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ESCAP Economic and Social Commission for Asia and the Pacific

THAILAND

MACROECONOMIC PLANNING FOR GREEN AND CLIMATE POLICY OPTIONS IN THAILAND

Maximizing a quality of Decision Making

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Macroeconomic planning for green and climate policy options in Thailand

1. Introduction

Many Asia-Pacific countries including Thailand need to project a comprehensive picture of the impacts, not only economic dimension but inclusive social and environmental aspects while selecting a precise tools and measures for public policies which some traditional macroeconomic models may not provide the typical outputs as required.

The PAGE report of stocktaking on green economy in Thailand conducted by Partnership for Action on Green Economy (PAGE)[1] during 2021-2022 revealed that one of the weaknesses of Thailand's inclusive green economy transition was maintaining macroeconomics prudence. It is necessary for a large-scale investments and major policy implementation in the national strategies and plans to demand a comprehensive analytical model capable of assessing the benefits and costs of different scenario options with integrated future risks or uncertainties.

The report specifically pointed out that there is a need to develop macroeconomic models and policy tools that enable policy makers to make more precise decisions on intra and inter temporal trade-off impacts among policy alternatives. Developing such macroeconomic models to serve as a decision-making tool will ensure the inclusive green economy transition by minimizing losses resulting from uninformed policy prescriptions and implementing sound policy recommendations. (PAGE, 2023[2])

The PAGE Green Transformation Economic Advisory Mechanism (Green TEAM) in 2022 made decision in favor of stocktaking result to support strategic macroeconomic planning and analysis capacity in responding to accelerate green economy in Thailand. The activity was planned to construct or adapt macroeconomic models that can integrate multiple sectors of an inclusive green economy while analyzing the different socio-economic and environmental impacts in the short term and long-term perspectives. Such macroeconomic models aim to be supportive as single decision-making tool.

The United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) had developed the Macroeconomic Model to support the design of economic recovery packages for countries in the Asia and Pacific during the post-COVID times, while enhancing sustainability along economic, social, and environmental dimensions. The model runs on the EViews software with global scope, at least 46 individual country models in the Asia and Pacific and smaller models of 9 key trading partners outside of the region, plus aggregate models for the remaining countries grouped into 4 regions. These individual models are linked together via trade, remittances, and financial markets, as well as global carbon emissions and energy markets.

In this context, PAGE in collaboration with UNESCAP as part of its capacity building project, the National Economic and Social Development Council (NESDC) of Thailand (PAGE focal point agency), and UN Resident

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[1] PAGE initiative brings together the specialized expertise of five United Nations agencies: UN Environment Programme (UNEP), International Labour Organization (ILO), UN Development Programme (UNDP), UN Industrial Development Organization (UNIDO) and UN Institute for Training and Research (UNITAR) to accelerate a sustainability revolution and green and inclusive economic transformation, including through recovery efforts.

[2] PAGE, 2023. Green Economy Policy Scoping Report of Thailand https://www.un-page.org/countries/thailand/#knowledge-hub

Coordinator Office in Thailand (RCO Thailand) has conducted macroeconomic modeling exercise to assess the socioeconomic and environmental impacts of selected national policy scenarios in Thailand.

The selected policy scenarios covered major climate policies to achieve the Paris Agreement including carbon pricing mechanism and energy related efficiency. Additionally, bio-circular-green economy strategy to achieve sustainability and inclusive economy, society, and environment is incorporated.

The two main outputs of this exercise are (a) a macroeconomic model that is based on the region wide ESCAP macroeconomic model but tailored to Thailand's context; and (b) a national study that examines the socio-economic and environmental implications of selected policy scenarios in Thailand.

2. Overall selected green and climate policy options

The model is applied to study a set of policy relevant scenarios for Thailand, which focus on several broad areas of policy design that can be explored with the ESCAP Macroeconomic Model, and that may be of particular relevance for Thailand: introducing a carbon tax, implementing energy-related investments or increasing 'Bio-Circular-Green' investment. In order to evaluate different scenarios, the model generates alternative scenarios that compare trajectories of economic, social, and environmental indicators to the baseline forecast, providing insights into how they would differ from business-as-usual (BAU) values[3].

The key policy messages from these scenarios can be summarised as:

- Thailand's decision to introduce a carbon tax and withdraw carbon-linked subsidies would significantly help to achieve the GHG emission reduction target[4] of 30% by 2030 and avoid competitiveness loss coming from the international (EU) carbon price scheme. However, the tax on its own can make only part of the progress towards meeting the emission reduction targets.
- Taxing carbon will increase inflation temporarily, but has the potential to generate significant fiscal revenue that can be channelled into priority spending areas, while encouraging a decline in CO_2 emissions.
- If the carbon revenue is channelled back into the economy as government spending in social and environmental sectors (education, health, social and environmental spending), it can gradually increase economic activity and productivity; reduce inequality and poverty; make some progress towards emissions reduction targets and reduce air pollution.
- Policy senarios can be aligned with government priorities: implementation of well-targetes low-carbon transportation investment, energy efficiency investment and environmental protection investment, paired with carbon taxation, can generate sufficient space to finance the transfers, and deliver important environmental returns, while simultaneously supporting economic activity.
- The Bio-Circular-Green government spending will improve energy efficiency, environmental protection, and strenghten social and health sectors. Although substantial increase in investments could trigger some economic imbalances in the coming years, the fiscal situation would deteriorate only until mid-2040 if the government program utilizes additional revenue gained from the carbon

[3]The baseline scenario suggests an average of 3% GDP growth and 2% inflation on the forecast horizon, a 38% GDP debt ratio, and 370 Mt of CO_2 emissions in 2050. The baseline simulation is based on data up until 2019 but incorporates the effects of COVID-19 on economic activity.

[4] Thailand's 2nd Updated National Development Contribution Plan: https://unfccc.int/sites/default/files/NDC/2022-11/Thailand%202nd%20Updated%20NDC.pdf

tax. In the long run, fiscal sustainability risks would ease and real economic situation would improve.

The paper is organized as follows: the next section reviews some of the main medium-term development challenges for Thailand; Section 4 develops the policy scenarios and policy recommendations and Section 5 concludes. The appendix provides a technical description of the ESCAP Macroeconomic model.

3. Medium-term development plan challenges

Thailand's Twenty-Year National Strategy (2018-2037)[5] was established to support the vision of 'Thailand's becoming a developed country with security, prosperity, and sustainability in accordance with the Sufficiency Economy Philosophy'. This long-term national strategy, which fully integrates the 2030 Sustainable Development Goals (SDG), aims to make Thailand an upper-middle-income country by 2037. The recently accepted 13th National Economic and Social Development Plan (NESDP, 2023-2027)[6] determines the short-term directions and goals of the long-term National Strategy. The plan focuses on five development targets, which are:

- Restructuring the manufacturing and service sectors towards an innovation-based economy
- Developing human capital for the new global era
- Creating a society of opportunities and fairness
- Ensuring the transition of production and consumption towards sustainability
- Enhancing Thailand's capability to cope with changes and risks in the new global context

The Plan builds around 13 milestones: high value agriculture; value tourism; electric vehicle; comprehensive medical and health services; regional logistics; smart electronic and digital services; sustainably growing social/local enterprises; modern and liveable cities; low intergenerational poverty and adequate social protection; circular economy and low-carbon society; natural disaster and climate change impact mitigation; high-skill workers to serve market demands; and high-efficiency public sector.

These priorities are well-aligned with advancing the SDGs and are in line with the United Nations Sustainable Development Cooperation Framework[7] (UNSDCF, 2022-2026). The strategic outcomes of the UNSDCF support 12 out of the 13 milestones set by the government. Another crucial cornerstone in sustainability policy making is the 'Bio-Circular-Green' economic model, which was introduced by the Thai government in 2021. This model will play a significant role to boost technological development and provide a balanced, resilient, and sustainable development path post-COVID, aligning with the SDGs and Sufficiency Economy Philosophy.

During the past few decades, Thailand has made a relatively rapid transition from a low-income country to an upper-middle-income country, maintaining economic stability with low inflation, a stable exchange rate, a moderate fiscal deficit, and a favorable external balance. Over the past 20 years until 2019, the country experienced an average economic growth of 4%. Additionally, significant progress has been made in terms of social development, including notable reductions in poverty, improvements in the education system, and nearly universal access to basic health services and digital connectivity throughout the country.

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[5] National Economic and Social Development Board, 'National Strategy 2018 – 2037 (Summary)', https://www.bic.moe.go.th/images/stories/pdf/National_Strategy_Summary.pdf

[6] National Economic And Social Development Council, 'THE THIRTEENTH NATIONAL ECONOMIC AND SOCIAL DEVELOPMENT PLAN (2023-2027)', https://www.nesdc.go.th/article_attach/article_file_20230615134223.pdf

[7] UN, 'United Nations Sustainable Development Cooperation Framework (UNSDCF) 2022–2026', https://thailand.un.org/en/166885-united-nations-sustainable-development-cooperation-framework-unsdcf-2022%E2%80%932026

However, there are still existing structural issues in Thailand, such as inequality, external economic vulnerability, and climate risks, which have been brought to the forefront by the COVID-19 pandemic. In 2020, the country experienced a sharp decline in economic activity, with a 6.1% contraction, particularly affecting the tourism and exporting industries. This downturn had a negative impact on the labor market and exacerbated the challenges faced by low-income populations, the younger generation, and migrant workers. Similar to other ASEAN countries, Thailand is highly susceptible to the effects of climate change. These effects include rising sea levels, extreme weather conditions that deteriorate agriculture and tourism, and heat stress that impairs labor productivity. Addressing climate change, reducing greenhouse gas (GHG), especially CO_2 emissions, and managing marine waste are significant national priorities for Thailand, as it ranks as the 22nd largest GHG producer and the 10th largest contributor to marine waste. Therefore, sustainable economic development and increasing investment in these sectors are crucial for mitigating social, economic, and environmental challenges in Thailand.

The scenarios that follow in the next sections explore the key areas discussed in the 13th NESDP, and the interactions between policy initiatives, economic activities, public finances, and social development and environmental indicators. In particular, there will be a special focus on implementing a carbon tax in Thailand to facilitate a shift in the energy mix and decrease the demand for fossil fuels. Also, special emphasis is placed on increasing investment to support environmental, social, and sustainable economic goals.

4. Macroeconomic Modeling outputs

4.1. Scenario 1: Pricing carbon emissions

Relative prices and costs impact the production and consumption choices made by individuals. The GHG that are emitted by burning fossil fuels and other carbon-intensive activities bear a heavy environmental and social cost. These costs are borne by society, but generally entail very little direct cost to the individuals involved in choosing the related production technologies or consumption goods. This “externality” distorts the true costs of carbon intensive activities, and allows a much higher level of GHG to be emitted than is socially optimal. Policy instruments, such as subsidies related to the consumption and production of energy derived from burning fossil fuels, distort these costs further.

In Thailand, energy-related subsidies were relatively low before the pandemic, amounting to approximately $1.5 per tonne of CO_2 in 2019. However, carbon-linked subsidies temporarily increased to $8.6 per tonne of CO_2 in 2021 after the government implemented a price cap on diesel, natural gas, and LPG. This carbon subsidy hinders the progress of an energy transition. By reducing carbon subsidies and in parallel implementing a carbon tax, the energy transition could be accelerated, creating incentives for change.[8] Removing carbon-linked subsidies and introducing a tax on carbon would improve government budget balance, creating space to finance new government programmes. It would align incentives with the need to a transition towards cleaner energy sources and improving energy efficiency. Using cleaner energy will reduce carbon emissions and reduce air pollution, with important health benefits. Air pollution is a major cause of respiratory illness. The World Health Organization (WHO)[9] attributes over 33,000 deaths in 2016 in Thailand to ambient and household air pollution. In addition to the impacts on the quality of life and

[8] Apart from implementing a carbon tax and eliminating carbon subsidies, countries have the option to establish carbon markets to encourage reduced emissions in production. However, the ESCAP global macroeconomic modeling setup is not suitable for assessing the impact of implementing such market development, which is primarily influenced by changes in regulations. Therefore, such a scenario has not been developed.

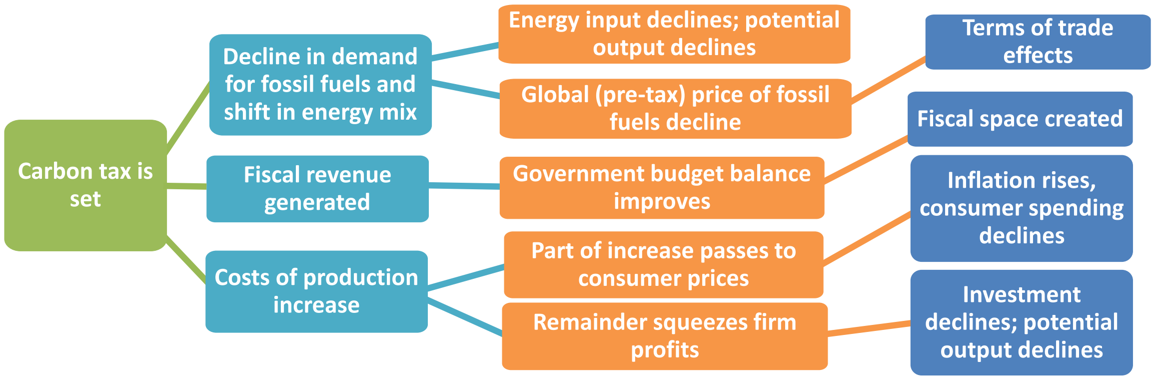
[9] https://www.who.int/thailand/news/detail/08-06-2022-the-cost-of-clean-air-in-thailand

mortality, the health consequences of high air pollution also impact productivity and economic activities, and there will be wide ranging benefits to Thailand for transitioning to a cleaner energy mix.

However, taxing carbon will also come at a cost, pushing up inflation and production costs, and potentially disrupting energy supply. The ESCAP Macroeconomic Model can be used to assess the macroeconomic implications of a carbon tax and the impacts on inflation and production costs, in order to study the appropriate speed of subsidy withdrawal and introduction of a carbon price and to understand the economic, social and environmental trade-offs and benefits.

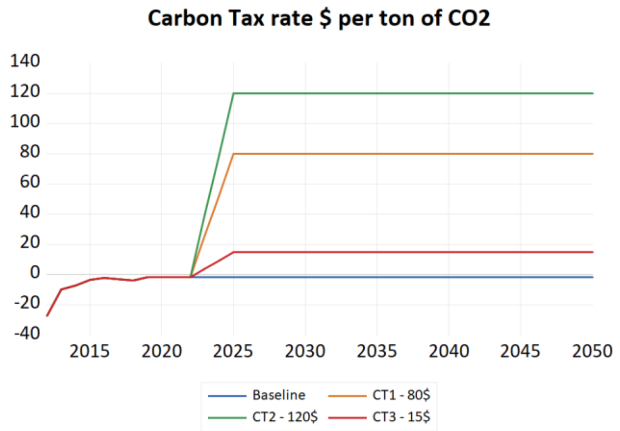
Figure 1 traces the transmission channels of a carbon tax in the ESCAP Macroeconomic Model for Thailand. Carbon-linked subsidies, such as energy subsidies, follow a similar transmission path, although with the opposite sign. For example, rather than a decline in demand for fossil fuels, a subsidy would encourage a rise in demand for fossil fuels.

Figure 1. Transmission channels of a carbon tax in ESCAP Macroeconomic Model for Thailand



Based on the international and local agendas concerning various carbon pricing mechanisms, we have developed three different carbon tax scenarios. Different carbon tax rates are visible in Figure 2.

Figure 2. Carbon Tax rates under different scenarios



Scenario 1a: Introducing a carbon tax at $80 per ton of CO_2

The EU Carbon Border Adjustment Mechamism (CBAM)[10] was signed in May 2023 and is scheduled to take effect in October 2023. CBAM is designed as a carbon pricing framework aimed at encouraging non-EU countries and businesses to adopt less carbon-intensive production methods. During the initial implementation period from 2023 to 2026, no additional fees will be charged for high-carbon production[11], however, starting from 2026, CBAM will ensure that the carbon price of imports is equivalent to that of domestic production for selected products.

If a non-EU exporting country fails to account for the environmental cost of carbon emissions, this regulation will effectively increase the import prices. Consequently, unless Thailand implements a carbon tax by 2026, the country's competitiveness and exports to the EU might be negatively impacted by the new carbon pricing system on Thai exports to the EU. Additionally, the revenue generated from the CBAM would not be collected by Thailand's authorities. Therefore, in Scenarios 1a and 1b, we simulate the potential effects of the increased production costs resulted from the implementation of carbon taxation. This is done in order to avoid the EU CBAM and retain the new revenues generated from carbon taxation within the Thai government budget.

The carbon price in the EU was effectively 77 EUR ($83) per ton of CO_2 in 2021. In Scenario 1a, we make the assumption that this carbon tax rate will remain relatively stable, despite indications that the EU authorities may consider future increases. Therefore, in Scenario 1a, we have eliminated pre-COVID subsidies amounting to $1.45 per ton of CO_2 and introduced a phased implementation of an $80 per ton of CO_2 carbon tax over a span of three consecutive years (2023-2025). This approach aligns with the requirements for CBAM implementation.

[10] https://taxation-customs.ec.europa.eu/carbon-border-adjustment-mechanism_en

[11] Sectors, which are covered in the CBAM first phase are: cement, iron & steel, aluminum, fertilizer, electricity, and hydrogen. On a later stage, indirect emissions could be also covered under the CBAM regulation.

Figure 3. Impact of introducing carbon tax at $80 per ton of CO2 (in terms of percentage difference from the baseline)

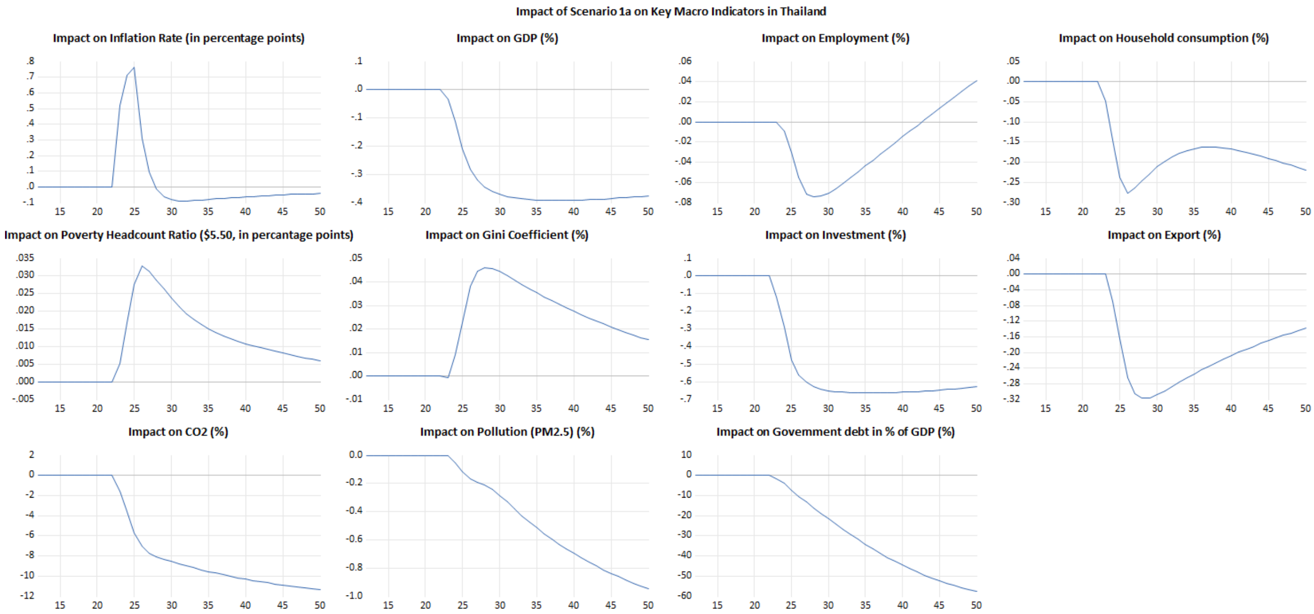


Figure 3 illustrates the effect of Scenario 1a. The withdrawal of carbon-linked subsidies, coupled with the gradual implementation of an $80 carbon tax, is expected to have a moderate impact on inflation in Thailand, resulting in an increase of approximately 1 percentage point. However, these effects are temporary and dissipate quickly. The shift in relative prices would encourage a 4.9% growth in renewables until 2030 (assuming there is no other incentive). As a result, CO_2 emissions are projected to decrease by around 8.6% by 2030, leading to improved air quality and subsequent health benefits that contribute to overall productivity growth. While the policy has a negative net impact on GDP, household consumption, investment, and exports, its affect on various real economic variables, especially employment and exports, is relatively small. Moreover, the revenue generated from the carbon tax and the savings from eliminating carbon-linked subsidies create significant fiscal space. This allows the government debt in percentage of GDP ratio to decline by 21.5% compared to the baseline scenario until 2030. A portion of this government revenue can be reinvested into the economy, prioritizing areas such as energy infrastructure, transportation improvements, or enhancing energy efficiency, as discussed in the subsequent scenarios. Furthermore, the revenue can also be directed towards crucial sectors such as social protection, healthcare investments, or educational initiatives. This approach can effectively offset the negative effects on GDP and yield substantial economic and social returns.

Scenario 1b: Introducing a carbon tax at $120 per ton of CO_2

In Scenario 1b, we adopt a more ambitious approach by implementing a higher increase in carbon prices. The CBAM system will be priced at the average weekly price of European Carbon Price auctions, where we can expect a gradual increase in carbon prices.[12] Thus, in Scenario 1c, we eliminate pre-COVID subsidies amounting to $1.45 per ton of CO_2 and introduce a phased implementation of a $120 per ton of CO_2 carbon tax over three consecutive years (2023-2025).

Scenario 1c: Introducing a carbon tax at $15 per ton of CO_2

Local discussions regarding the implementation of a carbon tax have been also under consideration, with a focus on reducing emissions in the energy, transportation, and industry sectors.[13] In order to align with the preliminary excise tax data provided by the authorities and eliminate the carbon subsidies, Scenario 1c

[12] European carbon prices are currently trading at a price of $100 per ton of CO2: https://carboncredits.com/

[13] https://www.enerdata.net/publications/daily-energy-news/thailand-plans-impose-carbon-tax-energy-transport-and-industry.html

incorporates a conservative and gradual increase in the carbon tax over three consecutive years, reaching a level of $15.

Figure 4. Impact of introducing a carbon tax at $80 (Scenario 1a), $120 (Scenario 1b), $15 (Scenario 1c) (in terms of percentage differences from the baseline)

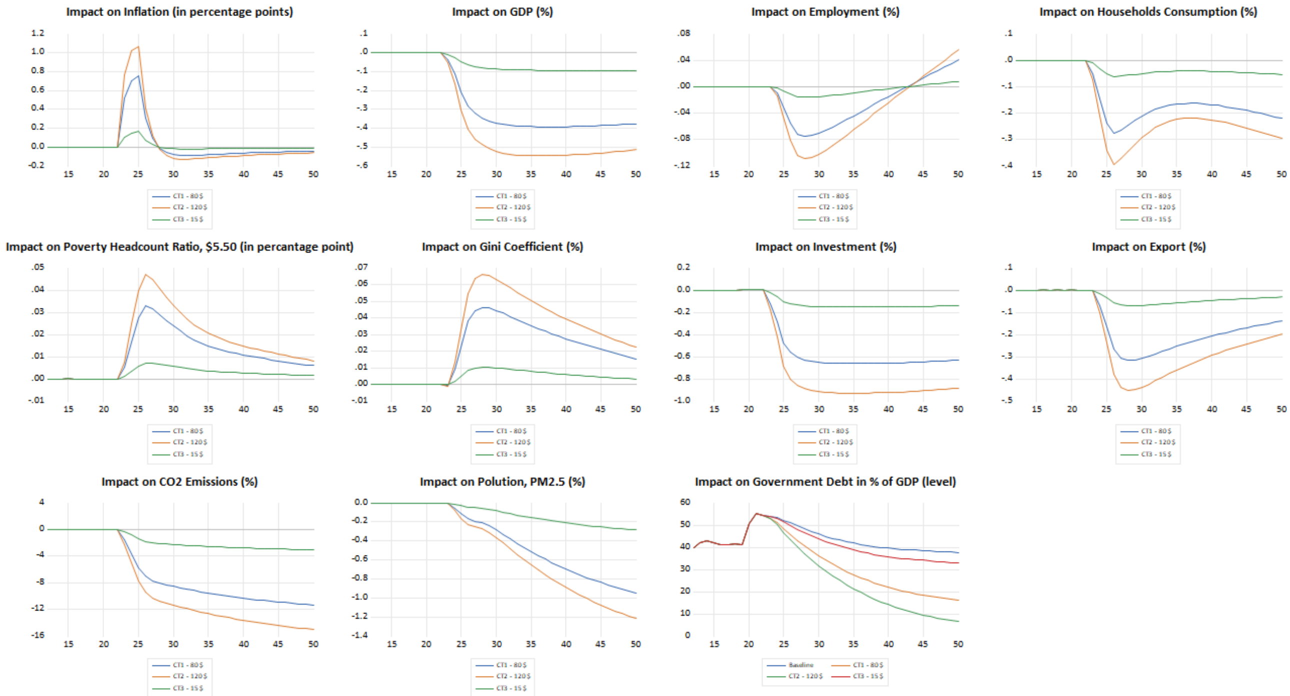


Figure 4 illustrates the effect of Scenarios 1b and 1c. The withdrawal of carbon-linked subsidies, coupled with the introduction of a $120 carbon tax in Scenario 1b, is expected to have a greater impact on inflation, exceeding the baseline by approximately 1 percentage point for several years. In contrast, the inflationary effect of the less ambitious $15 carbon tax in Scenario 1c is negligible. The shift in relative prices would encourage a 6.8% increase (Scenario 1b) and a 1% increase (Scenario 1c) in renewables in 2030 compared to the baseline. Consequently, CO_2 emissions are projected to decrease by around 11.3% by 2030 in Scenario 1b, but only around 2.2% in Scenario 1c. The decline in pollution would deliver health benefits and contribute to overall productivity growth.

Since the carbon tax revenue is not spent in these scenarios, the introduction of the carbon tax has negative effects on GDP, household consumption, export, employment, poverty, and investment. In Scenario 1b, it would result in around 1% drop in investment in 2030, while in Scenario 1c, the impact is only 0.1%. Although the effect of Scenario 1b on the real economy is negative, it creates fiscal space, leading to a decline in government debt to around 32% of GDP compared to 46% of GDP in the baseline scenario in 2030. In Scenario 1c, the government debt decreases to 44% of GDP. For comparison, the government debt stands at 36% of GDP in Scenario 1a in 2030.

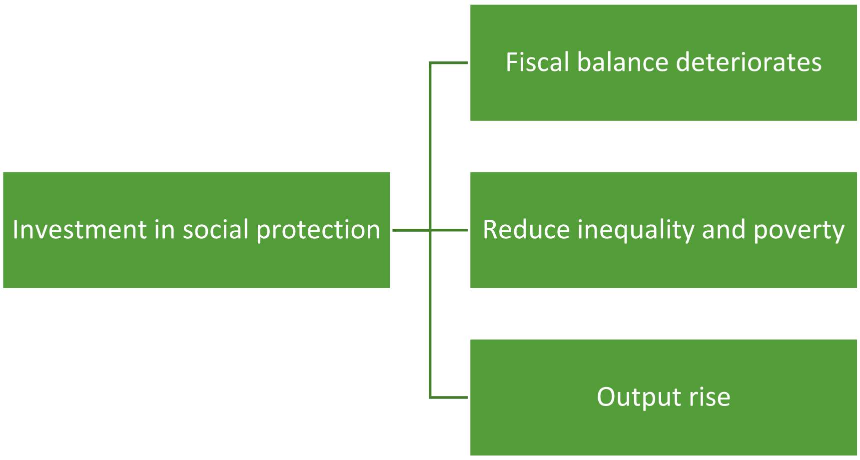
Overall, the introduction of a more aggressive carbon tax in Scenario 1b, without channeling back the tax revenue, would have a significant negative effect on the real economy but result in sizeable environmental benefits. The negative impact of the less ambitious carbon tax in Scenario 1c on the real economy is negligible, but it would not be sufficient to generate substantial environmental consequences. In the coming scenarios, Scenario 1a, a $80 carbon tax, is used as the baseline carbon tax scenario.

4.2. Scenario 2: Carbon tax revenue spending

The revenue generated by a carbon tax can be channelled back into the economy in a number of ways. All the options have slightly different impact on the key social, economic and environmental indicators, so policy can be aligned with government priorities. The policy options available within the ESCAP Macroeconomic Model for Thailand include:

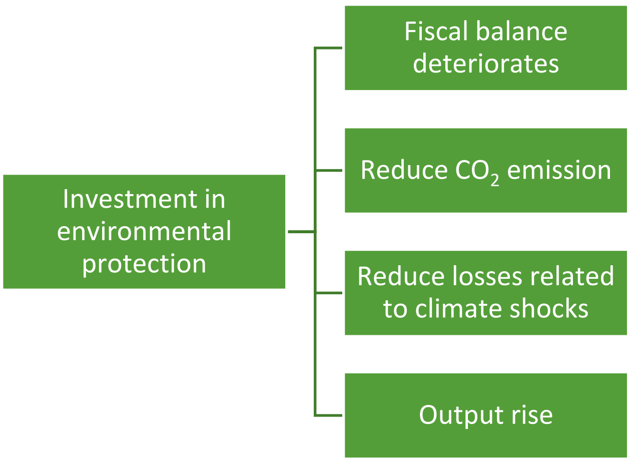
- ***Spending on social protection***. This increases household incomes and supports household consumption spending, which in turn raises GDP. As the measures tend to be targeted towards the more vulnerable members of society and those on lower incomes, it also reduces inequality and poverty. Channelling some of the revenue from a carbon tax towards social protection can offset the impact of higher energy costs on the more vulnerable households.

Figure 5. Transmission channels of investment in social protection



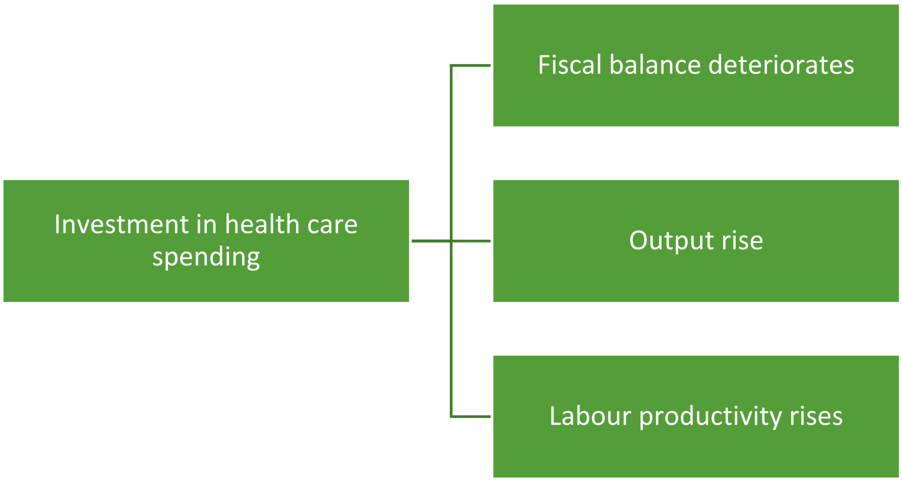
- ***Spending on environmental protection***. The additional government spending (both consumption and investment spending) on environmental protection acts as a short-term stimulus to the economy. It also builds resilience against climate change and protects against future losses related to climate shocks, reduces air pollution and reduced CO_2 emissions. The decline in air pollution brings health benefits that also raise labor productivity.

Figure 6 Transmission channels of investment in environmental protection



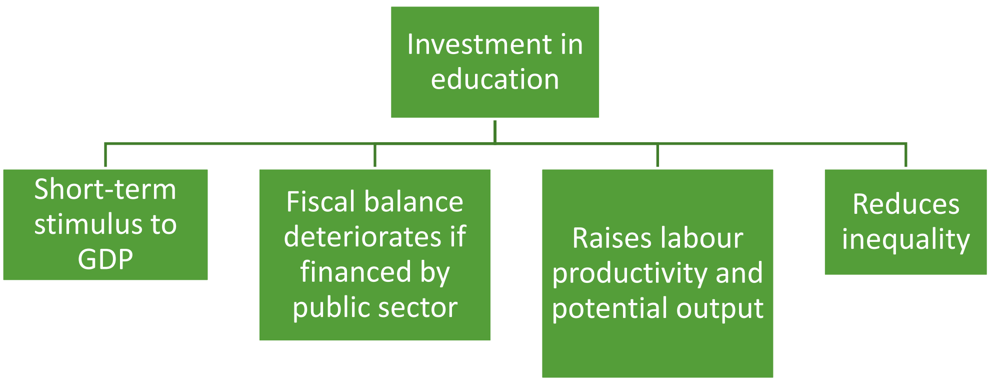
- ***Spending on health***. This acts as a short-term stimulus to the economy through the provision of goods and services (for example, hospital meal services) and investment in health infrastructure (for example, upgrading hospitals). The social returns of investment in healthcare are well-documented. In addition to improving health outcomes, a healthy workforce is more productive, which translates into higher levels of GDP, higher levels of government revenue, lower unemployment and higher real personal disposable incomes.

Figure 7. Transmission channels of investment in health



- ***Spending on education***. Government spending on education also acts as a short-term stimulus to the economy. The returns to education have been widely studied in academic literature. We assume a benchmark estimate that a 1% of GDP rise in spending on education adds about 0.1 percentage points to trend productivity growth per year, calibrated with reference to the social returns to education reported by Botev, Égert, Smidova and Turner (2019). Broader access to education is also expected to reduce income inequality and raise labor productivity over the longer term. The modelling assumption applied is that a 1% of GDP rise in spending on education delivers a 1% decline in the Gini coefficient in the long run, which in turn raises trend productivity.

Figure 8. Transmission channels of investment in education



- ***Spending on debt reduction***. If additional revenue is not used to boost government expenditure, it allows the level of fiscal deficit and therefore government debt to decline, which may ease pressure on the country risk premium if debt levels are high. (As it is illustrated in Scenarios 1a and 1c.)

Scenario 2a: Carbon tax revenue spending on BAU

In Scenario 2a, we assume that the additional government revenue from the carbon tax will be allocated to various sectors during the extra investment period from 2023 till 2027. The allocation is in line with the 2020 total government budget execution based on government data. Specifically, we allocate 12.9% of the additional revenue to social protection, 9.2% to health, 0.4% to environmental protection, and 15.4% to education. Within the education sector, 50% of the spending is directed towards other government consumption, such as salaries, while the remaining 50% is allocated to other government investment, such as the development of school infrastructure. The remaining extra government revenue from the carbon tax will be used for debt reduction.

Figure 9 shows how Scenario 2a affects government spending:

Figure 9. Impacts of Scenario 2a on government spending

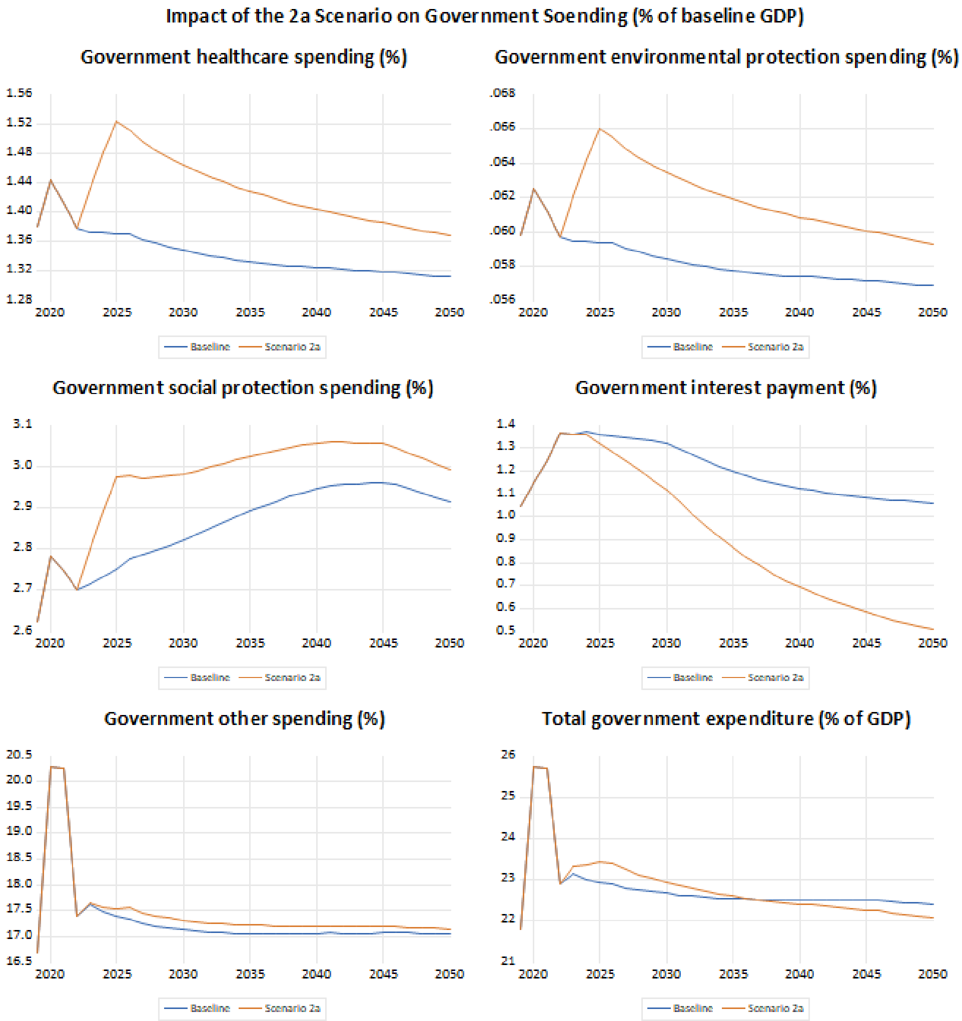
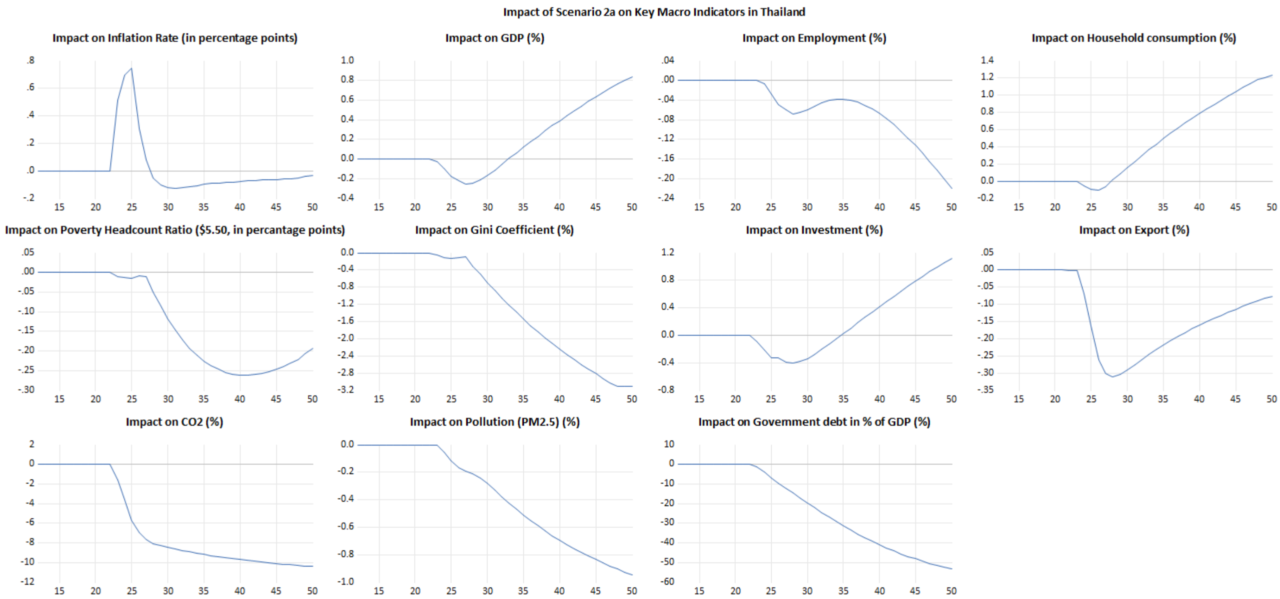


Figure 10 illustrates the expected impact of Scenario 2a, which shows the difference from the baseline. In the short run, this scenario exerts similar pro-inflationary pressure as Scenario 1a, although the price growth is slightly lower due to the compensatory effect of that part of executed spending that has positive impact on productivity (health and education). Over the long run, the additional government investment offsets the negative impact of the carbon tax on the real economy, resulting in an estimated 0.8% increase in GDP by 2050 compared to the baseline scenario. Household consumption, investment and export growth are boosted by a faster increase in potential output, primarily driven by the extra investment in education. On the other hand, productivity improvements result in a decline in employment, although the effect is rather small.

Similar to Scenario 1a, this scenario has a largely positive environmental impact, as CO_2 emissions are projected to decline by 8.4% in 2030. However, the impact is somewhat smaller compared to Scenario 1a, as the increased economic activity generates additional emissions that are not fully compensated by slightly higher government spending on environmental protection. The additional spending on social protection and education has a beneficial social impact, contributing to a reduction in both poverty and inequality. The poverty ratio is expected to decline by 3.3% or 0.12 percentage points compared to the baseline by 2030. Additionally, since a portion of the carbon tax revenue being used to reduce public debt and the potential output is higher, interest payment declines which outweights the higher other spending and leads to somewhat lower overall government spending in the long run. Larger nominal GDP together with narrowing interest payment result in declining ratio of public debt to GDP, by around 19.5% of GDP, in 2030 compared to the baseline.

Figure 10. Impacts of Scenario 2a (in terms of percentage differences from the baseline)



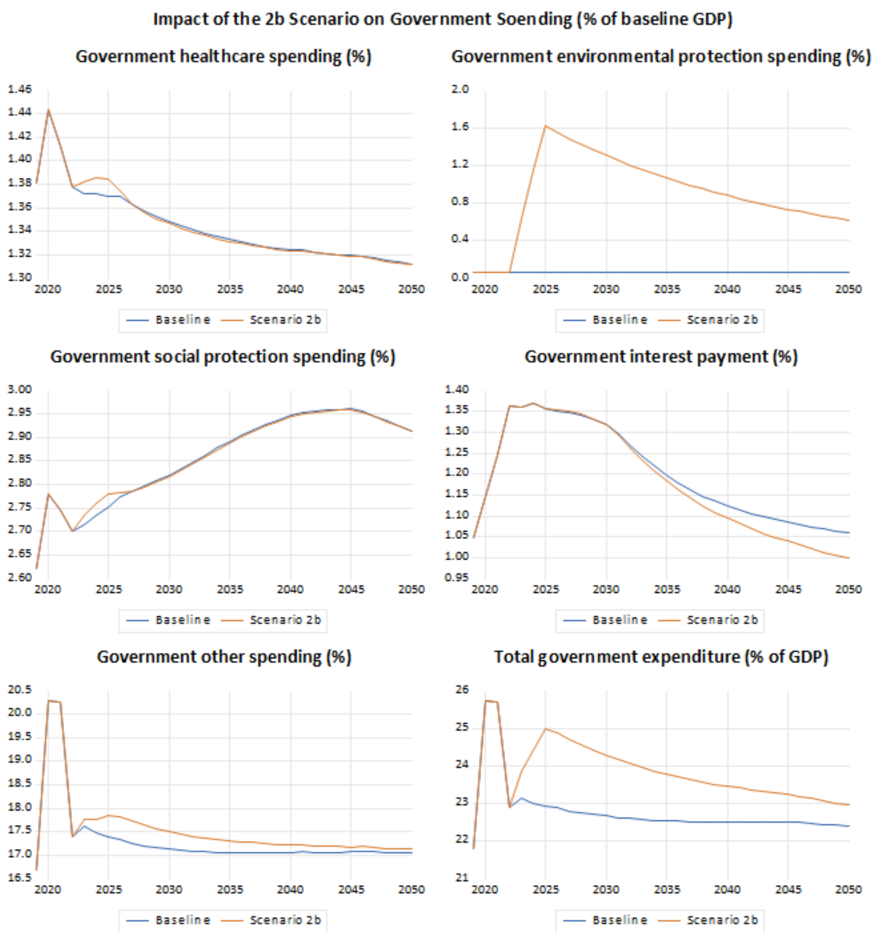
Scenario 2b: Carbon tax revenue spending on environmental protection

In Scenario 2b, we consider that the additional government revenue generated from the carbon tax will be entirely allocated to environmental protection. Environmental spending in Thailand has been relatively low in the past years, with the Thai government averaging an expenditure of 0.05% of GDP on environmental protection from 2013 to 2021. In comparison, the global average for countries with available data was 0.55% of GDP.[14]

Recognizing the importance of addressing sustainability issues and climate risks, the 13th NESDP emphasizes the need to accelerate government expenditure in this area. The NESDP outlines two key milestones: promotion of a circular economy and transition towards a low-carbon society, as well as efforts to mitigate the impacts of natural disasters and climate change. To achieve these objectives, several policy areas are proposed, including waste management improvement (10th Milestone, Sub-Strategy 1.2), encouraging forest plantations (10th Milestone, Sub-Strategy 2.6), incentivizing the population towards low-carbon consumption (10th Milestone, Sub-Strategy 5.2), raising awareness (11th Milestone, Strategy 2).

If all of the carbon tax revenue is used for general environmental protection, it would increase environmental protection spending throughout the forecast horizon to an average of 1% of GDP, compared to the 0.06% of GDP in the baseline (Figure 11).

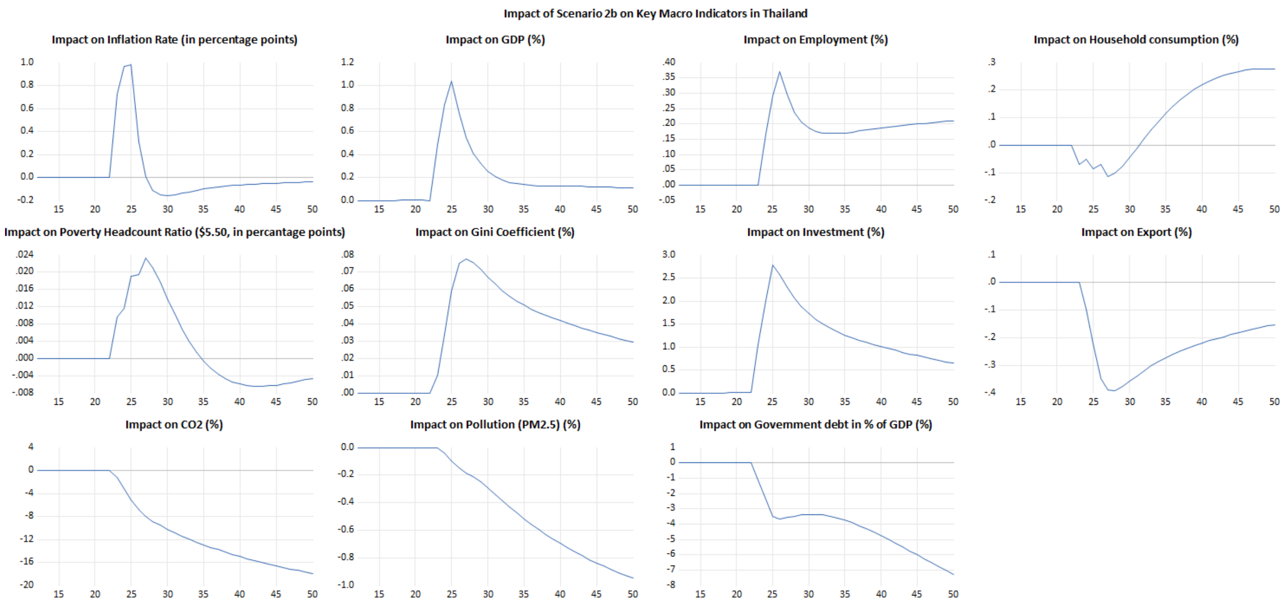
Figure 11. Impacts of Scenario 2b on government spending



[14] IMF, 'Government Finance statistics', https://data.imf.org/?sk=5804C5E1-0502-4672-BDCD-671BCDC565A9

Figure 12 illustrates the expected impacts of Scenario 2b, when all of the additional revenue generated by the $80 per ton CO_2 carbon tax is spent on environmental protection.

Figure 12. Impacts of Scenario 2b (in terms of percentage differences from the baseline)



The extra spending, combined with fiscal stimulus, results in an increase in inflation around 1 percentage point higher than the baseline scenario, slightly higher than in Scenario 1a. Rapid investment leads to an average annual increase in GDP of 0.6% until 2030 and a gradual rise in employment due to the increased demand for human capital resulting from the investment shock. However, the long-term effect of this type of investment on the real economy is moderate.

On the other hand, the environmental effect of this scenario is significant, gradually reducing CO_2 emissions by 10.2% in 2030, which is a larger drop than in Scenario 1a or Scenario 2a. Pollution and climate losses also decline. However, the social impact of the extra expenditure on environmental protection is negligible. Since all of the carbon tax revenue is channelled into government spending, the public debt decreases only moderately by around 3.4% until 2030, with the decline mostly attributed to the higher nominal GDP.

4.3. Scenario 3: Energy related investment scenarios

As discussed in Scenario 2b, the country's investment in green development remains relatively low. To address the future economic, environmental, and social needs, a significant increase in energy infrastructure investment is needed, specifically targeting the expansion of transportation infrastructure, low-carbon energy, and efficiency improvements. Well-targeted and effectively allocated government spending would yield environmental benefits by reducing CO_2 emissions and air pollution.

In light of this target, we have developed scenarios to assess the impact of various energy-related investments discussed in the 13th NESDP. The additional investment will be introduced in 2023 and will continue until 2027, aligning with the 5-year development plan. Although the investment program is implemented at the national level for the purposes of these scenarios, in practice, the Government may choose to initiate small pilot projects at the local level to demonstrate feasibility before committing to nationwide investment allocations. The estimated scale of the additional investment and its effects are benchmarked by ESCAP costing estimates[15] to the Asia-Pacific region.

To develop this scenario, we consider 3 key areas of government spending:

(1) Investment in environmentally friendly transportation

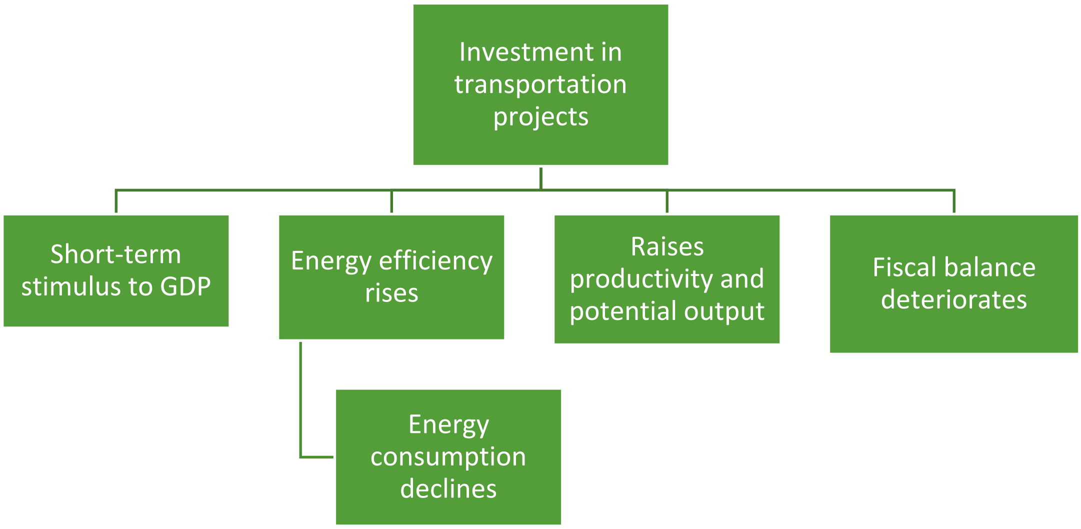
Given that 23% of Thailand's CO_2 emissions stem from transportation, it is crucial to prioritize emissions reduction in this sector to accomplish climate objectives. The transportation policy package, primarily highlighted in the 10th and the 3rd Milestones of the 13th NESDP (circular economy and low-carbon society, electric vehicles), places significant emphasis on addressing this issue. The policies aim to focus on the enhancement of the railway system, promotion of low-carbon public transportation, and adoption of electric vehicles in both public and private transportation sectors.

ESCAP estimates that Thailand needs to invest approximately 0.28% of GDP per year in transport infrastructure over a 10-year period to achieve significant results. Consequently, a climate-friendly transportation system, coupled with direct investment in energy efficiency, is expected to double the rate of energy efficiency gains compared to the baseline scenario over the same 10-year period. Therefore, if a 5-year investment plan of the same magnitude is pursued, energy efficiency is projected to improve by approximately 50% more than in the baseline scenario. Furthermore, according to a study by Briceño-Garmendia, Estache, and Shafi (2004), historical data indicates that investments in transport infrastructure in the South Asia region have yielded a social rate of return of 24.1%. This suggests that a 1% of GDP investment will enhance productivity in the long run by 0.241 percentage points.

Figure 13 illustrates the transmission of gains from green transportation projects through the ESCAP Macroeconomic Model for Thailand. By increasing the adoption of low-carbon transportation methods, the energy required for transporting goods and people is reduced, leading to a decrease in overall energy demand while simultaneously increasing production levels. As long as the reduction in energy consumption surpasses the growth in output, aggregate CO_2 emissions will decrease. The implementation of more efficient road vehicles and transportation systems will yield a positive social return, ultimately enhancing productivity.

[15] https://www.unescap.org/publications/economic-and-social-survey-asia-and-pacific-2019-ambitions-beyond-growth
Note: No specific estimates were available for Thailand, we used estimated investment at the Asia-Pacific regional level.

Figure 13. Transmission channels of green transportation projects



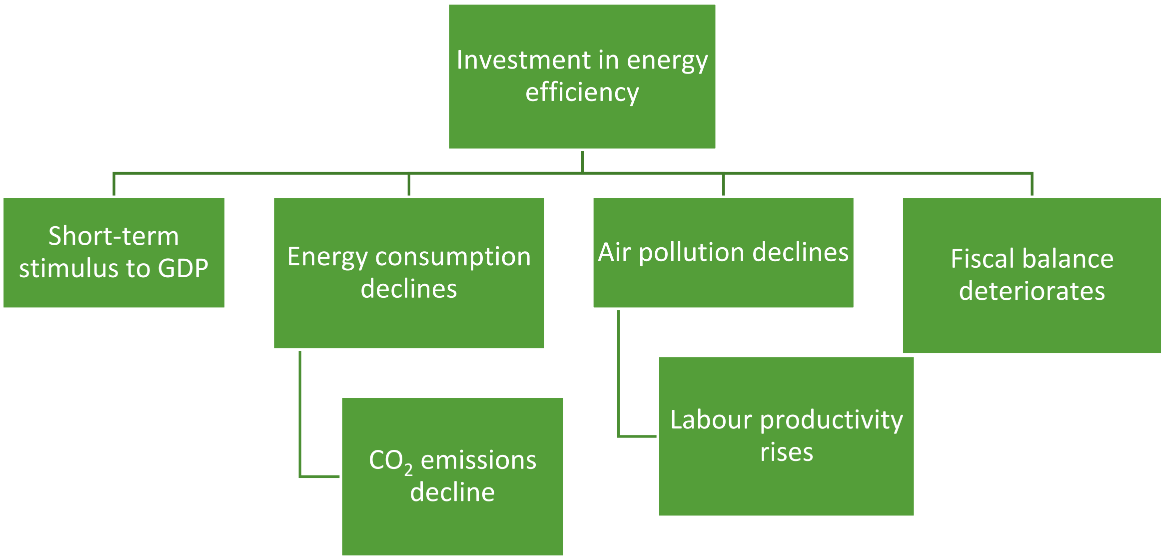
(2) Investment in energy efficiency

As explicitly stated in the 13th NESDP, particularly in relation to the agenda of the 10th Milestone, Thailand faces challenges with low energy efficiency and inefficient resource utilization. This leads to issues concerning waste management, air pollution, and water pollution. Consequently, investing in energy efficiency improvement becomes crucial. Implementing policies such as the establishment of an improved waste recycling system and the promotion of energy-saving innovations are vital measures to support achieving the environmental objectives.

ESCAP estimates that investment in energy efficient infrastructure in the range of 0.47% per annum is needed in Thailand over 10 years to reach significant result. As a result, energy efficiency indicators, together with direct investment in green transportation are expected to double the rate of energy efficiency gains over the 10-year period. Therefore, if a 5-year investment plan of the same magnitude is pursued, energy efficiency is projected to improve by approximately 50%. Moreover, energy efficiency improvement helps to reduce pollution as well.

Figure 14 illustrates the transmission of energy efficiency gains in the ESCAP Macroeconomic Model for Thailand. With improved energy efficiency, the amount of energy required to produce each unit of output decreases. Consequently, there is a reduction in total energy demand while simultaneously increasing production levels. As long as the decrease in energy consumption outweighs the increase in output, aggregate CO_2 emissions will also decline. Additionally, the enhancements in energy efficiency are expected to contribute to a decrease in air pollution. This reduction supports improvements in public health and leads to an increase in labor productivity.

Figure 14. Transmission channels of energy efficiency projects



(3) Investment in renewable energy

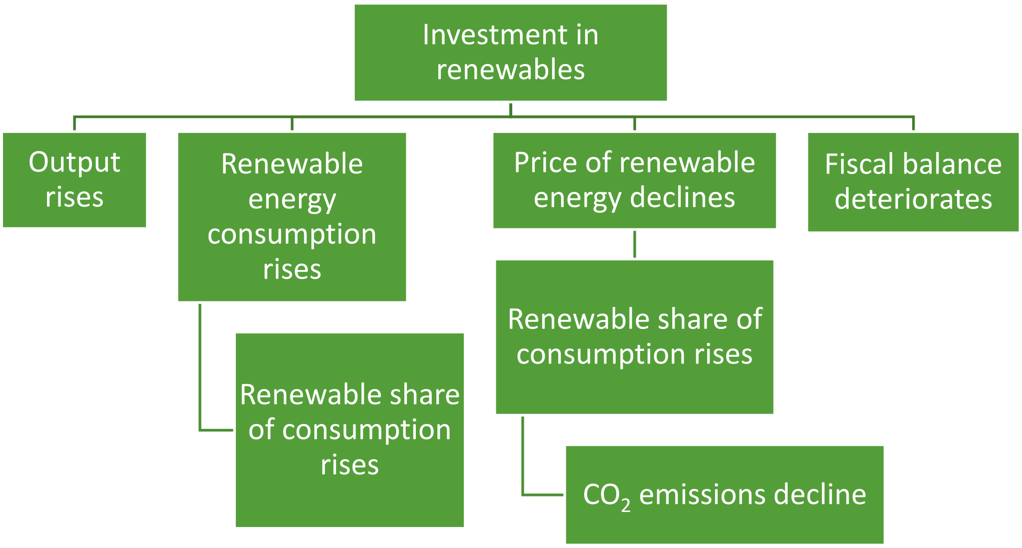
Investing in renewable energy is a key priority for the Thai government to achieve its goal of reaching a 30% share of renewable energy in total energy consumption by 2037. There is significant potential in boosting the generation of renewable energy[16], particularly in solar[17] and wind. For example, the implementation of planned projects for renewable electricity generation, along with government investments to incentivize and subsidize private industries' and households' renewable energy generation, can contribute to meeting the country's environmental objectives.

ESCAP estimates that investment in renewable energy in the range of 0.67% per annum is needed in Thailand over 10 years to achieve significant results. Consequently, this level of investment would lead to a substantial increase in the share of renewable energy, effectively doubling the renewable energy capacity compared to the baseline scenario over the 10-year period. Therefore, if a 5-year investment plan of the same magnitude is pursued, the renewable energy capacity would increase by approximately 50% compared to the baseline scenario.

Figure 15 illustrates how investments in renewables are transmitted in the ESCAP Macroeconomic Model for Thailand. These investment serve as short-term stimulus 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 CO_2 emissions and air pollution. However, if the government finances the investment in renewables, it may have a negative impact on the fiscal balance.

[16] https://www.irena.org/-/media/files/irena/agency/publication/2017/nov/irena_outlook_thailand_2017.pdf
[17] https://globalsolaratlas.info/global-pv-potential-study

Figure 15. Transmission channels of renewable energy investment



In Scenarios 3a and3b, we consider a scenario where the government implements additional investments in the three aforementioned types of energy-related investments over a 5-year period from 2023 until 2027. The magnitude of these additional investments is roughly aligned with the total revenue generated from the carbon tax (introduced in Scenario 1a) throughout the investment period. The allocation of these investments is based on the same proportions as mentioned in the ESCAP estimation. Therefore, we have allocated approximately 0.28% of GDP per year to green transportation, 0.47% of GDP per year to energy efficiency improvement, and 0.67% of GDP per year to renewable energy investments for a period of 5 years. The overall size of the investment is around 1400 bln THB.

Scenario 3a: Energy related investment from newly issued debt

In Scenario 3a, we implement the additional energy related investment without introducing carbon tax, so investment is financed fully from newly issued debt. Figure 16 shows how this additional investment would increase government spending.

Figure 16. Impacts of Scenario 3a on government spending (% of baseline GDP)

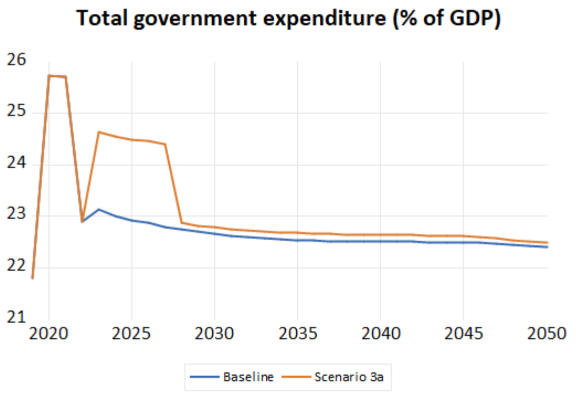
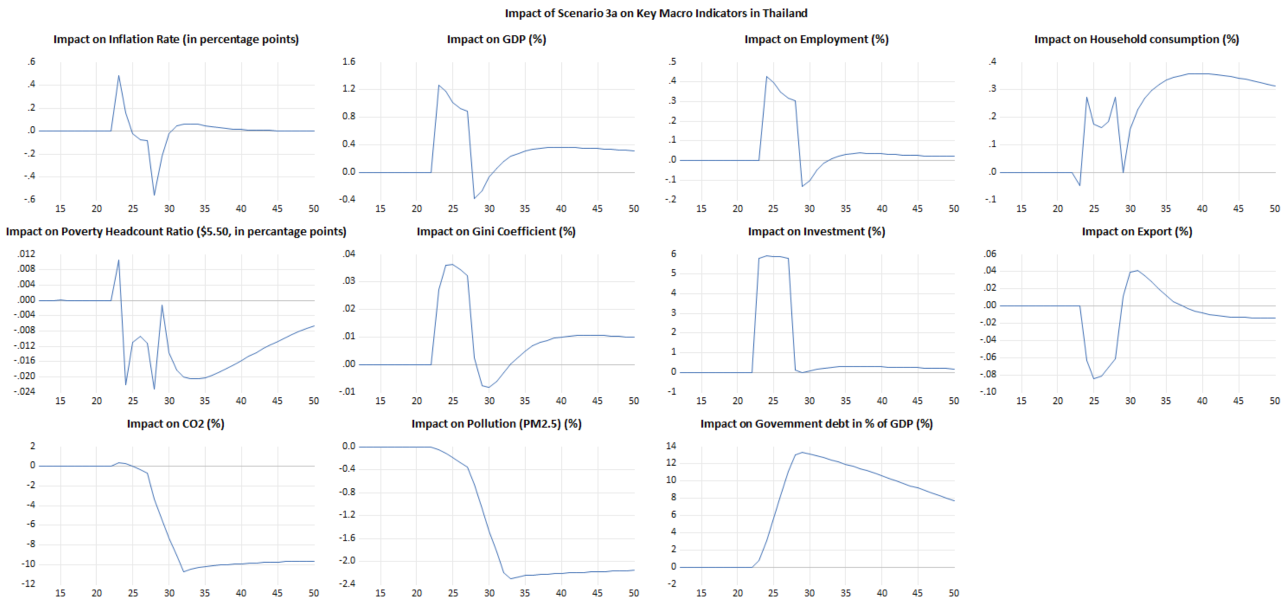


Figure 17 illustrates the expected impacts of the Scenario 3a:

Figure 17. Impacts of energy- related investments from newly issued debt on key indicators (in terms of percentage differences from the baseline)



The extra spending on energy-related investments results in short term economic stimulus, pushing up inflation, real GDP and employment during the investment period (from 2023-2027). However, after the phase-out of the spending, correction in the economic activity is expected to happen. General improvement in productivity (coming from lower pollution and better health and productivity) slightly pushes up the long-term GDP growth potential by around 0.4%.

The environmental effect of this scenario is sizeable. Although there is a temporary stable CO_2 emissions due to higher investment which offsets the positive effect for some years, the impact of the green energy investments becomes apparent later, leading to 7.3% decrease in CO_2 emissions by 2030. While this drop is smaller compared to Scenarios 1a, 2a, or 2b, it still represents a significant decline. The additional investment, particularly in energy efficiency, results in a pollution reduction of approximately 1.5% by 2030 compared to the baseline scenario. Since all of the additional government spending is financed by new debt, the public debt in percentage of GDP increases by 13% in 2030 compared to the baseline.

Overall, this level of targeted, specific energy-related investment would result in a manageable fiscal imbalance while yielding positive environmental effects similar to Scenario 1a.

Scenario 3b: Energy related investment from carbon tax revenue

In Scenario 3b we implement the additional energy related investment with the combination of $80 per ton of CO_2 carbon tax (as discussed in Scenario 1a). Its impact on government spending is illustrated in Figure 18.

Figure 18. Impacts of Scenario 3b on government spending (% of baseline GDP)

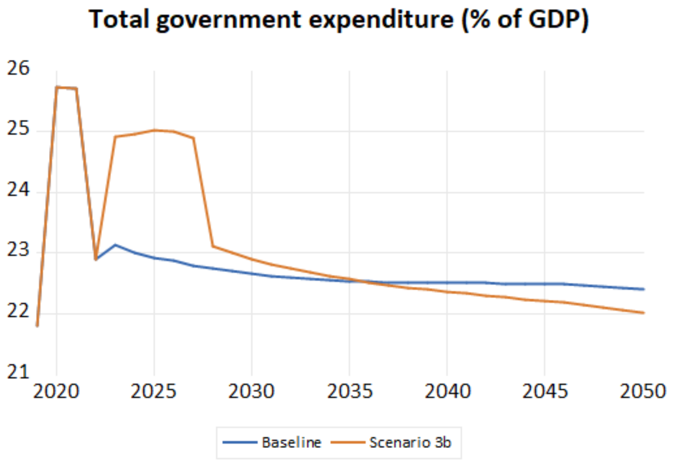
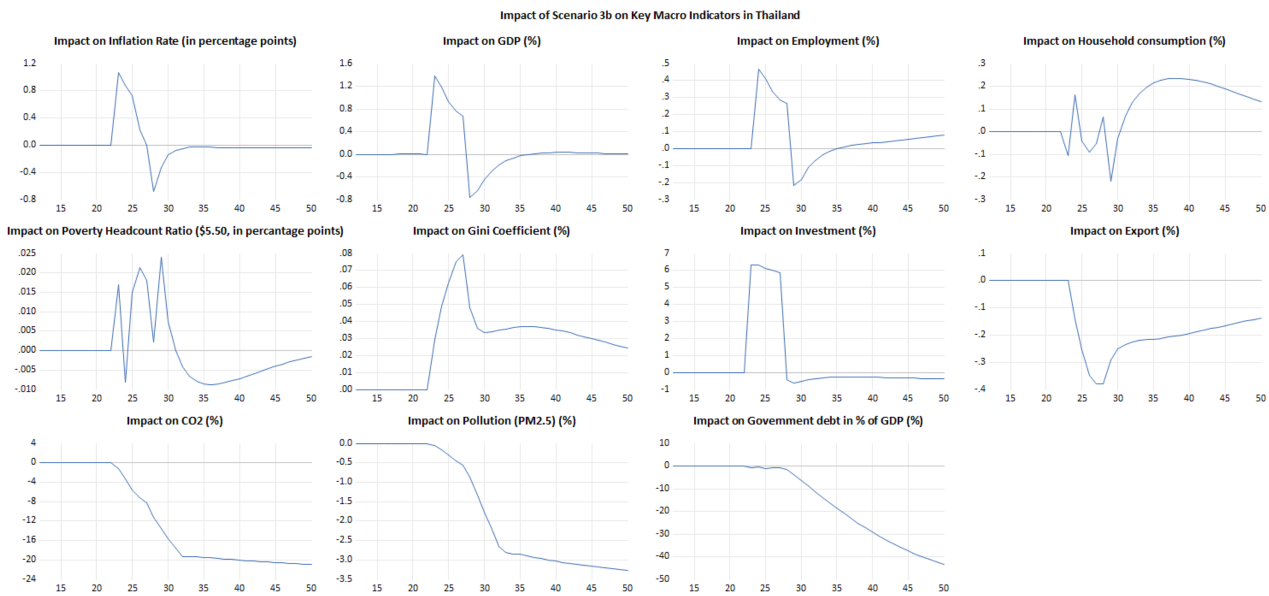


Figure 19 illustrates the expected impacts of the Scenario 3b:

Figure 19. Impacts of carbon tax and energy-related investments on key indicators (in terms of percentage differences from the baseline)



This policy combination, similar to Scenario 3a, would result in some short-term economic stimulus, although real GDP and employment growth in the short run are slightly lower than in Scenario 3a, as the carbon tax offsets some of the economic gains from the additional investment. Following the phase-out of the investment in 2027, a small economic correction is expected to occur. In the long run, the productivity improvements resulting from the extra investment offset the negative effect of the carbon tax, resulting in GDP growth similar to the baseline scenario.

The environmental impact of this scenario is substantial. In the short run, decline in CO_2 emissions is slower as higher investment spending somewhat offsets the carbon tax effect. However, the long-run effect of the green energy investment and the carbon tax becomes evident, leading to a 15.6% reduction in CO_2

emissions by 2030, which is the largest decline among all the scenarios so far. The additional investment, particularly in energy efficiency, contributes to a decline in pollution of around 1.8% by 2030 compared to the baseline scenario. As the investment is financed by the carbon tax, the average public debt as a percentage of GDP remains similar to the baseline scenario through the investment period. In Scenario 3b, the average public debt, from 2023 to 2030, as a percentage of GDP is 51%, while in the baseline it is 49%. Later on, additional investment from carbon tax will result in lower public debt.

Overall, well-targeted public energy infrastructure projects coupled with a carbon tax can support environmental goals and have a faster effect than in Scenario 2b. Although it creates some short-term fiscal and economic imbalances, the long-term positive effects of these policies can offset the short-term challenges.

4.4. Scenario 4: Bio-Circular-Green (BCG) Economy scenarios

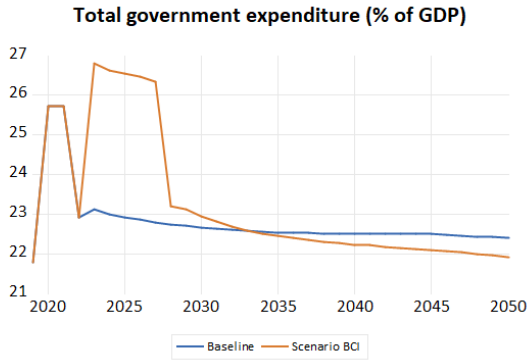
The 'Bio-Circular-Green' Economy model is a crucial framework for achieving sustainable post-pandemic recovery. In Scenario 4, we introduce a significant amount of government investment aligned with the BCG framework in the areas of environmental efficiency, environmental protection, health, and social protection. Overall, the investment amounts to 25% of the 2019 GDP, approximately 4,200 billion THB. It is equally distributed among different areas, and for modelling purposes, the policy areas are rearranged into larger investment categories. Table 1 summarizes the policy measures, investment categories, and the corresponding amount of additional spending:

Table 1. Government investment in Bio-Circular-Green Economy scenario

Policy targets	Investment categories	Total investment (% of 2019 GDP)	Total investment (billion THB)
***Investment in biodiversity**: biodiversity protection products; environmental-friendly production; soil, forest, wildlife and animal protection*	Environmental protection	4.2	701.2
***Healthcare**: technological investment to produce medicine and medical equipment*	Health spending	4.2	701.2
***Energy material and biochemical**: R&D in new renewable energy and technology, energy storage, value-added bio-based materials and biochemical to replace petroleum products*	Environmental protection	4.2	701.2
Green Tourism and cultural and natural sustainability, healthcare and wellness tourism	Health and environmental protection (50%-50%)	4.2	701.2
***Circular economy**: to support efficiency in production from design to waste in large size and SME scale*	Environmental efficiency	4.2	701.2
***Agriculture and Food:** value-added agricultural products and food safety products*	Social protection	4.2	701.2
	SUM	25	4,207.1

As a result of the regrouping, this scenario suggests additional spending of 1,750 billion THB in environmental protection, extra spending of 1,050 billion THB in healthcare, 700 billion THB in energy efficiency, and 700 billion THB in social protection (Figure 19). All of the spending is evenly distributed over the next 5 years. In addition to the extra investments, this scenario also implements a carbon tax, similar to the implementation in Scenario 1a. Therefore, the extra government investment is financed by the revenue from the carbon tax, and when it is needed also through newly issued debt.

Figure 20. Impacts of Scenario 4 on government spending (% of baseline GDP)



The impact transmission channels of a carbon tax in the ESCAP Macroeconomic Model for Thailand have already been summarized in Scenario 1. The transmission channels for health, environmental protection, and social spending align with those were summarized in Scenario 2. The transmission channels of environmental efficiency spending were discussed in Scenario 3.

Figure 21. Impacts of a carbon tax and BCG investments on key indicators (in terms of differences from the baseline)

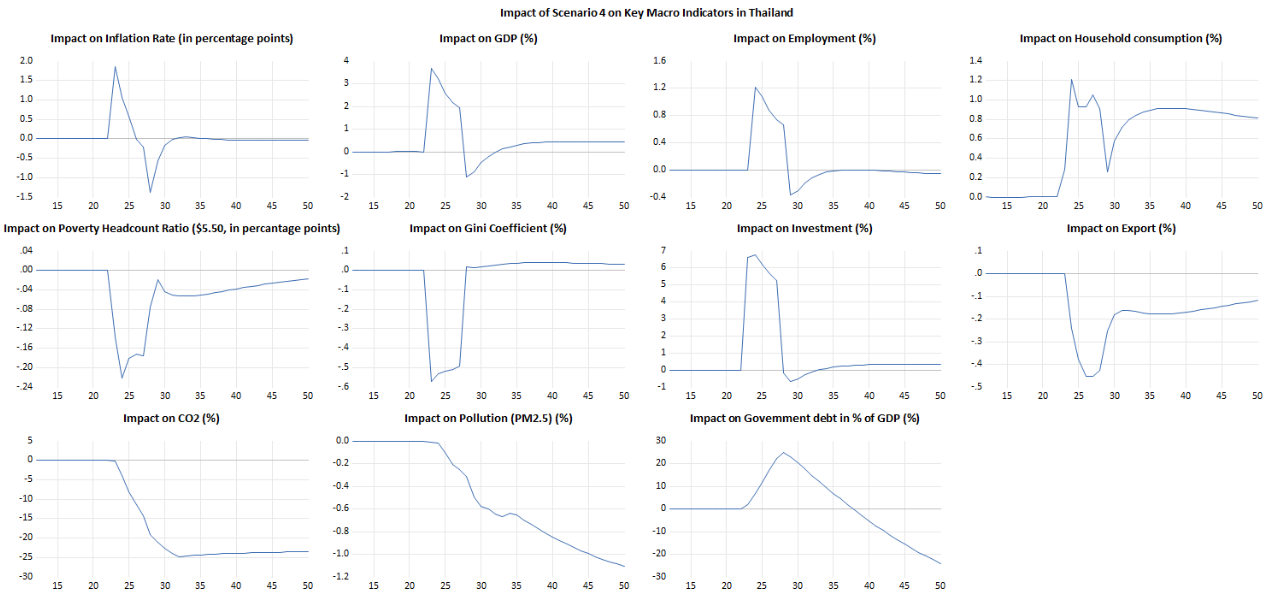


Figure 21 illustrates the expected impact of Scenario 4, when a significant amount of government spending is implemented according to the BCG framework, and financed through carbon tax revenue and newly issued debt. The additional spending creates some imbalances in the short run, leading to inflation rates that are more than 1.5 percentage points higher than in the baseline scenario for a few years. It also causes a considerable GDP increase, on an average of 2.7% compared to the baseline until 2027. As we assume government spending to normalize after 2028, real economic variables experience a sharp decline, with output and inflation correcting and economic activity slowing down.

In the long run, the targeted government spending results in a positive gain of 0.5% higher GDP. Since only a portion of the spending is allocated to social protection and the investment is temporary, social variables such as poverty ratio and GINI coefficient decline only marginally over the long term. As expected, the substantial increase in government spending on environmental protection and efficiency improvement, along with a $80 per ton CO_2 carbon tax, leads to a reduction of around 23% in CO_2 emissions until 2030. For a few years, the revenue generated from the carbon tax is less than the additional government spending, therefore the public debt increases. By 2030, the public debt as a percentage of GDP increases by around 20% compared to the baseline scenario. However, after the investment period, the carbon tax revenue will ease the fiscal pressure, the public debt decreases below the baseline by 20% until 2050.

Overall, the substantial amount of additional government spending within such a short time frame would result in significant volatility in the economy in the upcoming years. Although, the positive environmental and long-term economic effects are beneficial, a more gradual increase in spending and stronger social compensation should be considered.

5. Conclusion

Thailand is highly exposed to the effects of climate change, and its current economic activity heavily exploits natural resources. The level of waste and pollution could deteriorate long-term economic and social development. Slowing down the pace of global climate change and easing environmental degradation are national priorities, as evidenced by the National Strategy and the 13th NESDP. While the COVID-19 pandemic may have temporarily distracted attention from green ambitions, the re-prioritized commitment discussed in the 13th NESDP is crucial for solving Thailand's development challenges. The country is facing a joint challenge of meeting the energy needs of a growing economy while simultaneously meeting the emissions reduction commitments.

This paper develops a set of scenarios with the ESCAP Macroeconomic Model for Thailand that explore the potential economic, social, and environmental impacts of climate policies that can help Thailand accelerate progress toward a sustainable economy. One effective way to reduce emissions and promote renewable energy sources is the introduction of a carbon tax. Using the “new” government revenue generated from the carbon tax to accelerate public investment in various climate-friendly policies could help tackle not only environmental issues but also contribute to social and economic development. The scenarios and their modelling simulations explore the interactions between selected policy initiatives, economic activities, public finances, social development, and environmental indicators.

To accelerate low-carbon energy transition, Thailand is considering phasing out fossil fuel subsidies and introducing a carbon tax. However, a small-scale policy measure alone cannot make enough progress to meet the emissions reduction target of 30% by 2030. Therefore, higher carbon tax scenarios are also estimated in the paper. Introducing a more substantial carbon tax will temporarily increase inflation but has the potential to generate significant fiscal revenue that can be channeled into priority spending areas. It can also encourage a shift in the energy mix and a decline in greenhouse gas emissions.

By channeling the carbon tax revenue into business-as-usual policy spending, mainly on social protection, health, and education, additional expenditure could create beneficial long-term social and economic effects. However, it might not contribute enough to the environmental commitments. On the other hand, a gradual acceleration of environmental spending would significantly help meet the environmental targets in the long run. Nevertheless, without specific short-term public investment projects, the immediate effect could be less than desired.

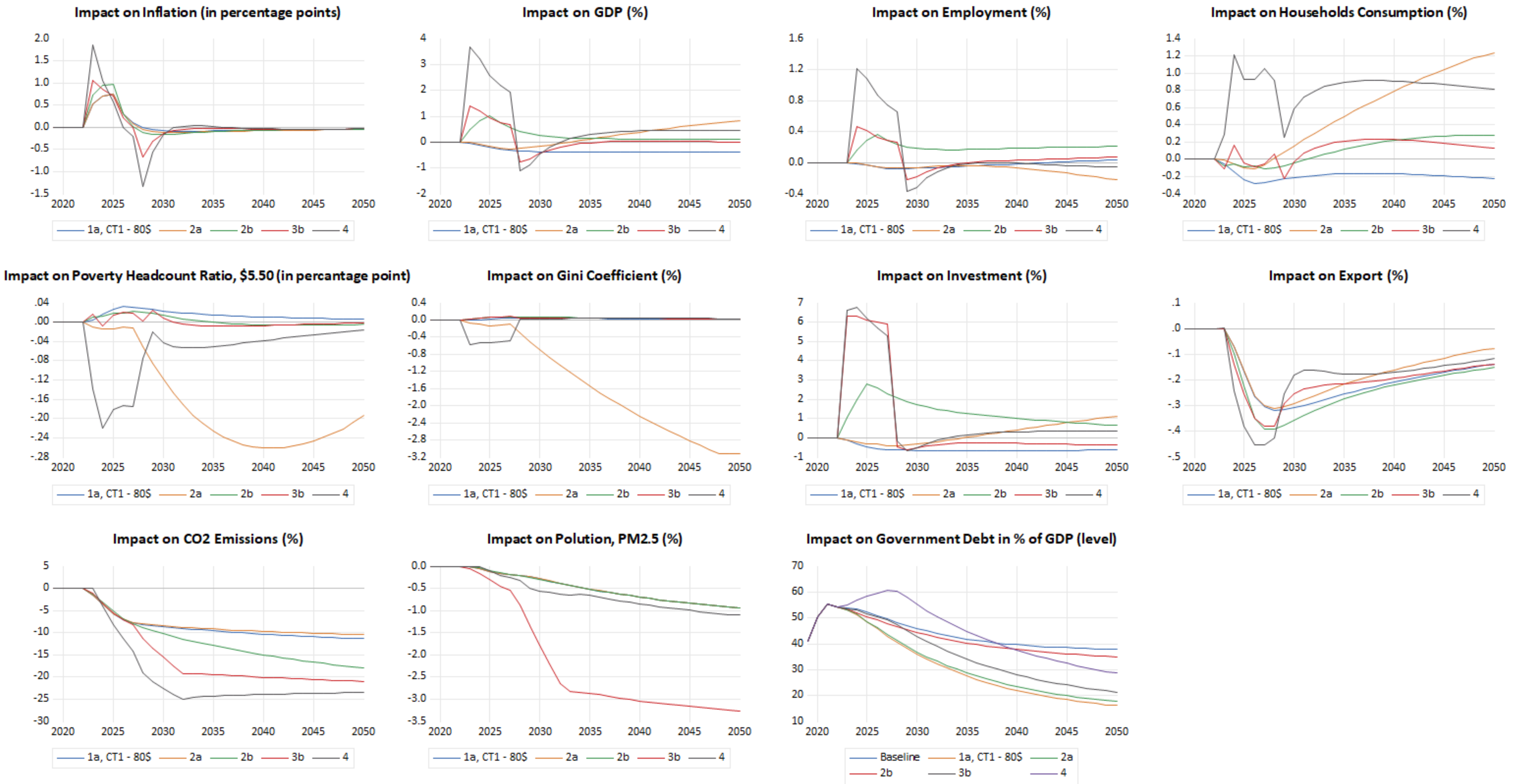
A targeted investment package in the coming years in energy efficiency, green transportation, and environmental protection could encourage a relatively rapid decline in emissions and pollution. Financing it from carbon tax revenue could mitigate fiscal burdens. However, policymakers should be aware that too quick implementation of a policy package might distrupt economic stability in the short run, even if the policies are targeting sustainable development goals and are partly financed by carbon taxes.

The scenarios (summarized in the Table 2. demonstrate the importance of carbon taxation and well-targeted and efficiencly allocated government spending. A substantial decline in emissions is achievable by government policies, particularly through an investment in low-carbon energy sectors. However, special attention should be given to economic and fiscal sustainability and social factors, as poverty and inequality reduction are key cornerstones of Thailand's development.

Table 2. Summary table of the Scenarios

Scenario		Implemented policies						Difference from the baseline (%)					Interpretation of the results
		Carbon Tax	***Carbon tax rate ($ per ton CO_2)***	***Extra gov. spending?***	***Extra government spending in which sectors (% of carbon revenue)***	***Extra gov. spending is from carbon tax?***	***Extra gov. spending time frame***	***CO_2 Reduction in 2030***	***Real GDP Change in 2030***	***Real GDP Change in 2050***	***% of GDP Public Debt Change in 2030***	***% of GDP Public Debt Change in 2050***	
1	***a***	yes	80	no	-	no	-	8.6	-0.4	-0.4	-21.4	-57.4	Small negative effects on the real economy and social indicators. Moderate environmental effects and significant fiscal space.
1	***b***	yes	120	no	-	no	-	11.3	-0.5	-0.5	-30.9	-82.5	Negative effects on the real economy and social indicators. Sizeable environmental effects and significant fiscal space.
1	***c***	yes	15	no	-	no	-	2.2	-0.1	-0.1	-4.6	-12.5	Negligible effects on economic, social, and environmental variables. Limited fiscal space.
2	***a***	yes	80	yes	Social protection (12.9%), health (9.2%), education (15.4), environmental protection (0.4%), debt reduction (62.1%)	yes	2023-2050	8.4	-0.2	0.8	-19.7	-53.2	Systematically higher social, education, and environmental spending from carbon tax results in positive social and economic effects. Environmental effects are similar to Scenario 1a, while the positive fiscal outcome is somewhat smaller.
2	***b***	yes	80	yes	Environmental protection (100%)	yes	2023-2050	10.2	0.3	0.1	-3.4	-7.3	When all the revenue generated from the carbon tax is spent on environmental projects, it has a moderate but positive economic effect. Environmental effects are larger than in Scenario 1a, but fiscal improvement is close to the baseline scenario.
3	***a***	no	-	yes	Energy efficiency, renewable energy, transportation infrastructure	no	2023-2027	7.3	-0.1	0.3	13.1	7.7	Well-targeted energy-related infrastructure projects have a negligible effect on the real economy and social indicators. However, the positive effect on environmental issues is similar to Scenario 1a. The fiscal situation deteriorates but remains manageable.
3	***b***	yes	80	yes	Energy efficiency, renewable energy, transportation infrastructure	yes	2023-2027	15.6	-0.4	0.0	-6.3	-43.4	Well-targeted energy-related infrastructure projects, coupled with a carbon tax can support environmental goals and have a faster impact than in Scenario 2b. Although it creates some short-term fiscal and economic imbalances, the long-term positive effects of these policies can offset the short-term challenges.
4		yes	80	yes	Environmental protection, health spending, environmental efficiency, social spending	partly	2023-2027	22.7	-0.5	0.4	20.4	-24.0	A substantial increase in government spending and a carbon tax would result in the largest decrease in emissions. The long-term environmental and fiscal effects of these policies are positive. However, additional investment within such a short time frame would lead to significant volatility in the economy in the upcoming years.

Figure 22 Supplementary comparison charts for scenarios with $80 per tonne CO_2 tax rate



6. References

Botev, Jarmila, Balazs Egert, and Fredj Jawadi (2019). The non-linear relationships between economic growth and financial development: Evidence from developing, emerging and advanced economies. International Economics, 160, 3-13.

Botev, J., Égert, B., Smidova, Z., and Turner, D. (2019). "A new macroeconomic measure of human capital with strong empirical links to productivity," OECD Economics Department Working Papers 1575, OECD Publishing.

Briceño-Garmendia, Cecilia, Antonio Estache, and Nemat Shafi (2004). Infrastructure Services in Developing Countries: Access, Quality, Costs and Policy Reform. World Bank Policy Research Working Paper 3468.

European Central Bank (ECB) (2017). Does trade play a role in helping to explain productivity growth? Economic bulletin, Issue 7.

Griscom and others (2017). Natural climate solutions. Proceedings of the National Academy of Sciences of the United States of America, 114(44), 11645-11650.

Holland, D., & Sirimaneetham, V. (2021). MPFD Working Paper on Policy Scenarios to build forward better in Asia and the Pacific. Retrieved from https://www.unescap.org/kp/2021/mpfd-working-paper-policy-scenarios-build-forward-better-asia-and-pacific

International Energy Agency (IEA) (2019 and 2020). World Energy Outlook.

OECD (2019). Sustainable Infrastructure for Low-Carbon Development in Central Asia and the Caucasus: Hotspot Analysis and Needs Assessment, Green Finance and Investment, OECD Publishing, Paris, https://doi.org/10.1787/d1aa6ae9-en.

Wang, Fuhmei (2015). More Health Expenditure, Better Economic Performance? Empirical Evidence from OECD Countries. Inquiry, 52, 1-5

UNDP (2022). COUNTRY PROGRAMME DOCUMENT FOR THE KINGDOM OF THAILAND 2022-2023, https://www.undp.org/thailand/publications/country-programme-document-2022-2026

7. Appendix: Technical description of the ESCAP Macroeconomic Model for Thailand

7.1. Summary

The ESCAP Macroeconomic Model is a global model and comprises 46 individual full-country models for the Asia-Pacific region, including a model of Thailand, smaller models of 9 key trading partners outside of the region, plus aggregate models for the remaining world's economies grouped into 4 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 labor, while firms produce output, hire labor 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, and 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 labor force, capital stock, energy use, energy efficiency, trend productivity growth and damage from climate shocks. The labor force depends on demographic factors and the labor 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 percent 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 $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.

7.2. ESCAP Macroeconomic Model equation listing

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

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

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 Policy-Related Interest Rate, 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)

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

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

Female employment, 1000s (LNNF)

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

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 Good & 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, Billions 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, US$ billion (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, US$ billion (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)

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

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)

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

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 ($ per barrel)

Deflator for Export of Good & Services, US$, 2015 =100 (XTD$)

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

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 ($ 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$ billion (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)

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

EXR Exchange rate (national currency / US$)

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

Real effective exchange rate, 2015 = 1 (REFEX)

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

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 CO2. (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)

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

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)

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

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 CO2.
CO2	Territorial carbon dioxide emissions, MtCO2
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)

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

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)

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

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)

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

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)

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

$CDF_{LOGNORMAL}$	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)

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

$CDF_{LOGNORMAL}$	Log normal cumulative distribution, evaluated at $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)

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

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 meter
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)

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

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)

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

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)

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

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)

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

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, MtCO2 (CO2)

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

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 CO2.

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 CO2.

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 CO2.

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

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

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)

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

$CO2^{WLD}$	World carbon dioxide emissions, MtCO2

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

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

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

Primary energy consumption, Exojoules (EC)

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

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)

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

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)

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

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)

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

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)

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

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

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

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

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

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

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

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

7.3. 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.
CO2	Territorial carbon dioxide emissions, MtCO2	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 CO2 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 CO2 emissions from gasl 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 CO2.	Estimated as net carbon tax revenue as a share of CO2 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 $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 $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 fo 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 CO2 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 Moodys 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 Good & 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, Billions US$	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, Billions US$	Export volumes in domestic currency converted to US$
YBAR	Survey mean 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, Billions US$	Trend output in domestic currency converted to US$