}{100} \right) \right) * \left(GDFXSH_t * \left(\frac{EXR_t}{EXR_{t-1}} \right) + (1 - GDFXSH_t) \right)$$

GDN	General government gross debt, Billions National Currency
GINT	General government average interest rate on outstanding debt
GDFXSH	Foreign currency share of general government gross debt
EXR	Exchange rate (national currency / US$)

General government net lending (fiscal balance), Billions National Currency (GLN)

$$GLN_t \equiv REV_t - EXP_t$$

REV	General government revenue, Billions National Currency
EXP	General government expenditure, Billions National Currency

General government net lending (fiscal balance), % GDP (GLNRATIO)

$$GLNRATIO_t \equiv \frac{GLN_t}{YEN_t} * 100$$

GLN	General government net lending (fiscal balance), Billions National Currency
YEN	Gross Domestic Product (GDP), Current prices, Billions National Currency

General government fiscal balance target, % GDP (GLNT)

$$GLNT_t = \beta_1 * GLNT_{t-1} + (1 - \beta_1) * (-2)$$

Trend TFP growth rate, expressed as log change (TFP)

$$TFP_t = LABSH_t * (TECHL_t - TECHL_{t-1})$$

LABSH	Share of labour compensation in GDP at current national prices
TECHL	Labour augmenting technical progress trend, indexed to GDP per employee in 2015

Share of labour compensation in GDP at current national prices (LABSH)

$$LABSH_t = LABSH_{t-1}$$

Labour Force, 1000s (LFN)

$$LFN_t \equiv LRX_t * POPWA_t$$

LRX	Participation ratio
POPWA	Population aged 15-64, 1000s

Participation ratio (LRX)

$$LRX_t = LRX_{t-1} + \beta_1 * ln\ ln\left(\frac{YER_{t-1}}{YFT_{t-1}}\right)$$

YER	Gross Domestic Product (GDP), constant 2015 prices, Billions National Currency
YFT	Trend output, Constant 2015 prices, Billions National Currency

Unemployment rate (ILO definition) (URX)

$$URX_t \equiv \left(1 - \frac{LNN_t}{LFN_t}\right) * 100$$

LNN	Employment, 1000s
LFN	Labour Force, 1000s

Female unemployment rate (ILO definition) (URXF)

$$URXF_t = URXF_{t-1} * \frac{URX_t}{URX_{t-1}} * \frac{\frac{LNN_t}{LNNF_t}}{\frac{LNN_{t-1}}{LNNF_{t-1}}}$$

URX	Unemployment rate (ILO definition)
LNN	Employment, 1000s
LNNF	Female employment, 1000s

Survey mean consumption or income per capita, total population (2011 PPP $ per day) (YBAR)

$$\Delta\ ln\ ln\ (YBAR_t)\ = \beta_1 * \Delta\ ln\ ln\ \left(\frac{PCR_t}{POPT_t}\right)$$

PCR	Household consumption expenditure (including non-profit institutions serving households), Constant 2015 prices, Billions National Currency
POPT	Total population, 1000s

Standard deviation of log income (SDLI)

$$SDLI_t = 2 * erf^{-1}[GINI\_DISP_t]$$

erf	Inverse error function (approximated with gamma quantile function)
GINI_DISP	Estimate of Gini index of inequality in equivalized household disposable (post-tax, post-transfer) income.

Poverty headcount ratio at $1.90 a day (2011 PPP) (% of population) (HEAD19)

$$HEAD19_t = HEAD19_{t-1} * \frac{\left[CDF_{LOGNORMAL}\left(\$1.90, ln(YBAR_t) - 0.5 * {SDLI_t}^2, SDLI_t\right)\right]}{\left[CDF_{LOGNORMAL}\left(\$1.90, ln(YBAR_{t-1}) - 0.5 * {SDLI_{t-1}}^2, SDLI_{t-1}\right)\right]}$$

$CDF_{LOGNORMAL}$	Log normal cumulative distribution, evaluated at $1.90
YBAR	Survey mean consumption or income per capita, total population (2011 PPP $ per day)
SDLI	Standard deviation of log income

Poverty headcount ratio at $5.50 a day (2011 PPP) (% of population) (HEAD55)

$$HEAD55_t = HEAD55_{t-1} * \frac{\left[CDF_{LOGNORMAL}\left(\$5.50, ln(YBAR_t) - 0.5 * {SDLI_t}^2, SDLI_t\right)\right]}{\left[CDF_{LOGNORMAL}\left(\$5.50, ln(YBAR_{t-1}) - 0.5 * {SDLI_{t-1}}^2, SDLI_{t-1}\right)\right]}$$

$CDF_{LOGNORMAL}$	Log normal cumulative distribution, evaluated at US$5.50
YBAR	Survey mean consumption or income per capita, total population (2011 PPP $ per day)
SDLI	Standard deviation of log income

Exports of goods and services, constant 2015 prices, Billions National Currency (XTR)

$$\Delta\, ln\, ln\,(XTR_t) = \Delta\, ln\, ln\,(WDR_t) + (1 - CXS_t) * \left(\beta_1 * \Delta\, ln\, ln\left(\frac{XTDNO\$_t}{CXUD_t}\right)\right) + \beta_2 * \Delta\, ln\, ln\,(ARRIVALS_t)$$

WDR	Trade-weighted external demand, constant 2015 prices, US$ billion
CXS	Exports of Primary commodities, precious stones and non-monetary gold as a share of Total Merchandise exports plus Total Services exports
XTDNO$	Non-oil export price deflator, US$, 2015 =100
CXUD	Global non-oil export price, US$, 2015 = 1
TOURSH	Travel and transport services exports as a share of nominal GDP
ARRIVALS	Inbound tourist arrivals, 1000s

Non-oil export price deflator, US$, 2015 =100 (XTDNO$)

$$XTDNO\$_t = XTDNO\$_{t-1} * \left[\beta_1 * \left\{\Delta ln\left(\frac{YED_{t-1}}{EXR_{t-1}}\right) + 1\right\} + (1-\beta_1) * \{\Delta ln(CXUD_{t-1}) + 1\}\right] * \frac{1 + GTRADER_t}{1 + GTRADER_{t-1}}$$

YED	Deflator for GDP, National Currency, 2015 =100
EXR	Exchange rate (national currency / US$)
CXUD	Global non-oil export price, US$, 2015 = 1
GTRADER	Tax rate on international trade and transactions

Labour augmenting technical progress trend, indexed to GDP per employee in 2015 (TECHL)

$$\Delta(TECHL_t) = \Delta(TECHL_t^{WLD}) + \beta_1 * \left(\frac{EXPH_{t-1}}{YEN_{t-1}}\right) - \beta_2 * \left(\frac{EXPH_{t-1}}{YEN_{t-1}}\right)^2 - \beta_3 * \Delta(GINI\_DISP_t) - \beta_4 * \Delta(PM25_t) - \beta_5 * PREM_t + \beta_6 * \Delta\left(\frac{XTR_{t-1} + MTR_{t-1}}{YER_{t-1}}\right)$$

$TECHL^{WLD}$	Labour augmenting technical progress trend, indexed to GDP per employee in 2015, World
EXPH	General government expenditure on health, Billions National Currency
YEN	Gross Domestic Product (GDP), current prices, Billions National Currency
EXPH	General government expenditure on health, Billions National Currency
GINI_DISP	Estimate of Gini index of inequality in equivalized household disposable (post-tax, post-transfer) income.
PM25	PM2.5 air pollution, mean annual exposure, micrograms per cubic metre
PREM	Country-specific risk premium, basis points.
XTR	Exports of goods and services, constant 2015 prices, Billions National Currency
MTR	Imports of goods and services, constant 2015 prices, Billions National Currency
YER	Gross Domestic Product (GDP), constant 2015 prices, Billions National Currency

Relative redistribution parameter (percentage difference between Gini Coefficients measures in terms of gross and disposable income) (REL_RED)

$$REL\_RED_t = \beta_0 + \beta_1 * \left(\frac{EXPSP_t}{YEN_t}\right)$$

EXPSP	General government expense on social benefits, Billions National Currency
YEN	Gross Domestic Product (GDP), current prices, Billions National Currency

Estimate of Gini index of inequality in equivalized household disposable (post-tax, post-transfer) income. (GINI_DISP)

$$\Delta\, ln\, ln\, (GINI\_DISP_t) = \beta_1 * \Delta\, ln\, ln\, \left(1 - \frac{REL\_RED_t}{100}\right) + \beta_2 * (FINC_t - FINC_{t-1})$$

REL_RED	Relative redistribution parameter (percentage difference between Gini Coefficients measures in terms of gross and disposable income)
FINC	Benchmark index for financial inclusion.

Household consumption expenditure (including non-profit institutions serving households), constant 2015 prices, Billions National Currency (PCR)

$$\begin{aligned}\Delta\, ln\, ln\, (PCR_t) &= \beta_0 + \beta_1 * \left(ln\, ln\, (PCR_{t-1}) - ln\, ln\, (RPDI_{t-1}) - \beta_2 * (FINC_{t-1})\right) + \beta_3 * \Delta\, ln\, ln\, (RPDI_t) \\ &+ (1 - \beta_3) * \Delta\, ln\, ln\, (POPT_t) + \beta_4 * \left(\Delta\, ln\, ln\, (HIC_t) - \frac{INFT_t}{100}\right) - \beta_5 * \frac{LOCK_t}{100} - \beta_5 * \beta_6 \\ &* \frac{LOCK_{t-1}}{100} + \beta_7 * (ln\, ln\, (YFT_{t-1}) - ln\, ln\, (YER_{t-1}))\end{aligned}$$

RPDI	Real personal disposable income, constant 2015 prices, Billions National Currency
FINC	Benchmark index for financial inclusion.
POPT	Total population, 1000s
HIC	Consumer Price Index, period average, 2015 = 100
INFT	Inflation target (not necessarily explicit)
LOCK	Change in stringency of measures introduced to contain the pandemic
YFT	Trend output, constant 2015 prices, Billions National Currency
YER	Gross Domestic Product (GDP), constant 2015 prices, Billions National Currency

Private gross fixed capital formation, constant 2015 prices, Billions National Currency (IPR)

$$\Delta\, ln\, ln\,(IPR_t) = \beta_0 - \beta_1 * \left(ln\, ln\left(\frac{IPR_{t-1}}{YFT_{t-1}}\right) + \beta_2 * USER_{t-1} - \beta_3 * FINC_{t-1}\right) + \beta_4 * \Delta$$
$$ln\, ln\left(PCR_t + GCR_{t-1} + IGR_{t-1} + \frac{XTN_t}{YED_t}\right) + \beta_5 * \Delta\, ln\, ln\,(IPR_{t-1}) - \beta_6$$
$$* (USER_t - USER_{t-1}) - \left(\beta_7 * TOURSH + \beta_8 * (1 - FUELSH - TOURSH)\right) * \frac{LOCK_t}{100} - \beta_9$$
$$* \left(\beta_7 * TOURSH + \beta_8 * (1 - FUELSH - TOURSH)\right) * \frac{LOCK_{t-1}}{100} + \beta_{10}$$
$$* (ln\, ln\,(YFT_{t-1}) - ln\, ln\,(YER_{t-1}))$$

YFT	Trend output, constant 2015 prices, Billions National Currency
USER	User cost of capital, per cent
FINC	Benchmark index for financial inclusion.
PCR	Household consumption expenditure (including non-profit institutions serving households), constant 2015 prices, Billions National Currency
GCR	General government final consumption expenditure, constant 2015 prices, Billions National Currency
IGR	Public gross fixed capital formation, constant 2015 prices, Billions National Currency
XTN	Exports of goods and services, current prices, Billions National Currency
YED	Deflator for GDP, National Currency, 2015 =100
IPR	Private gross fixed capital formation, constant 2015 prices, Billions National Currency
FUELSH	Fuel exports (SITC 3) as a share of nominal GDP
TOURSH	Travel and transport services exports as a share of nominal GDP
LOCK	Change in stringency of measures introduced to contain the pandemic
YER	Gross Domestic Product (GDP), constant 2015 prices, Billions National Currency

Imports of goods and services, constant 2015 prices, Billions National Currency (MTR)

$$\Delta\, ln\, ln\,(MTR_t)$$
$$= \beta_0 - \beta_1$$
$$* \left(ln\, ln\,(MTR_{t-1}) - ln\, ln\,(PCR_{t-1} + ITR_{t-1} + GCR_{t-1} + XTR_{t-1}) + ln\, ln\left(\frac{YFT_{t-1}}{YER_{t-1}}\right) + \beta_2\right.$$
$$\left. * ln\, ln\left(CMUD_{t-1} * \frac{EXR_{t-1}}{YED_{t-1}}\right) - \beta_3 * OMS_t * ln\, ln\,(OILC_{t-1})\right) + \beta_4 * \Delta\, ln\, ln\,(XTR_t) + \beta_5$$
$$* \Delta ln\,(PCR_t) + \beta_6 * \Delta ln\,(IPR_t) + \beta_7 * \Delta ln\,(GCR_t + IGR_t)$$

PCR	Household consumption expenditure (including non-profit institutions serving households), Constant 2015 prices, Billions National Currency
ITR	Gross fixed capital formation (including Acquisitions less disposals of valuables), constant 2015 prices, Billions National Currency
GCR	General government final consumption expenditure, constant 2015 prices, Billions National Currency
XTR	Exports of goods and services, constant 2015 prices, Billions National Currency
YFT	Trend output, Constant 2015 prices, Billions National Currency
YER	Gross Domestic Product (GDP), constant 2015 prices, Billions National Currency
CMUD	Non-oil import price, US$, 2015 = 1
EXR	Exchange rate (national currency / US$)
YED	Deflator for GDP, National Currency, 2015 =100
OMS	Imports of petroleum, petroleum products and related materials as a share of Total Merchandise imports plus Total Services imports
OILC	Oil consumption, Exojoules
IPR	Private gross fixed capital formation, constant 2015 prices, Billions National Currency
IGR	Public gross fixed capital formation, constant 2015 prices, Billions National Currency

Territorial carbon dioxide emissions, $MtCO_2$ (CO_2)

$$\Delta ln(CO2_t) = \Delta ln(\beta_1 * COALC_t + \beta_2 * GASC_t + \beta_3 * OILC_t) - \beta_4 * [ln(CO2_{t-1}) - ln(\beta_1 * COALC_{t-1} + \beta_2 * GASC_{t-1} + \beta_3 * OILC_{t-1})] + \beta_4 * \Delta ln(ARRIVALS_t)$$

COALC	Coal consumption, Exojoules
GASC	Natural gas consumption, Exojoules
OILC	Oil consumption, Exojoules
ARRIVALS	Inbound tourist arrivals, 1000s

Domestic price of oil, inclusive of net carbon tax, US$ per Mn kJ (POIL)

$$POIL_t = POIL_{t-1} * \frac{POIL_t^{WLD}}{POIL_{t-1}^{WLD}} + \beta_1 * (GCARBR_t - GCARBR_{t-1})$$

$POIL^{WLD}$	World price of oil, inclusive of net carbon tax, US$ per Mn kJ
GCARBR	General government net (after subsidies) carbon tax rate, expressed as US$ per tonne of CO_2.

Domestic price of natural gas, inclusive of net carbon tax, US$ per Mn kJ (PG)

$$PG_t = PG_{t-1} * \frac{PG_t^{WLD}}{PG_{t-1}^{WLD}} + \beta_1 * (GCARBR_t - GCARBR_{t-1})$$

PG^{WLD}	World price of natural gas, inclusive of net carbon tax, US$ per Mn kJ
GCARBR	General government net (after subsidies) carbon tax rate, expressed as US$ per tonne of CO_2.

Domestic price of coal, inclusive of net carbon tax, US$ per Mn kJ (PC)

$$PC_t = PC_{t-1} * \frac{PC_t^{WLD}}{PC_{t-1}^{WLD}} + \beta_1 * (GCARBR_t - GCARBR_{t-1})$$

PC^{WLD}	World price of coal, inclusive of net carbon tax, US$ per Mn kJ
GCARBR	General government net (after subsidies) carbon tax rate, expressed as US$ per tonne of CO_2.

Domestic price of renewable energy, US$ per Mn kJ (PR)

$$\Delta\, ln\, ln\, (PR_t) = \Delta\, ln\, ln\, (PR_t^{WLD})$$

PR^{WLD}	World price of renewable energy, US$ per Mn kJ

Domestic price of energy, inclusive of net carbon tax, US$ per Mn kJ (PE)

$$PE_t = PE_{t-1} * \left(\frac{OILC_{t-1}}{OILC_{t-1} + COALC_{t-1} + GASC_{t-1} + RC_{t-1}} * \frac{POIL_t}{POIL_{t-1}} + \frac{GASC_{t-1}}{OILC_{t-1} + COALC_{t-1} + GASC_{t-1} + RC_{t-1}} * \frac{PG_t}{PG_{t-1}} + \frac{COALC_{t-1}}{OILC_{t-1} + COALC_{t-1} + GASC_{t-1} + RC_{t-1}} * \frac{PC_t}{PC_{t-1}} + \frac{RC_{t-1}}{OILC_{t-1} + COALC_{t-1} + GASC_{t-1} + RC_{t-1}} * \frac{PR_t}{PR_{t-1}} \right)$$

OILC	Oil consumption, Exojoules
COALC	Coal consumption, Exojoules
GASC	Natural gas consumption, Exojoules
RC	Consumption of non-fossil fuel energy (nuclear, hydro and renewables), Exojoules
POIL	Domestic price of oil, inclusive of net carbon tax, US$ per Mn kJ
PG	Domestic price of natural gas, inclusive of net carbon tax, US$ per Mn kJ
PC	Domestic price of coal, inclusive of net carbon tax, US$ per Mn kJ
PR	Domestic price of renewable energy, US$ per Mn kJ

Depreciation rate of capital stock (DEP)

$$\Delta(DEP_t) = \beta_1 * \Delta \, ln \, ln \, (CO2_t^{WLD})$$

$CO2^{WLD}$	World carbon dioxide emissions, $MtCO_2$

PM2.5 air pollution, mean annual exposure, micrograms per cubic metre (PM25)

$$\Delta \, ln \, ln \, (PM25_t) = \beta_1 * \left(\frac{COALC_{t-1}}{EC_{t-1}} - \frac{COALC_{t-2}}{EC_{t-2}} \right) + \beta_2 * \left(\frac{COALC_{t-2}}{EC_{t-2}} - \frac{COALC_{t-3}}{EC_{t-3}} \right) + \beta_3 * \left(\frac{OILC_{t-1}}{EC_{t-1}} - \frac{OILC_{t-2}}{EC_{t-2}} \right) + \beta_4 * \left(\frac{OILC_{t-2}}{EC_{t-2}} - \frac{OILC_{t-3}}{EC_{t-3}} \right) + \beta_5 * \Delta \, ln \, ln \, (ARRIVALS_t)$$

COALC	Coal consumption, Exojoules
EC	Primary energy consumption, Exojoules
OILC	Oil consumption, Exojoules
ARRIVALS	Inbound tourist arrivals, 1000s

Primary energy consumption, Exojoules (EC)

$$\Delta\, ln\, ln\,(EC_t) = \beta_1 * \Delta\, ln\, ln\,(YER_t) + \beta_2 * \Delta\, ln\, ln\,(YER_{t-1}) + \beta_3 * \Delta\, ln\, ln\,(YER_{t-2}) + \beta_4 * \Delta\, ln\, ln\,(YER_{t-3}) - \beta_5 * \beta_1 * \Delta\, ln\, ln\left(PE_t * \frac{EXR_t}{HIC_t}\right) - \beta_5 * \beta_2 * \Delta\, ln\, ln\left(PE_{t-1} * \frac{EXR_{t-1}}{HIC_{t-1}}\right) - \beta_5 * \beta_3 * \Delta\, ln\, ln\left(PE_{t-2} * \frac{EXR_{t-2}}{HIC_{t-2}}\right) - \beta_5 * \beta_4 * \Delta\, ln\, ln\left(PE_{t-3} * \frac{EXR_{t-3}}{HIC_{t-3}}\right) - (EFF_t - EFF_{t-1})$$

YER Gross Domestic Product (GDP), constant 2015 prices, Billions National Currency

PE Domestic price of energy, inclusive of net carbon tax, US$ per Mn kJ

EXR Exchange rate (national currency/US$)

HIC Consumer Price Index, Period Average, 2015 = 100

EFF Energy efficiency index

Coal consumption, Exojoules (COALC)

$$\Delta\, ln\, ln\,(COALC_t) = \Delta\, ln\, ln\,(EC_{t-1}) - \beta_1 * \left(ln\, ln\left(\frac{COALC_{t-1}}{EC_{t-1}}\right) - ln\, ln\left(\frac{PE_{t-1}}{PC_{t-1}}\right)\right)$$

EC Primary energy consumption, Exojoules

PE Domestic price of energy, inclusive of net carbon tax, US$ per Mn kJ

PC Domestic price of coal, inclusive of net carbon tax, US$ per Mn kJ

Natural gas consumption, Exojoules (GASC)

$$\Delta\, ln\, ln\,(GASC_t) = \Delta\, ln\, ln\,(EC_{t-1}) - \beta_1 * \left(ln\, ln\left(\frac{GASC_{t-1}}{EC_{t-1}}\right) - ln\, ln\left(\frac{PE_{t-1}}{PG_{t-1}}\right)\right)$$

EC Primary energy consumption, Exojoules

PE Domestic price of energy, inclusive of net carbon tax, US$ per Mn kJ

PG Domestic price of natural gas, inclusive of net carbon tax, US$ per Mn kJ

Consumption of non-fossil fuel energy (nuclear, hydro and renewables), Exojoules (RC)

$$RC_t = EC_t - COALC_t - GASC_t - OILC_t$$

EC	Primary energy consumption, Exojoules
COALC	Coal consumption, Exojoules
GASC	Natural gas consumption, Exojoules
OILC	Oil consumption, Exojoules

Oil consumption, Exojoules (OILC)

$$\Delta\, ln\, ln\, (OILC_t) = \Delta\, ln\, ln\, (EC_{t-1}) - \beta_1 * \left(ln\, ln \left(\frac{OILC_{t-1}}{EC_{t-1}}\right) - ln\, ln \left(\frac{PE_{t-1}}{POIL_{t-1}}\right)\right)$$

EC	Primary energy consumption, Exojoules
PE	Domestic price of energy, inclusive of net carbon tax, US$ per Mn kJ
POIL	Domestic price of oil, inclusive of net carbon tax, US$ per Mn kJ

Exchange rate (national currency / US$) (EXR)

$$EXR_t = EXR_{t-1} * \left(\frac{EXR_t^{IND}}{EXR_{t-1}^{IND}}\right)$$

EXR^{IND}	India's exchange rate to US$

Non-oil import price, US$, 2015 = 1 (CMUD)

$$CMUD_t = \sum_{i \in \{AFG, ARM \ldots\}} \beta_i * XTDNO\$_t^i$$

$XTDNO\$^i$	Non-oil export price deflator, US$, 2015 =100, for country *i*

Global non-oil export price, US$, 2015 = 1 (CXUD)

$$CXUD_t = \sum_{i \in \{AFG, ARM \ldots\}} \beta_i * XTDNO\$_t^i$$

XTDNO^i Non-oil export price deflator, US$, 2015 =100, for country *i*

Trade-weighted external demand, Constant 2015 prices, US$ billion (WDR)

$$WDR_t = \sum_{i \in \{AFG, ARM \ldots\}} \beta_i * MTR\$_t^i$$

MTR^i Imports of goods and services, Constant 2015 prices, US$ billion, for country *i*

List of variables and data sources

Variable	Definition	Data source
ALPHA	Energy share of production costs (constant)	Derived from energy consumption and GDP
ARRIVALS	Inbound tourist arrivals, 1000s	UNWTO
CAN	Current Account Balance, US$ billion	IMF WEO Extended Database
CANOTH	Other items for current account, including net ODI and other grants, US$ billion	Derived as residual on current account balance.
CANRATIO	Derived as ratio of current account balance to nominal GDP in US$	Derived as ratio of current account balance to nominal GDP in US$
CLIMLOSS	Financial losses from climate shocks, Constant prices, Billions National Currency (exogenous)	Derived from EM-DAT
CMUD	Non-oil import price, US$, 2015 = 1	Trade-weighted average of global export prices, with weights based on share of NPLs imports. See matrix_equations.prg for details.
CO_2	Territorial c, Hoong Kong Electric carbon dioxide emissions, $MtCO_2$	Global Carbon Project, Gilfillan et al. (2019), UNFCCC (2019), BP (2019)
COALC	Coal consumption, Exojoules	bp Statistical Review of World Energy. Missing values estimated based on CO_2 emissions from coal from Global Carbon Project.

CTAX	General government taxes on income, profits, and capital gains, payable by corporations, Billions National Currency	IMF WEO Extended Database. Missing values filled from IMF Government Finance Statistics Revenue database where available. Where unavailable, Asia-Pacific average revenue shares are applied to total revenue.
CTAXR	Corporate tax rate	Derived as corporate tax revenue as a share of profits
CXS	Exports of Primary commodities, precious stones and non-monetary gold as a share of Total Merchandise exports plus Total Services exports	UNCTAD
CXUD	Global non-oil export price, US$, 2015 = 1	Trade-weighted average of global export prices, with weights based on share of global exports. See matrix_equations.prg for details.
DAMAGE	Average annual damages from weather-related shocks, % GDP (exogenous)	Derived from EM-DAT
DEP	Depreciation rate of capital stock	Derived as Asia-Pacific average
EC	Primary energy consumption, Exojoules	bp Statistical Review of World Energy. Missing values derived as sum of coal, oil, gas and renewable consumption.NPL_EXR.LABEL(D) Exchange rate (national currency / US$)
EFEX	Effective exchange rate, 2015 = 1	Trade-weighted average of global exchange rates, with weights based on bilateral trade as a share of reporting country total trade. See matrix_equations.prg for details.
EFF	Energy efficiency index (exogenous)	Derived from panel estimation
EXP	General government expenditure, Billions National Currency	Derived from general government revenue and general government net lending
EXPE	General government expenditure on environmental protection, Billions National Currency	IMF Government Finance Statistics, Expenditure by Functions of Government Database. Missing values estimated from Asia-Pacific average expenditure share.
EXPH	General government expenditure on health, Billions National Currency	IMF Government Finance Statistics, Expenditure by Functions of Government Database. Missing values estimated from Asia-Pacific average expenditure share.

EXPSP	General government expense on social benefits, Billions National Currency	IMF WEO Extended Database. Missing values estimate from IMF Government Finance Statistics, Expenditure by Functions of Government Database where available. Where unavailable estimated with Asia-Pacific average expenditure share.
EXR	Exchange rate (national currency/US$)	Derived as ratio of GDP in current domestic prices to GDP in current US$
FINC	Benchmark index for financial inclusion.	World Bank WDI Database. Account ownership at a financial institution or with a mobile-money-service provider (% of population ages 15+). Missing values filled with Asia-Pacific regional averages.
FUELSH	Fuel exports (SITC 3) as a share of nominal GDP (constant)	Derived from 2018 benchmark fuel exports from ESCAP Excel Model, which is sourced from UNCTADStat, Trade structure by partner, product or service category.
GASC	Natural gas consumption, Exojoules	bp Statistical Review of World Energy. Missing values estimated based on CO_2 emissions from gasoline from Global Carbon Project.
GCARB	General government net (after subsidies) carbon tax revenue, Billions National Currency	Gross carbon tax revenue assumed zero to 2019. Gross subsidies from IEA fossil fuel subsidies database. Missing values treated as zero subsidies.
GCARBR	General government net (after subsidies) carbon tax rate, expressed as US$ per tonne of CO_2.	Estimated as net carbon tax revenue as a share of CO_2 emissions.
GCOM	General government resource-related revenue, Billions National Currency	Derived from Resource revenue share from ESCAP Excel Model, which is based on IMF WEO Extended Database and National Resource Governance Institute.
GCR	General government final consumption expenditure, Constant 2015 prices, Billions National Currency	United Nations Statistics Division National Accounts Main Aggregates Database
GDFXSH	Foreign currency share of general government gross debt	Derived from IMF WEO Extended Database. Missing values filled from FX share applied in ESCAP Excel Model, which was derived from

		World Bank Database of Fiscal Space or Asia-Pacific regional average.
GDI	Gross domestic income (terms of trade adjusted), Constant 2015 prices, Billions National Currency	Derived by revaluing exports and imports in GDP with a domestic demand deflator
GDN	General government gross debt, Billions National Currency	IMF WEO Extended Database
GDNRATIO	Gross government debt, % of GDP	Derived from Gross government debt and nominal GDP
GINI_DISP	Estimate of Gini index of inequality in equivalized household disposable (post-tax, post-transfer) income.	Standardized World Income Inequality Database (SWIID).
GINT	General government average interest rate on outstanding debt	Ratio of government interest payments to government debt. Missing values set to Asia-Pacific regional average.
GIP	Gross government interest payments, Billions National Currency	IMF WEO Extended Database. Missing values estimated by applying Asia-Pacific regional average interest rate to government debt.
GLN	General government net lending (fiscal balance), Billions National Currency	IMF WEO Extended Database.
GLNRATIO	General government net lending (fiscal balance), % GDP	Derived as ratio of fiscal balance to nominal GDP
GLNT	General government fiscal balance target, % GDP	Baseline set to historical deficit ratio, converging gradually to 2% of GDP
GOTH	Government other net revenue, Billions National Currency	Derived as residual on fiscal balance.
GTRADE	General government taxes on international trade and transactions, Billions National Currency	IMF WEO Extended Database. Missing values estimate from IMF Government Finance Statistics, Revenue Database where available. Where unavailable estimated with Asia-Pacific average revenue share.
GTRADER	Tax rate on international trade and transactions	Derived as ratio of tax on international trade and transactions to nominal exports
HEAD19	Poverty headcount ratio at U$1.90 a day (2011 PPP) (% of population)	World Bank WDI Database. Missing values filled by interpolation and via assumption of lognormality for a given mean income and Gini coefficient.

HEAD55	Poverty headcount ratio at US$5.50 a day (2011 PPP) (% of population)	World Bank WDI Database. Missing values filled by interpolation and via assumption of lognormality for a given mean income and Gini coefficient.
HIC	Consumer Price Index, Period Average, 2015 = 100	IMF WEO Extended Database.
IGR	Public gross fixed capital formation, Constant 2015 prices, Billions National Currency	Based on investment shares from IMF WEO Extended Database. Where unavailable, based on IMF Investment and Capital Stock Database. Missing values estimated with Asia-Pacific regional average share of total investment.
INFT	Inflation target (not necessarily explicit)	Recent values from Central Bank News. Historical information from Jahan, Inflation Targeting: Holding the Line. For countries without an explicit inflation target, estimated based on trend inflation.
INT	Monetary Policy-Related Interest Rate, Percent per annum	IMF International Financial Statistics. Missing values filled with IMF WEO Extended Database Short-term interest rate, or maintaining differential against the US in long-term interest rates.
IPR	Private gross fixed capital formation, Constant 2015 prices, Billions National Currency	Based on investment shares from IMF WEO Extended Database. Where unavailable, based on IMF Investment and Capital Stock Database. Missing values estimated with Asia-Pacific regional average share of total investment.
ITAX	General government taxes on goods and services, Billions National Currency	IMF WEO Extended Database. Missing values estimate from IMF Government Finance Statistics, Revenue Database where available. Where unavailable estimated with Asia-Pacific average revenue share.
ITAXR	Tax rate on goods and services	Derived as ratio of tax on goods and services to nominal consumption
ITR	Gross fixed capital formation (including Acquisitions less disposals of valuables), constant 2015 prices, Billions National Currency	United Nations Statistics Division National Accounts Main Aggregates Database

K	Capital stock, constant 2015 prices, Billions National Currency	Derived as accumulation of investment from 1970, applying Asia-Pacific average rate of depreciation
LABSH	Share of labour compensation in GDP at current national prices	Penn World Tables
LFN	Labour Force, 1000s	Derived from total employment and unemployment rate
LIVES	Lives lost from climate shocks (exogenous)	Derived from EM-DAT
LNN	Employment, 1000s	ILO Modelled Estimates
LNNF	Female employment, 1000s	ILO Modelled Estimates
LOCK	Change in stringency of measures introduced to contain the pandemic	From ESCAP Excel Model, which is sourced from Oxford COVID-19 Government Response Tracker
LRX	Participation ratio	Derived as ratio of labour force to working age population
LTI	Long-term bond yield, per cent	IMF WEO Extended Database. Missing values estimated from IMF International Financial Statistics Government Bonds rate or Lending rate, or as the country-specific risk premium mark-up over US rates.
MTD	Deflator for Imports of Goods and Services, National currency, 2015 = 100	Derived as the ratio of current price imports in domestic currency to constant price imports in domestic currency
MTN	Imports of goods and services, Current prices, Billions National Currency	United Nations Statistics Division National Accounts Main Aggregates Database
MTN$	Imports of goods and services, Current prices, US$	Derived as imports in domestic currency adjusted by exchange rate.
MTR	Imports of goods and services, Constant 2015 prices, Billions National Currency	United Nations Statistics Division National Accounts Main Aggregates Database
MTR$	Imports of goods and services, Constant 2015 prices, US$ billion	United Nations Statistics Division National Accounts Main Aggregates Database
OGC	Other general government consumption expenditure, Billions National Currency	Derived as government consumption in current prices less a share of expenditure on health and environmental protection

OGI	Other general government investment expenditure, Billions National Currency	Derived as government investment in current prices less a share of expenditure on health and environmental protection
OILC	Oil consumption, Exojoules	bp Statistical Review of World Energy. Missing values estimated based on CO_2 emissions from oil and gas flaring from Global Carbon Project.
OMS	Imports of petroleum, petroleum products and related materials as a share of Total Merchandise imports plus Total Services imports	UNCTAD
OXS	Exports of Petroleum, petroleum products and related materials as a share of Total Merchandise exports plus Total Services exports	UNCTAD
PC	Domestic price of coal, inclusive of net carbon tax, US$ per Mn kJ	Global coal price per metric ton converted to Mn kJ, plus net carbon tax times carbon per Mn kJ of coal
PCR	Household consumption expenditure (including Non-profit institutions serving households), constant 2015 prices, Billions National Currency	United Nations Statistics Division National Accounts Main Aggregates Database
PE	Domestic price of energy, inclusive of net carbon tax, US$ per Mn kJ	Derived as weighted average of domestic oil, gas, coal and renewable prices. Weights based on consumption shares.
PG	Domestic price of natural gas, inclusive of net carbon tax, US$ per Mn kJ	Global gas price per Mn BTU converted to Mn kJ, plus net carbon tax times carbon per Mn kJ of gas
PM25	PM2.5 air pollution, mean annual exposure, micrograms per cubic meter	World Bank WDI Database. Missing values filled by interpolation.
POIL	Domestic price of oil, inclusive of net carbon tax, US$ per Mn kJ	Global oil price per barrel converted to Mn kJ, plus net carbon tax times carbon per Mn kJ of oil
POPT	Total population, 1000s	United Nations Population Division, World Population Prospects
POPWA	Population aged 15-64, 1000s	United Nations Population Division, World Population Prospects

PR	Domestic price of renewable energy, US$ per Mn kJ	Global average renewable price per kWh converted to Mn kJ
PREM	Country-specific risk premium, basis points.	Derived from Moody's credit ratings, following methodology of Aswath Damodaran. Missing values benchmarked from lending spreads or government bond spreads relative to the US.
PROF	Profits, Billions National Currency	Derived as the non-labour share of nominal GDP less indirect taxes, less depreciation
RC	Consumption of non-fossil fuel energy (nuclear, hydro and renewables), Exojoules	derived from bp Statistical Review of World Energy. Missing values estimated from World Bank WDI series: Renewable energy consumption (% of total final energy consumption)
REFEX	Real effective exchange rate, 2015 = 1	Trade-weighted average of global exchange rates deflated by consumer prices, with weights based on bilateral trade as a share of reporting country total trade. See matrix_equations.prg for details.
REL_RED	Relative redistribution parameter (percentage difference between Gini Coefficients measures in terms of gross and disposable income)	Standardized World Income Inequality Database (SWIID).
REMIT	Inflow of personal remittances, Billions National Currency	Derived from World Bank WDI Database, Personal remittances, received (% of GDP). Missing values set to zero.
REV	General government revenue, Billions National Currency	IMF WEO Extended Database.
REVG	General government revenue, grants, Billions National Currency	IMF WEO Extended Database. Missing values filled from IMF Government Finance Statistics Revenue database where available. Where unavailable, Asia-Pacific average revenue shares are applied to total revenue.
RPDI	Real personal disposable income, constant 2015 prices, Billions National Currency	Derived to reflect developments in labour compensation, remittances, social protection spending and income tax
SCR	Accumulation of inventories, constant 2015 prices, Billions National Currency	Derived as residual on national accounts

SDLI	Standard deviation of log income	Derived from Gini coefficient, based on assumption that income approximately follows a lognormal distribution
SOLV	Solvency rule switch (exogenous)	Set to 1 to impose solvency
TAX	General government taxes on income, profits, and capital gains, payable by individuals, plus social contributions, Billions National Currency	IMF WEO Extended Database. Missing values filled from IMF Government Finance Statistics Revenue database where available. Where unavailable, Asia-Pacific average revenue shares are applied to total revenue.
TAXR	Income tax rate	Derived as income tax revenue as a share of income
TECHL	Labour augmenting technical progress trend, indexed to GDP per employee in 2015	Derived from decomposition of capacity output growth
TFP	Trend TFP growth rate, expressed as log change	Derived as labour share times trend labour augmenting technical progress growth
TOURSH	Travel and transport services exports as a share of nominal GDP (constant)	Derived from 2018 benchmark fuel exports from ESCAP Excel Model, which is sourced from UNCTADStat, Trade structure by partner, product or service category.
URX	Unemployment rate (ILO definition)	ILO Modelled estimates
URXF	Female unemployment rate (ILO definition)	ILO Modelled estimates
USER	User cost of capital, per cent	Derived from long-term real interest rate, depreciation rate and corporate tax rate
WDR	Trade-weighted external demand, constant 2015 prices, US$ billion	Trade-weighted average of import volumes, with weights based on share of NPLs exports. See matrix_equations.prg for details.
XTD$	Deflator for Export of Goods and Services, US$, 2015 =100	Derived as ratio of exports in current US$ to exports in constant US$
XTDNO$	Non-oil export price deflator, US$, 2015 =100	Derived from XTD$ and oil share of exports (OXS)
XTN	Exports of goods and services, Current prices, Billions National Currency	United Nations Statistics Division National Accounts Main Aggregates Database
XTN$	Exports of goods and services, Current prices, US$ billion	Exports in domestic currency converted to US$
XTR	Exports of goods and services, Constant 2015 prices, Billions National Currency	United Nations Statistics Division National Accounts Main Aggregates Database

XTR$	Exports of goods and services, Constant 2015 prices, US$ billion	Export volumes in domestic currency converted to US$
YBAR	Survey means consumption or income per capita, total population (2011 PPP $ per day)	World Bank WDI Database. Missing values interpolated or estimated with GDP per capita.
YED	Deflator for GDP, National Currency, 2015 =100	Derived as ratio of GDP in current domestic prices to GDP in constant domestic prices
YEN	Gross Domestic Product (GDP), current prices, Billions National Currency	United Nations Statistics Division National Accounts Main Aggregates Database
YEN$	Gross Domestic Product (GDP), current prices, US$ billion	United Nations Statistics Division National Accounts Main Aggregates Database
YER	Gross Domestic Product (GDP), constant 2015 prices, Billions National Currency	United Nations Statistics Division National Accounts Main Aggregates Database
YER$	Gross Domestic Product (GDP), constant 2015 prices, US$ billion	United Nations Statistics Division National Accounts Main Aggregates Database
YFT	Trend output, constant 2015 prices, Billions, National Currency	Derived from sum of filtered productivity growth and labour force growth
YFT$	Trend output, constant 2015 prices, US$ billion	Trend output in domestic currency converted to US$