National Institute of Economic and Social Research

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Scenarios for Assessing Climate-Related Risks:

New Short-Term Scenario Narratives by UNEP FI and NIESR

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About UNEP FI's Risk Centre

Since 2017, the UN Environment Programme Finance Initiative's (UNEP FI) Climate Risk and the Taskforce on Climate-Related Disclosures (TCFD) programme has taken a leadership role in developing good practices to identify, measure, disclose, and manage climate risk in the financial sector. Working with over 100 banks, insurers, and various investors, the programme has created numerous tools, frameworks, and guides to accelerate the implementation of good practices. Although the programme initially focused on implementing the recommendations of the TCFD, it has since broadened its scope to focus on legal risks, climate stress testing, climate scenarios, climate tools, and other related areas.

In 2024, UNEP FI launched its Risk Centre. This Risk Centre provides a resource tailored especially for risk managers, integrating all its existing climate and nature risk-related work programmes, tools, and peer learning opportunities for assessing and managing climate and nature risks. The Risk Centre is extending its offerings to cover other sustainability risks, such as pollution and just transition. It also aims to consolidate UNEP FI's diverse risk programming under one umbrella, fostering a holistic approach to sustainability risks. The Risk Centre consists of two main components: (1) a resource hub that disseminates knowledge on sustainability risks; and (2) technical programming facilitated by working groups with the aim of producing decision-useful resources for the finance sector, such as cutting-edge tools, guidance, and methodologies.

About NIESR

The National Institute of Economic and Social Research (NIESR), is Britain's longest -established independent research institute,. It is dedicated to conducting research on economic and social forces impactingthat impact people's lives and their. In this vein, its mission is to "carry out research into the economic and social forces that affect people's lives, to improve the understanding of these forces, and the ways in which policy can bring about change" (NIESR, 2023). Focused on enhancing understanding and influencing policy changes, NIESR collaborates with leading academic institutions, governments, and foundations.

NIESR's renowned NiGEM model (the National Institute Global Econometric model), utilised by central banks and international organizations, informs influential quarterly economic forecasts for the United Kingdom and global economies (NIESR, 2023). It is utilised primarily by central banks and international organisations

Contents

List of figures and tables

Figures

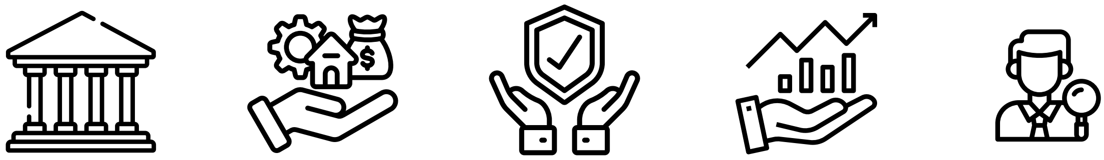
Tables

Purpose of the document

The use of climate scenario analysis as a tool has become widespread, but a major gap exists in short-term scenarios that explore near-term risks, economic volatility, and potential systemic vulnerabilities. The need for short-term scenarios for climate scenario analysis has grown rapidly in recent years as financial institutions acknowledge the need to take a closer look at how they can integrate climate commitments into their short-term planning strategies and address climate risks in the near term. However, the majority of currently available climate scenarios focus on long-term perspectives to explore climate risks, with only a limited number taking the short-term into account.

This report, and the accompanying Short-term climate scenarios tool, aim to bridge this gap in climate scenario analysis by identifying short-term scenario narratives for financial use. It serves as a guide to help financial institutions understand the implications and drivers of a range of short-term shocks. This report is accompanied by an Excel-based visualisation tool with new scenarios that explore a set of macroeconomic, transition, and physical risk shocks, allowing users to explore combinations of these three types of shocks.

Who is this report for?



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Executive summary

Climate scenarios are crucial tools for the finance sector to assess the effects of climate change on the economy and financial system. Traditionally, financial actors have viewed climate risks as long-term risks, but there is a growing realisation about the importance of assessing short-term climate risks. While long-term scenarios are vital for understanding transition costs and benefits, they offer only a partial view of near-term risks. Recognising short-term risks is crucial for central banks to fulfil their financial stability duties and for financial institutions to integrate climate risks into their near-term planning. Integrating short-term scenarios has become essential for financial institutions to comprehend the financial implications of transitioning to a net-zero economy. These short-term scenarios span one to five years. They are valuable for stress testing and aligning short-term strategies with climate risk mitigation and business planning, thus addressing the limitations of the medium- to long-term scenario analysis. Additionally, they allow for the translation of shocks into immediate impacts, considering both mitigation policies and the evolving impact of climate change on the financial system. However, the availability of short-term scenarios is limited, with most focusing on the long-term outlook of 2050 and beyond.

This report and the accompanying Short-term Climate Scenarios tool were developed in collaboration by UNEP FI and NIESR. Together, they offer financial institutions an added tool for performing short-term scenario analysis of climate risks. They explore the implications of short-term scenarios and investigate how a set of developed macroeconomic, transition, and physical shocks evolve and their economic impacts (Figure 1). The accompanying tool allows users to explore short-term shocks related to macroeconomic events, transition risks, and physical risks, either in combination or independently, across a five-year time-horizon for various jurisdictions and regions. Users can select a combination of shocks and a range of severities to generate their own potential shock scenarios for internal use (Figure 2). The methodology, assumptions, and key results of the shocks have been detailed in this report.

Figure 1: Use cases for UNEP FI and NIESR's short-term scenarios Excel-based tool

Figure 2: Screenshot of the Excel-based visualisation tool, including shock, variable, and region selection and visualisation of the results

These shocks have been developed using the National Institute's Global Econometric Model (NiGEM). The development of these shocks comprises four key components:

- **Narrative:** The shock being investigated and the reasoning behind the shock.
- **Source:** Area of the economy that causes the movement away from the base case (forecast).
  - Whether the source of the shock is domestic or international.
  - Whether the shock affects prices, supply, demand, and/or labour.
- **Channels:** Linkages in NiGEM that best describe how the shock propagates.
  - Country-specific or global shock.
  - Considerations of various shock components (such as demand, supply, and prices) and any unintended consequences of the shock.
- **Implementation:** Determine the size of the shock.
  - Direct implementation of shock size to relevant channel(s) of NiGEM.
  - Known impact implemented as a calibrated shock to the relevant channel(s).
  - Decisions related to the policy environment (adaptive, rational, monetary, and fiscal policy, etc.).

Overview of shocks developed in this exercise

Macroeconomic shocks

	Shock driven by geopolitical tension	Greenflation	Inflation
Narrative	▪ Based on SSP 3 with increased nationalism and regional rivalry in the green transition. ▪ Explores a rise in national priorities, resulting in competition between countries.	▪ Explores the impact of transitioning from fossil fuels to renewable energy technologies on metal prices, resulting in greenflation.	▪ Examines a macroeconomic situation where unforeseen events lead to record-high global inflation rates, as observed in 2022.
Source	▪ The main impact of the shock is the impact on trade. ▪ Impact is assumed to be similar to that seen during the COVID-19 pandemic.	▪ Shock is modelled by assuming the future metal price fluctuations' impact on the economy to the current impact of fossil fuel.	▪ Shock explores high levels of inflation, similar to the levels observed since the start of the Russian Federation-Ukraine conflict. ▪ A direct endogenous shock is applied to consumer expenditure deflator (CED) in all economies.
Channels	▪ Export volumes were scaled down in line with pandemic data. ▪ Global productivity is assumed to decrease. ▪ Commodity price shock to oil.	▪ Introduction of an energy shock. ▪ Implementation path of the shock was based on pre-financial crisis data for energy use.	▪ A calibration was performed based on the maximum value of inflation in a given quarter observed since the start of the conflict.

Implementation and size	▪ Three intensity levels for the shock are explored; high, medium, and low. ▪ Intensity based on price, productivity, and energy price shocks and their transmission channels.	▪ Three intensity levels for the shock are explored; high, medium, and low.	▪ Three intensity levels for the shock are explored; high, medium, and low.

Transition risk shocks

	Shock driven by geopolitical tension	**Greenflation**	**Inflation**
Narrative	▪ Carbon price increases by USD 57–USD 368 per ton of carbon dioxide (CO_2) across the five years.	▪ Consequences of a sudden and significant surge in green spending.	▪ Sudden occurrence of stranded fossil fuel assets from 2023 to 2027. ▪ Carbon price rises, fossil fuel consumers face a higher cost, and demand for fossil fuels decreases, resulting in a drop in fuel prices.
Source	▪ Full set of shocks from the NGFS Delayed Transition scenario are temporally shifted from 2031 to 2023.	▪ The level of spending assumed was taken to be the average spending in terms of percentage of gross domestic product (GDP) on research and development from 2010 to 2019 by countries.	▪ It is assumed that oil-producing countries experience a 50 per-cent reduction in the price of oil.
Channels	▪ Shocks are applied as an absolute delta for the carbon tax and energy tax revenue. ▪ Percentage delta shocks are applied for energy consumption and change in useful energy.	▪ This shock equates to both a productivity shock (through technology) and direct demand shock through government investment.	▪ Further shocks to domestic demand and trend capacity of output for oil-producing developing economies.
Implementation and size	▪ The carbon tax has the potential to generate government revenue but also impact business capital stock, thereby affecting business investment. ▪ Carbon price impacts domestic energy demand and the pricing and volume of imports and exports.	▪ Three intensity levels for the shock are explored; high, medium, and low.	▪ A global negative shock to equity prices and a positive shock to investment premia were added. ▪ An extra shock to investment premia is applied to cover the greater uncertainty. ▪ Three intensity levels for the shock are explored; high, medium, and low.

Physical risk shocks

	Climate migration	Acute physical shocks	Country-level physical effect
Narrative	▪ Extreme climate events drive climate migration from hotspots in Sub-Saharan Africa, East Asia and the Pacific, South Asia, North Africa, Latin America, Eastern Europe, and Central Asia.	▪ Explores the economic implications of severe drought, heatwaves, flooding, and cyclone events assumed to occur from 2023 to 2027.	▪ Extreme chronic risks are assumed to occur globally from 2023–2027.
Source	▪ The size of the shock is determined by the total number of individuals anticipated to be relocated by 2050, distributed from 2023 to 2027	▪ Shocks modelled from the Phase 4 NGFS scenarios. ▪ Cyclones, heatwaves, and droughts were modelled as stochastic shocks with 70, 80 and 90 per-cent confidence bounds. ▪ The flood shock was modelled as a single shock based on annual data from Climate Analytics.	▪ Shocks modelled from the Phase 4 NGFS scenarios.
Channels	▪ Internal migration is assumed to have a negative population shock. ▪ External migration was modelled as an increase in total population, but assumed that there is no effect on the labour force.	▪ Impact of heatwaves is estimated by estimating the population exposed to severe heat stress. ▪ Drought shock is estimated through the potential impact on national crop yield and its effects through shocks to productivity, exports, and prices. ▪ Flood shock is estimated by its impact on capital because of asset damages, which impacts the economy through investment premia shock. ▪ Cyclone shock is estimated based on the direct impact on capital caused by asset damages and investment premia shocks.	▪ Shocks are implemented via demand-side and supply-side shocks. ▪ The combination of these shocks must mimic the GDP effects supplied by the damage functions by the NGFS.
Implementation and size	▪ Three levels of severity were modelled for the shock; high, medium, and low. ▪ Severity is determined by an inflation shock and level of uncertainty.	▪ Country-level projections provided for GDP losses.	▪ Assessment of chronic risks is grounded in GDP impacts. ▪ High GDP impact version; 95th temperature percentile for the Current Policies scenario ▪ 50th percentile for the delayed transition and net-zero scenarios.

1. Introduction

Importance of short-term scenarios

Climate scenarios play a key role in helping policymakers, regulators, and financial institutions analyse the potential impact of climate and mitigation policies on the real economy and the broader financial system. Currently, climate-related risks are often looked upon as long-term risks by financial actors but in recent years, ever more institutions are considering short-term scenarios as part of their climate risk toolkit. However, the availability of these scenarios remains limited. The majority of publicly available scenarios for use look at the long-term horizon, typically covering the period to 2050 in five-year time steps. Long-term scenarios are key to understanding the costs of the transition as well as the long-term benefits coming from mitigating physical risks. However, long-term scenarios only provide a limited picture of the potential transition and acute physical risks that could arise in the near term. Identifying such short-term risks can be important for central banks to inform their financial stability responsibilities. For financial institutions, meanwhile, it can assist with accounting for climate risks in their near-term planning cycles, as well as assessing severe climate risks and identifying potential vulnerabilities to a rapidly changing world.

For these reasons, the integration of short-term climate scenarios has become important for financial institutions looking to improve their understanding of the potential financial impacts associated with the shift towards a net-zero economy. The severity of short-term scenarios makes them useful for stress testing, which aids financial institutions in aligning their short-term strategies for climate risk mitigation with their business planning horizons. Spanning a one-to-five-year time frame, short-term scenarios can address the limitations of assessing climate risks through scenario analysis focusing on medium- to long-term horizons (Table 1). Short-term scenarios also enable a translation of shocks to short-term impacts, incorporating the role of expectations and readiness of the financial system concerning both mitigation policies and the impact of climate change itself (NGFS, 2023).

Table 1: Limitations of long-term scenarios (UNEP FI, 2022)

Feature of scenarios	Limitation
5 to 10-year time steps	Users may need to undertake interpolation exercises to produce short-term estimates due to the typical 5 to 10-year time steps
Financial analyses	Financial analyses over long horizons become more speculative due to likely economic and business strategy changes
Level of uncertainty	The longer the time horizon, the greater the uncertainty in the scenario projections
Severity	Lessened severity of economic impacts when they occur in the far future and loss of the near-term economic dynamics when interpolation is undertaken

Recently, there has been notable progress in the creation of tools and resources designed to assist financial institutions in performing short-term scenario analysis. The National Institute of Economic and Social Research (NIESR), in collaboration with the United Nations Environment Programme Finance Initiative (UNEP FI), previously developed three short-term macroeconomic shock scenarios for financial institutions to identify near-term risks climate change might pose. The scenarios were developed to investigate what would occur if there were a sudden rise in carbon price, a spike in the oil price, or a trade war (UNEP FI, 2022).

In 2023, the Network for Greening the Financial System (NGFS) released a conceptual note on short-term climate scenarios. In this document, the NGFS outlines details of five distinct climate scenario narratives that are being developed as part of its short-term scenario initiative (NGFS, 2023). These scenario narratives are formed by incorporating different geopolitical, economic, and technological factors to show diverse potential near-term futures. Three of the scenarios concentrate on mitigating climate change through strict policies, with each incorporating different timings and variations of macro-financial and technology shocks. These scenarios pose substantial transition risks and are consistent with long-term scenarios that explore pathways for mitigating climate change. Another of the NGFS's short-term scenario narratives highlights imminent high physical risks, with the final scenario exploring significant transition and physical risks arising from international differences in policy ambition (NGFS, 2023). Furthermore, the University of Exeter, in collaboration with the Universities Superannuation Scheme (USS), published a report that introduces four new short-term climate scenarios. The aim of these scenarios is to examine nearer and more practical time horizons in order to better guide investment decision-making (University of Exeter, 2023). Banque de France has also published a working paper on the use of short-term scenarios to assess the macroeconomic impacts of climate change (Banque de France, 2023).

In recent years, supervisory climate stress tests, which initially focused on a long-term horizon, now also incorporate short-term scenarios. For example, the Hong Kong Monetary Authority's 2023–2024 Climate Risk Stress Test exercise consists of both long-term and short-term scenarios. The latter combines climate-related and macroeconomic shocks. It also features an acceleration in policy action, as well as an increase in the frequency of extreme climate events across a five-year horizon (HKMA, 2023). Similarly, the European Central Bank (ECB) incorporated a set of short-term scenarios into its 2022 Supervisory Climate Stress Test. The ECB included a short-term disorderly transition risk scenario to assess banks' short-term vulnerabilities experienced as a result of a sharp increase in the price of carbon emissions. To assess physical risks, the exercise included two scenarios; a severe drought and heatwave scenario, and a flooding scenario (ECB, 2022). Both scenarios covered a one-year time-horizon. The incorporation of short-term scenarios can help to return climate stress testing to the realm of more traditional capital adequacy stress tests by assessing whether firms are prepared to handle economically adverse and volatile conditions.

Scope of the report

This report explores the implications of short-term scenarios. It also investigates how various potential macroeconomic, transition, and physical shocks will evolve over time, and explores what their macroeconomic impacts might be. This report aims to analyse and measure the severity of these short-term scenarios in comparison to shocks that are currently being assessed by institutions unrelated to climate change; for example, recessionary shocks and their impacts, and the impact of COVID-19.

The report covers the key methodologies, assumptions, and results of its accompanying Excel-based Short-term Climate Scenarios tool. This tool has been developed in collaboration between UNEP FI and NIESR with the aim of investigating the combination of macroeconomic shocks, transition risk shocks, and physical risk shocks across a short-term horizon. The tool enables users to select a combination of shocks and their severities in order to generate their own shock scenarios for internal use.

2. Methodology and shock results

2.1 Overview of NiGEM

The National Institute's Global Econometric Model (NiGEM) was employed to simulate short-term shocks explored in this report and as part of the accompanying scenario visualisation tool.

Developed and maintained by NIESR, NiGEM is a globally recognised econometric model refined over the past three decades. Widely used by policymakers and private sector entities for economic forecasting, scenario analysis, and stress testing, NiGEM operates as a global model while also comprising individual country and regional models connected through trade and integrated capital markets. This enables NiGEM to evaluate policy impacts on a specific country and assess how these policies interact globally. NiGEM assumes a closed world, where outflows from one country or region are balanced by inflows into others.

NiGEM's equations depend on both theory and data with a relatively rigid long-run structure using a common (estimated and calibrated) underlying structure across all economies. However, NiGEM's key behavioural equations are estimated using historical data to provide country-specific responses. Classified as a global general equilibrium macroeconomic model, NiGEM follows a broadly New Keynesian structure. It features gradual adjustments in prices and wages, with interest rates influencing investment and consumption decisions. Short-term impacts include shifts in domestic demand affecting employment and production, while the supply side guides long-term economic activity. Figure 3 below illustrates a full country model structure in NiGEM.

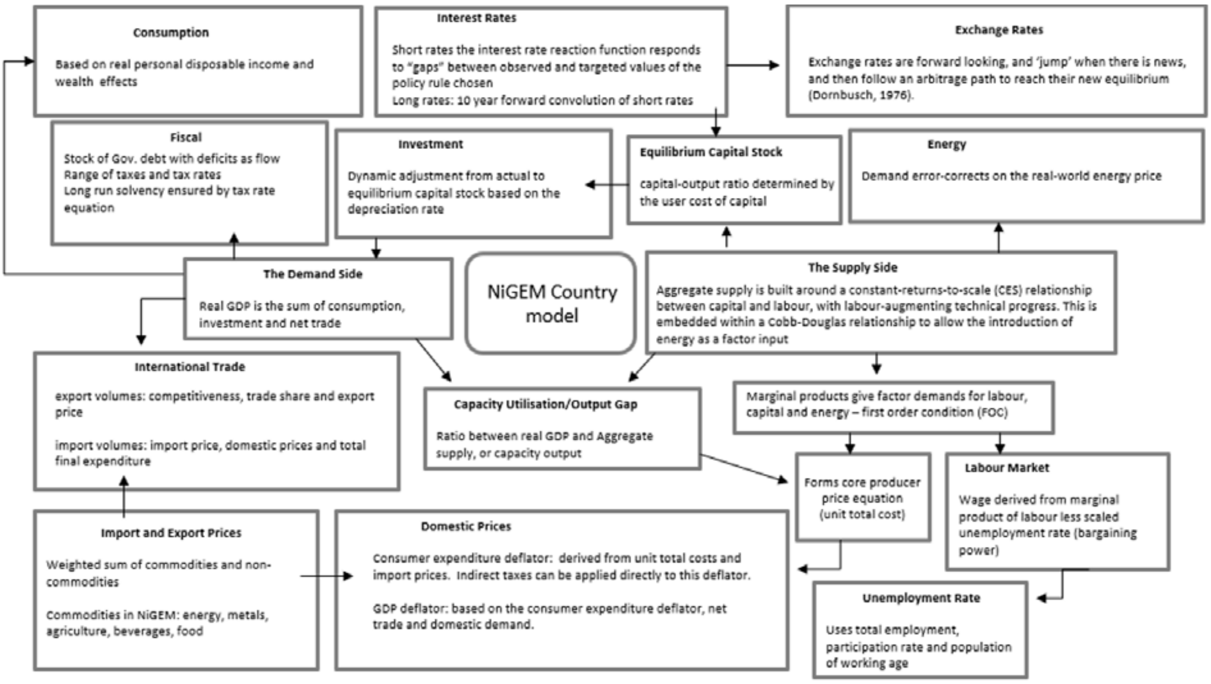

Figure 3: Full country model structure in NiGEM

NIESR has also developed a climate module in NiGEM to understand the interactions between the macroeconomy, climate-related shocks, and climate-related policy. Since 2021, NIESR has been a part of the modelling consortium of the NGFS climate scenarios. NiGEM provides greater macroeconomic detail, as well as details on the macroeconomic policy channels to complement the Integrated Assessment Models (IAMs) used by the NGFS. As part of the scenario generation, we have used the same model version of NiGEM used in the most recent NGFS scenarios. The model used in Phase IV of the NGFS was based on NiGEM v1.23, but was then expanded to include the economic channels used to model transition risk.[1]

2.2 Overview of the tool development methodology

UNEP FI and NIESR have collaborated to develop a short-term scenario tool that allows users to explore short-term macroeconomic, transition risk, and physical risk shocks in combination across a five-year time-horizon (Figure 4). Each scenario can include each of the following shocks:

- **Shock 1:** A macroeconomic shock: large-scale, unexpected impact on the economy.
- **Shock 2:** A physical risk shock: acute and chronic physical hazards and its accompanying consequences.
- **Shock 3:** A transition risk shock: driven by rapid policy implementation, technological advancements, and market shifts.

1 Further information on NiGEM can be found in the NGFS Climate Scenarios Technical Documentation and in the technical documentation by NIESR.

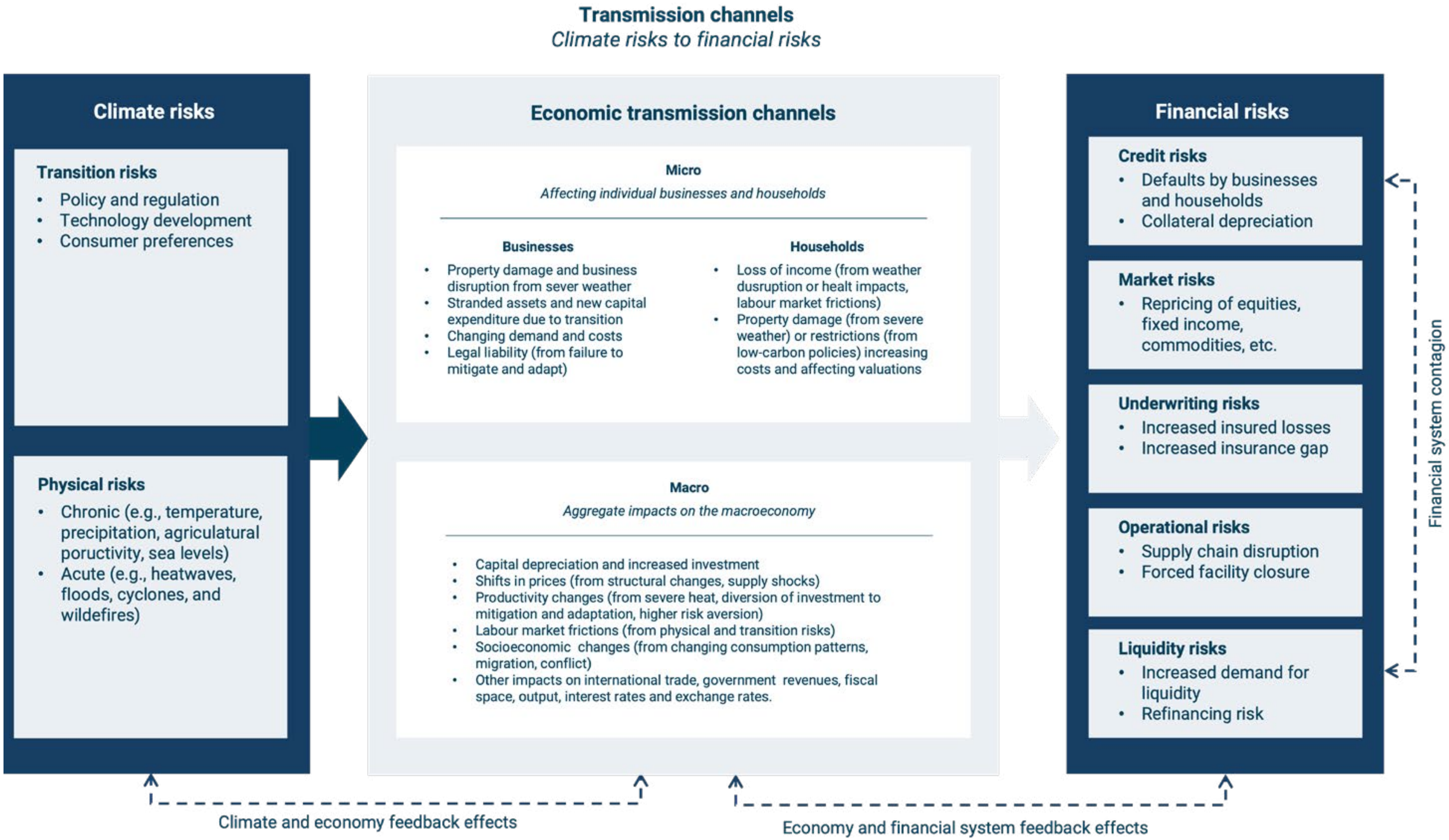

Figure 4: Climate risk transmission channels by the NGFS (adapted from NGFS, 2023)

The tool has been developed through engagement with members of UNEP FI's Climate Scenario Analysis Working Group, as part of its 2023 Climate Risk Programme. The engagement included workshops on the scope and features of the tool, as well as the short-term shocks in focus and the data used. Working Group members were also given the opportunity to pilot the tool ahead of the release. On top of input from UNEP FI members, the development of the tool included the incorporation of insights from academic literature, and as well as data from NIESR, such as on historical events and historical values for forecast.

2.3 Overview of the short-term shocks

The development of these shocks using NiGEM comprises of four key components:[2]

- **Narrative:** The shock being investigated and the reasoning behind the shock.
- **Source:** Area of the economy that causes the movement away from the base case (forecast).
  - Whether the source of the shock is domestic or international.
  - Whether the shock to prices, supply, demand and/or labour.
- **Channels:** Linkages in NiGEM that best describe how the shock propagates.
  - Country specific or global shock.
  - Considerations of various shock components (such as demand, supply, and prices) and any unintended consequences of the shock.
- **Implementation:** Determine the size of the shock.
  - Direct implementation of shock size to relevant channel(s) of NiGEM.
  - Known impact implemented as a calibrated shock to the relevant channel(s).
  - Decisions related to the policy environment (adaptive, rational, monetary, and fiscal policy, etc.).

The projected changes for each variable are internally consistent within the scenario. Where multiple shocks are applied to the model with several impacts covering a single scenario, these shocks are considered anticipated and interactive. Each shock is run independently, so the shocks can be considered unanticipated with regard to each other. Where suitable, various levels of severity of the shocks were explored. The impact of each shock on a variable is reported as a delta change from the base. The REMIND climate-neutral base was used as the baseline from which the percentage/absolute (value/volume/index variables are shown as % differences, while rates are shown as absolute) differences are reported.

2 The overview provided for each shock has been divided into the four components. To better understand the scenarios, it is recommended that users focus on the narrative, source, and channels. The implementation sections are made available for economics teams and other users.

2.3.1 Macroeconomic shocks

Shock driven from geopolitical tension

Narrative

This shock is a global shock based on the Shared Socioeconomic Pathway (SSP) 3 with increased nationalism and regional rivalry in the green transition. SSP3 is characterised by a resurgence in nationalism, where countries become more competitive and experience a rise in regional conflicts. In this pathway, nations shift their focus primarily to domestic and, to some extent, regional issues. Policies undergo a transformation to prioritise national and regional security concerns.

The shock explores a rise in national priorities as countries transition to a low-carbon economy in the near term, which results in competition between countries through the implementation of policies, (such as a rise in domestic subsidies and the imposition of carbon tariffs,) and a lack of global coordination to reach a consensus on aligning climate action with international trade rules.

Source

The main impact of the shock is the impact on trade due to increased nationalism, which is assumed to be similar to that seen during the COVID-19 pandemic.

Channels

The shock to the country-level price of exports was calibrated on a reduction in country-level export volumes based on that shown in the data for the pandemic. In addition, the lack of trade is assumed to lead to a reduction in global productivity. A decrease in world technological progress was imposed, equal to the fall in productivity observed over the past decade. Finally, the impact of the Russian Federation and Ukraine conflict was used as a guide for the size of the commodity price shock to oil.

Implementation

The transmission channels of the shock through NiGEM are illustrated below.

NiGEM links all trade (both prices and volumes) through the use of the Armington matrices.[3] As a result, the impact of a change in exports in any country is reflected by a change in imports in all other countries in the model based on trade links between countries. A rise in an external country's export prices will, in turn, raise import prices, which feeds directly into domestic prices. The resulting inflationary impact will affect labour and gross domestic product (GDP) of the given country. The price of exports has a direct impact on export volumes, therefore, a rise in a country's export prices will directly negatively impact that country's GDP (Figure 5).

3 Armington's (1969) principle is based on the fact that the total supply of an economy is an aggregate of domestic and imported foreign outputs. Domestic and foreign goods are considered substitutes and the output responds to both changes in relative prices and substitution elasticities.

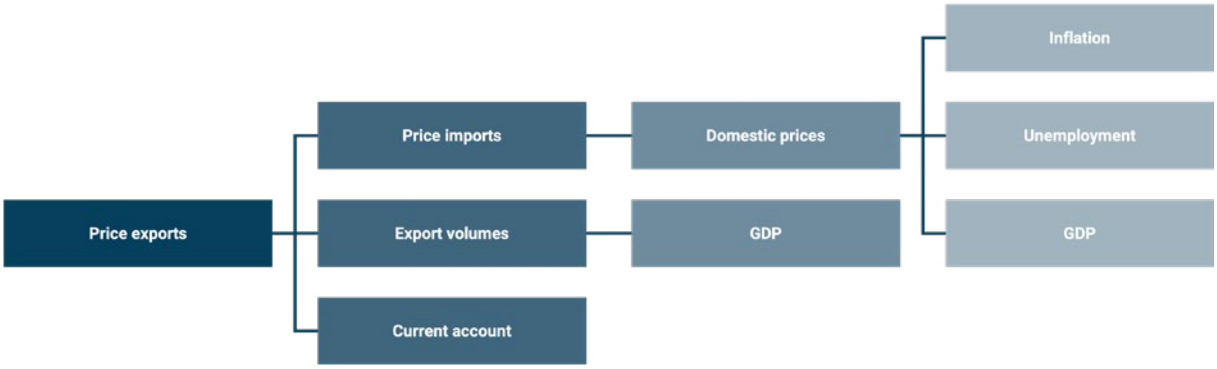

Figure 5: NiGEM transmission channels for the geopolitical tension shock on price exports

Trend capacity in NiGEM is governed by an underlying production function driven by the factors of production—namely, capital, labour, and energy. This is built around a constant-returns-to-scale (CES) relationship between capital (K) and labour (L), with labour-augmenting technical progress and embedded within a Cobb-Douglas relationship to allow the introduction of energy (M) as a factor input. The impact of a change in technical progress will affect economic productivity, government investment, and business stock.

NiGEM's labour demand and wage-price system is derived from the underlying production function where the profit-maximising condition from the labour side sets the real wage equal to the marginal product of labour. This forms the core long-run solution to three equations: labour demand (EE), nominal wages (WAGE), and unit or marginal costs (UTC). A change in technical progress will, therefore, also impact UTC directly, which in turn feeds into domestic prices (consumer expenditure deflator) (Figure 6).

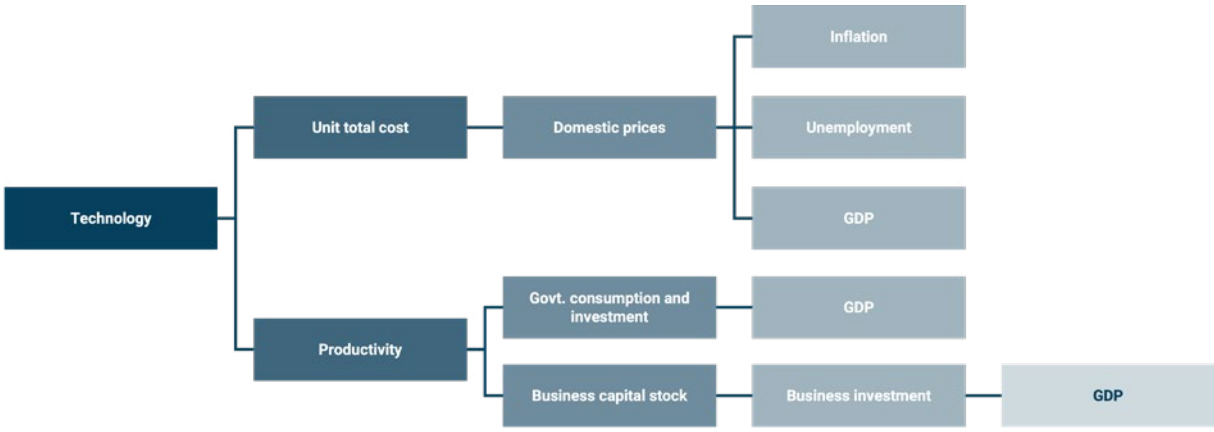

Figure 6: NiGEM transmission channels for the geopolitical tension shock on productivity and total unit cost

Energy prices form part of the production function and, hence, will directly impact the supply side of the economy. Domestic emissions taxes, such as an introduction of a carbon price on fossil fuels, act as an indirect tax. The carbon price, coupled with taxable emissions, impacts domestic prices in a similar manner to that of a VAT shock in the model, providing an inflationary impact (Figure 7).

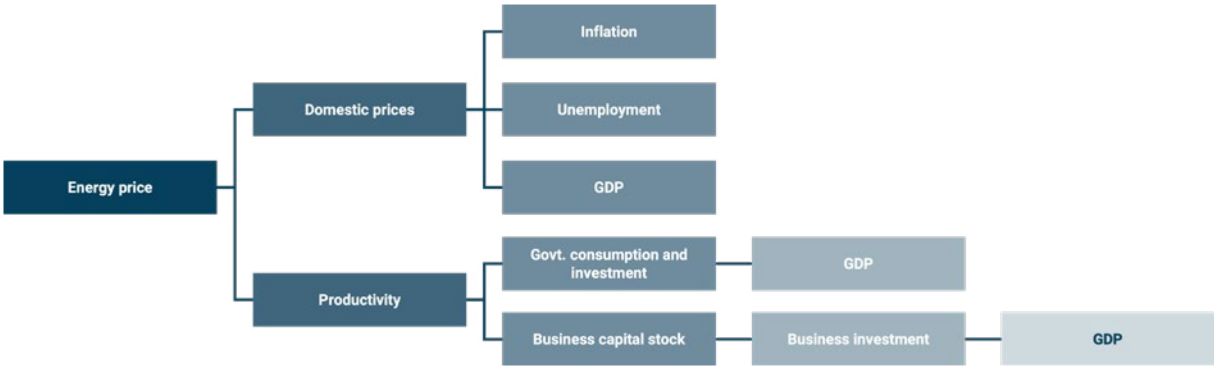

Figure 7: NiGEM transmission channels for the geopolitical tension shock on energy price

Three intensity levels for the shock are explored: high, medium, and low. The intensity is determined by the following three shocks:

- **Price shock:** This is represented by an export price shock, which is calibrated to provide the same impact on export volumes as was observed in the data around COVID-19.
- **Productivity shock:** This is a second calibrated shock using world technical progress (which feeds into all country-level productivity equations) to provide a fall in world productivity equivalent to the average of the past decade.
- **Energy price shock:** The duration of the shock mimics the period of pre-financial crisis economic expansion when increased energy demand was accompanied by an increase in the price of oil. The severity of the shock was based on the Russian Federation-Ukraine conflict.

The table below summarises the key attributes for each intensity level provided.

Table 2: Intensity levels provided for the shock and their descriptions

Intensity level	Description
Low	Energy price shock was removed but includes price and productivity shocks based on historical data.
Medium	Determined by the historical precedents of the price, productivity, and energy price shocks.
High	Includes price, productivity, and energy price shocks but all shock values were increased by 50 per cent.

Results and impacts on countries

Table 3: Global expected impact (as percentage difference) of the shock driven by geopolitical tension (high severity) for selected variables from 2023 to 2027

Variable	Year 1 (2023)	Year 2 (2024)	Year 3 (2025)	Year 4 (2026)	Year 5 (2027)
GDP	-1.6	-3.5	-4.2	-4.6	-4.9
Inflation	6.5	4.2	2.7	2.0	1.4

Figure 8 illustrates the expected impacts of the geopolitical tension shock (high severity) on import volume in selected economies. With increased nationalism and reduced international trade, import levels across selected economies are projected to decline. In the first year (2023) of the shock, all selected economies are expected to experience a drop in imports, with **South Africa facing a decline of up to 14 percentage points compared to the base**. This could be due to a large decrease in its largest import of mineral fuels, including oil, as trade levels decrease and South Africa transitions to a low carbon economy, resulting in the rise in alternative clean energy sources. By the fifth year of the shock (2027), significant decreases in imports are projected, with **some economies potentially witnessing declines exceeding 20 percentage points**. Over the five-year period, Brazil and China demonstrate the smallest percentage decrease in import volume in response to the shock.

Figure 9 illustrates the expected impacts of the geopolitical tension shock (high severity) on GDP (level) and inflation in selected economies. GDP is expected to decline in all the selected economies, and inflation is expected to rise. In Year 1 of the shock (2023), GDP is expected to decline by 1–3 per cent relative to the baseline. As nationalism intensifies over the five-year period, a further decline in GDP is expected. **Brazil and China exhibit greater resilience** to the GDP impacts compared to other selected economies, **with an expected decline of 1–2 per cent in 2027, while other economies may see GDP decreasing by 5–8 per cent.** Inflation is anticipated to experience a significant rise in the first year of the shock (2023), with a projected increase of up to 8 percentage points in the USA. Inflation is expected to continue rising until the fifth year of the shock (2027), albeit at a slower rate. Developing and emerging economies, including Brazil, China, and India, are projected to experience a lower impact on GDP and inflation compared to developed countries such as the USA and France. This difference between the USA and Brazil and China can be attributed to greater labour abundance in developing and emerging economies as global trade declines and domestic production rises. Additionally, China's large industrial capacity enables the country to swiftly diversify the production of goods in response to changing economic conditions. Higher inflation rates in the USA and France compared to emerging economies could also be due to the higher production costs in these countries as a result of higher costs for labour, materials, and overheads.

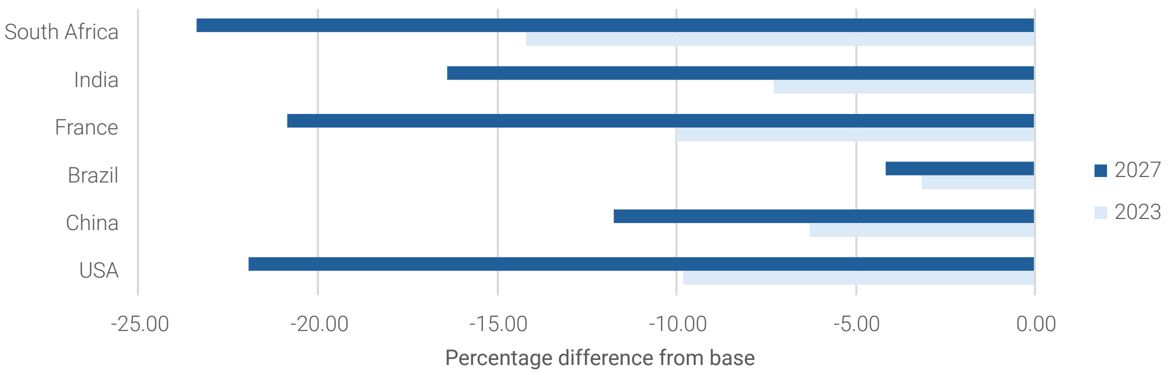

Figure 8: Impact of a geopolitical tension shock (high severity) on import volume for selected countries in 2023 and 2027

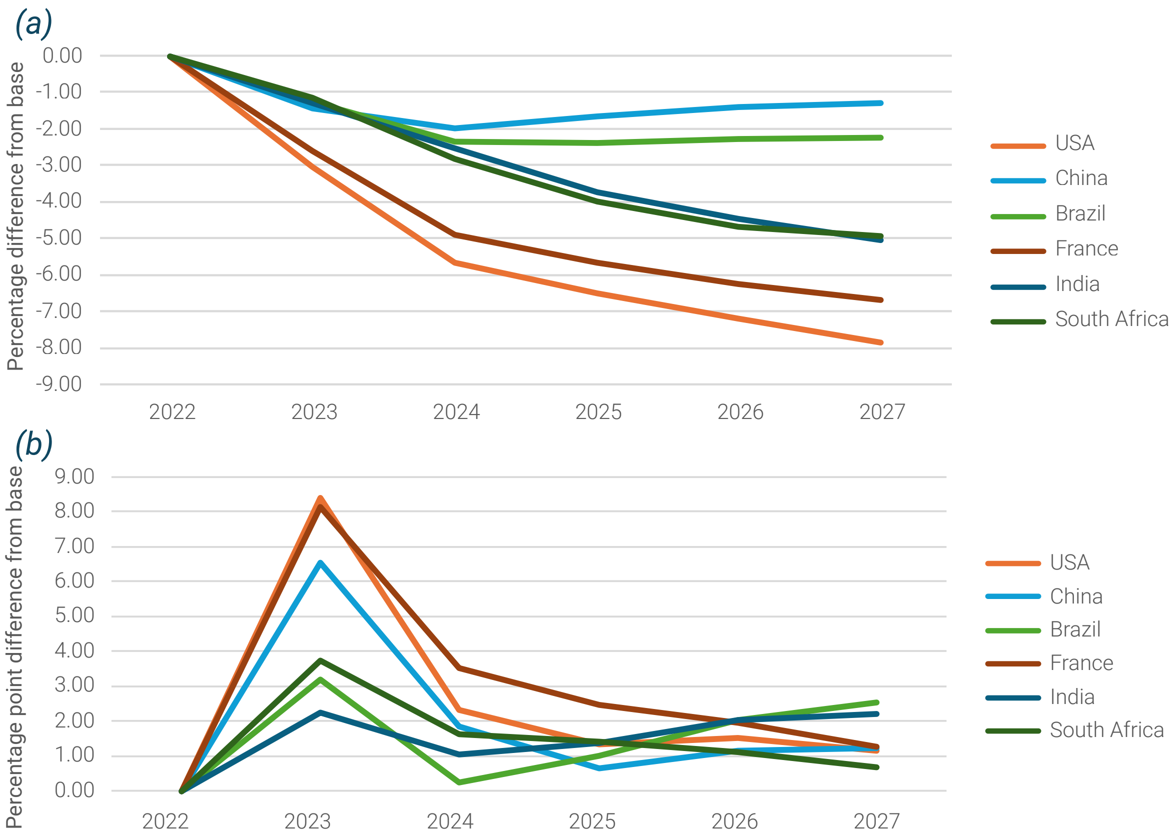

Figure 9: Impact of geo-political tension shock (high severity) on (a) GDP and (b) inflation, for selected countries

Greenflation

Narrative

Greenflation refers to an increase in the costs of raw materials and energy stemming from the transition to a low-carbon economy. This shock explores the impact of transitioning from fossil fuels to renewable energy technologies on metal prices.

According to the International Energy Agency (IEA), achieving net zero emissions by 2050 would require six times more critical minerals in 2040 compared to present levels (IEA, 2023). This shock explores the implications of a significant surge in demand for critical metals in the near future due to a sudden acceleration in the transition from fossil fuels to renewable energy technologies. As demand outpaces supply, the prices of critical metals are expected to rise rapidly. Metals like lithium, graphite, cobalt, nickel, and copper experience increased demand for applications in wind, solar, batteries, electric vehicles, and electricity networks (IEA, 2022).

The IEA estimates that the projected supply from currently announced projects would only meet approximately 65 per cent of the requirements by 2030 to achieve net zero by 2050 (IEA, 2023). Similarly, the shock assumes that the existing supply of critical metals falls short of meeting the necessary demand. The resulting increase in metal prices leads to higher energy costs, contributing to what is known as 'greenflation'.

Source

Since renewables rely significantly on critical metals, the shock is modelled by assuming the impact of metal price fluctuations in the future economy to be the equivalent of fossil fuel impacts in the current economy. No additional costs of transitioning between energy sources are considered.

Channels

Energy shock was introduced using data from the Russian Federation-Ukraine conflict to provide a baseline maximum size and the implementation path of the shock was based on pre-financial crisis data for energy use. There are no country-specific assumptions added to the shock, but the channels used by the shock reflect country-specific parameters.

Implementation

Three intensity levels for the shock are explored: high, medium, and low. Table 4 below summarises the key attributes for each intensity level provided. In all three cases, the duration and progression of the shock remain unchanged.

Table 4: Intensity levels provided for the shock and their descriptions

Intensity level	Description
Low	Modified the maximum size of historical precedents by a 50 per-cent reduction
Medium	Maximum historical precedents in terms of severity
High	Modified the maximum size of historical precedents by increases in severity by 50 per cent.

Results and impacts on countries

Table 5: Global expected impact (as percentage difference) of the greenflation shock (high severity) for selected variables from 2023 to 2027

Variable	Year 1 (2023)	Year 2 (2024)	Year 3 (2025)	Year 4 (2026)	Year 5 (2027)
GDP	-0.4	-1.0	-1.3	-1.4	-1.6
Inflation	0.3	1.1	1.5	1.8	1.7

This shock considers the impact of a rise in the cost of raw materials that is sustained for five years. This is driven by the transition to a low-carbon economy, causing an increase in demand for critical metals as these are the raw materials for renewable energy technologies. The result is a spike in energy prices. GDP is expected to **decrease by 1 to 3 per cent in the fifth year of the shock (2027) for selected countries and regions**. Similarly, due to rising energy costs, domestic demand is projected to decline, **falling by 4 per cent by Year 5 of the shock for the USA**. However, in the face of a greenflation shock, **the Middle East is expected to witness an increase in both GDP and domestic demand**. This could be attributed to the region's low electricity prices and substantial oil reserves. These factors could contribute to resilience against greenflation, enabling countries in the Middle East to rapidly diversify their electricity sources when costs for renewables rise.

Similarly, Figure 12 illustrates the expected impact of the shock on real disposable income for selected economies. **Countries such as the USA, the United Kingdom, and Germany are projected to experience a decrease in real disposable income of 4 to 9 per cent in 2027 as a result of greenflation**. China, Canada, and Denmark are expected to face a smaller impact on real disposable income, **with it decreasing by about 1.5 to 3 per cent**. Higher production costs due to greenflation can increase domestic prices in these countries, which leads to the lower purchasing power of households due to a reduction in real disposable income.

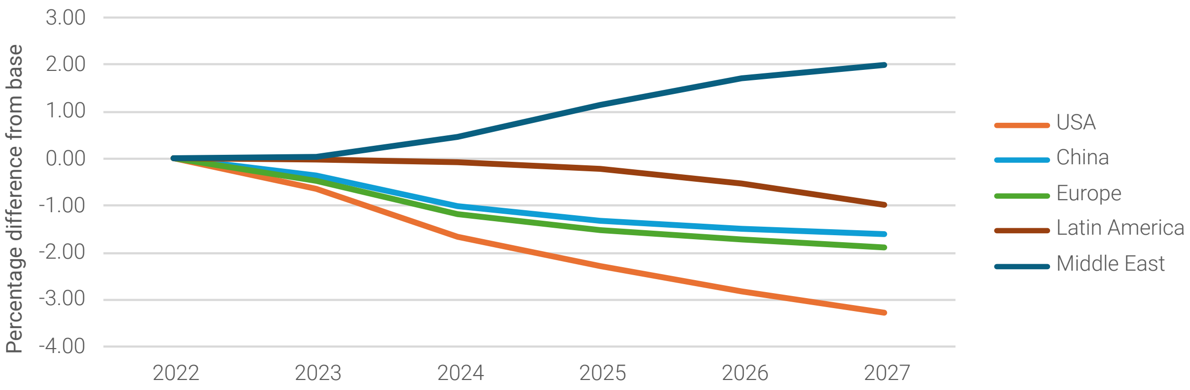

Figure 10: Impact of a greenflation shock (high severity) on GDP, selected economies

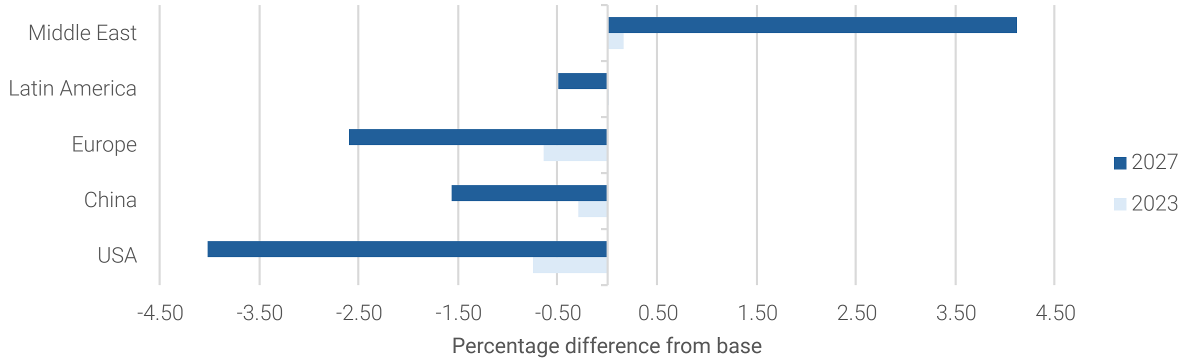

Figure 11: Impact of a greenflation shock (high severity) on domestic demand, selected economies in 2023 and 2027

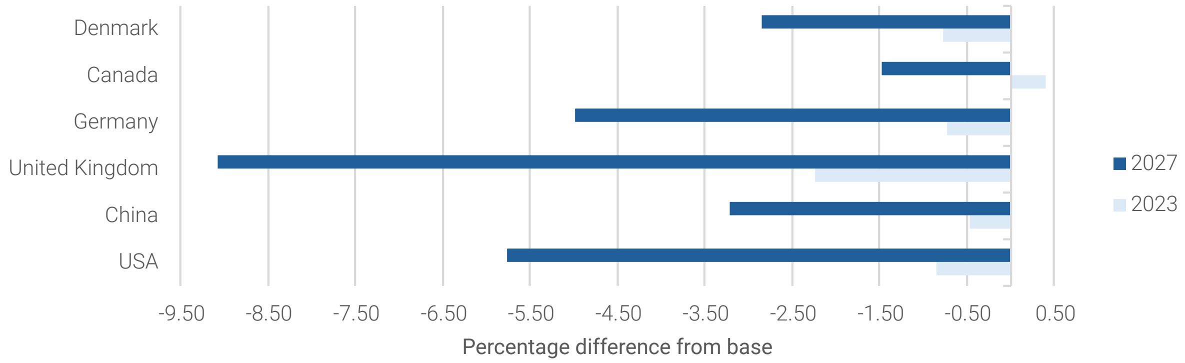

Figure 12: Impact of a greenflation shock (high severity) on real disposable income, selected economies in 2023 and 2027

Inflation (macroeconomic shock)

Narrative

In 2022, the conflict in Ukraine disrupted the global economic recovery from the COVID-19 pandemic, intensifying inflationary pressures worldwide (United Nations, n.d.). Many countries experienced unprecedented levels of inflation, with rates reaching multi-decade highs in Europe and the USA (Pew, 2022), which caught governments and central banks by surprise. This shock examines a similar macroeconomic situation where unforeseen events lead to record-high global inflation rates, as observed in 2022. This does not include changes in the inflation rate caused by climate change.

Source

This shock explores high levels of inflation, similar to the levels observed since the start of the Russian Federation-Ukraine conflict. A direct endogenous shock is applied to consumer expenditure deflator (CED) in all economies.

Channels

A calibration was performed based on the maximum value of inflation observed (in a given quarter) since the start of the conflict. All shocks were applied as a quarter of the final value and then stacked together to get the final full impact. The maximum observed shock value (annual inflation increase (relative to base) is comparable to annual inflation increase observed over 2022 in many economies) was applied to the first four quarters and then the 10th of the value for the next four quarters.

Implementation

Three intensity levels were explored for the shock: 150 per cent, 100 per cent, and 50 per cent of the maximum. These are categorised as high, medium and low inflation, respectively.

Similar to other scenarios, shocks are run based on default assumptions for monetary policy and fiscal reaction rules. Specifically, monetary policy will react to inflation and/or nominal GDP deviating from its target, while household tax rates will adjust if the budget deviates from the target. Higher domestic prices will constrain domestic demand via the consumption channel. Simultaneously, there will be an increase in interest rates to counteract inflation, which. This will constrain investment, reduce the accumulation of capital, and, ultimately, restrict potential output.

Results and impact on countries

Table 6: Global expected impact (as percentage difference) of the inflation shock (high severity) for selected variables from 2023 to 2027

Variable	Year 1 (2023)	Year 2 (2024)	Year 3 (2025)	Year 4 (2026)	Year 5 (2027)
GDP	-1.1	-3.2	-3.3	-2.9	-2.4
Inflation	7.2	10.2	0.8	-3.2	-3.7

Figures 13, 14, and 15 illustrate the expected impact of a highly severe inflation shock (i.e. 150 per cent of the maximum of the observed inflation as a result of the Russian Federation-Ukraine conflict). The inflation shock is projected to lead to a decline in GDP across a group of selected countries, encompassing both developed and emerging economies. In Year 1 (2023) of the shock, the decrease in GDP is expected to be limited to less than 2 per cent (Figure 13). In Year 5 (2027), the inflation shock is anticipated to further impact GDP, with **a decline of about 4 per cent for the USA**. Unexpected high inflation can reduce real household purchasing power. Meanwhile, lower demand for certain goods and services, as well as labour, can result in uncertainty in the economic outlook of a country. Such circumstances contribute to a decline in GDP for the USA (Federal Reserve Bank of St. Louis, 2022). By Year 5 (2027), among the selected countries, **only China shows economic growth**, albeit at a minor rate of 0.1 percentage points. China's GDP appears to be less affected by inflation compared to other countries, possibly due to consumption patterns and macroprudential policies related to borrowing costs, which are lower than those in other countries (Swiss Re, 2023). Domestic demand is expected to follow a similar trajectory, with a decline over the five-year period compared to the base year (2022). In Year 5 (2027) of the shock, the **USA is projected to experience a further 4 per-cent decrease in domestic demand**.

As a response to the inflation shock, long-term real interest rates are expected to rise, with a more substantial impact in the first year than in the fifth year of the shock. In Year 1 (2023), real interest rates are projected to **increase by 0.7 to 0.95 percentage points across the selected economies**.

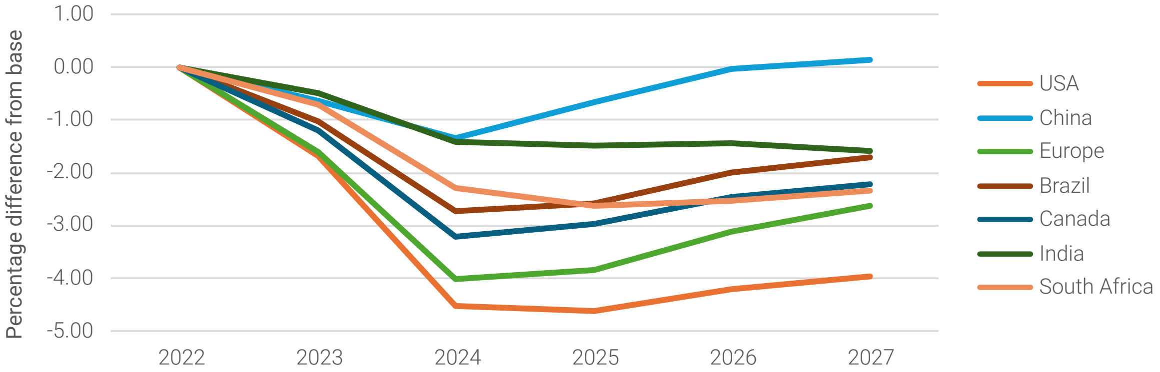

Figure 13: Impact of inflation shock on GDP, selected countries

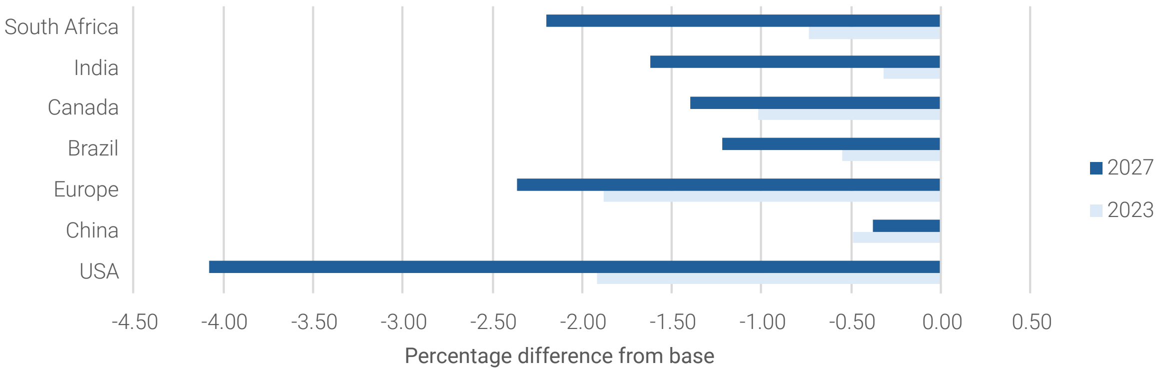

Figure 14: Impact of inflation shock on domestic demand, selected countries in 2023 and 2027

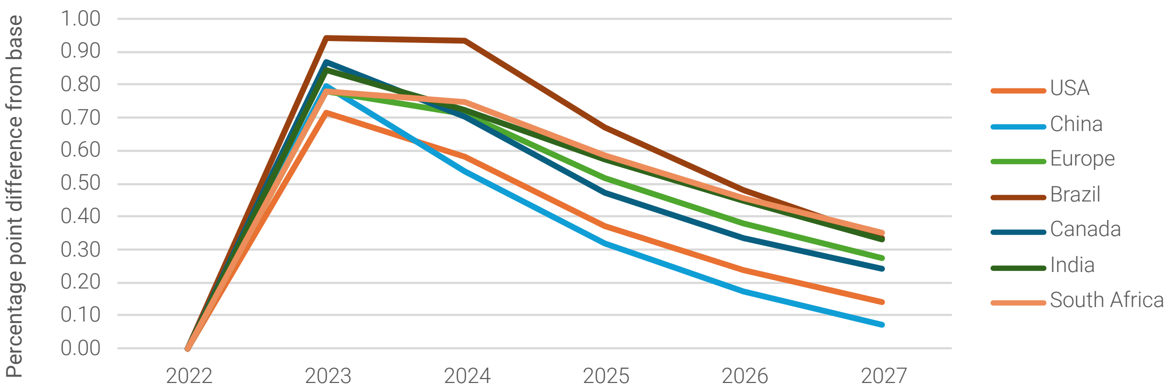

Figure 15: Impact of inflation shock on long term real interest rate, selected countries

2.3.2 Transition shocks

Imposition of stricter carbon price

Narrative

Globally, it has become evident that addressing climate change requires more aggressive and rapid action through a coordinated global policy effort. This leads to the sudden implementation of government policies, resulting in a sharp rise in the shadow carbon price. Over the course of five years, the carbon price increases by USD 57–USD 368 per ton of carbon dioxide (CO_2). Advanced economies adopt more ambitious pricing, reflecting the need for policy measures to induce additional behavioural changes.

Source

In this scenario, the full set of shocks from the NGFS Delayed Transition scenario using the REMIND IAM data is temporally shifted from 2031 to 2023. The carbon price increase is gradually implemented over a five-year period, and its stringency varies by country. Advanced economies are assumed to adopt more ambitious pricing, reaching an average carbon price of approximately USD 325 per ton by 2027, while most other regions are expected to maintain prices below USD 231 per ton. Country-specific carbon price levels can be found in Figure 16. The higher pricing in advanced economies reflects the necessary policy measures to bring about additional behavioural changes.

The assumption underlying the carbon price shock is based on a coordinated global policy effort aimed at mitigating climate change. While carbon prices may vary among countries, this primarily reflects disparities in each country's marginal abatement costs rather than differences in policy efforts.

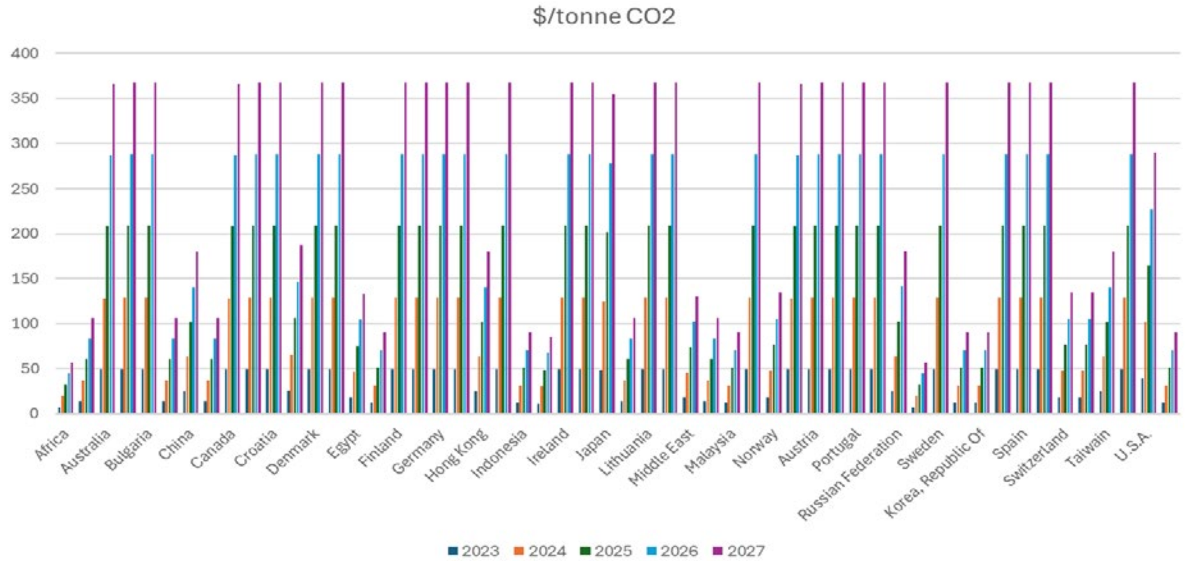

Figure 16: Country-specific carbon price levels across the five-year horizon

Channels

Shocks are applied as an absolute delta for the carbon tax and energy tax revenue, while percentage delta shocks are needed for energy consumption and change in useful energy. The first stage of the transition shock deals with the impact of the carbon price itself on the economy and relies on the combination of the inflationary impact of the energy tax rate (based on the energy tax revenue) coupled with the productivity impact of the change in useful energy. Both shocks are further augmented by energy consumption through the impact of a reduction in world fossil fuel prices (due to a fall in consumption) and a direct reduction in the trade share of fossil fuel producers, along with a change in the importance of fossil fuels in the import basket. The second stage of the transition shock reflects the impact of the recycling of the carbon tax revenue and includes both the recycling option chosen for that scenario as well as the revenue available in that country/region.

Implementation

Although NiGEM makes endogenous assumptions regarding the shift in the energy mix due to the change in price (for this shock), input from the NGFS IAM model was taken due to its detailed energy modelling. This transmission channel is modified by a set of exogenous shocks to energy of production and energy tax rate, as illustrated below. Through these transmission channels, the carbon tax has the potential to generate government revenue but can also have an impact on business capital stock, thereby affecting business investment (Figure 17). Additionally, the carbon price directly influences domestic (producer and consumer) prices, hence impacting both domestic energy demand and the pricing and volume of imports and exports (Figure 18).

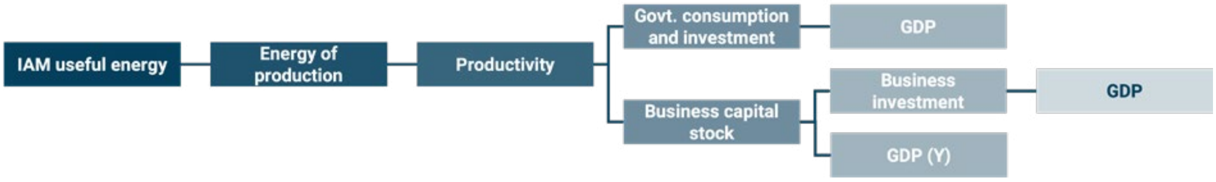

Figure 17: NiGEM transmission channels of a stringent carbon price shock on productivity

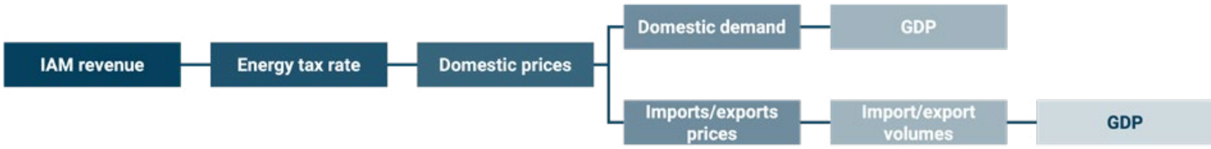

Figure 18: NiGEM transmission channels of stringent carbon price shock on domestic prices

Results and impact on countries

Table 7: Global expected impact (as percentage difference) of the carbon price shock for selected variables from 2023 to 2027

Variable	Year 1 (2023)	Year 2 (2024)	Year 3 (2025)	Year 4 (2026)	Year 5 (2027)
GDP	-0.4	-1.1	-1.2	-1.2	-1.1
Inflation rate	0.4	0.8	1.0	1.2	1.4

Figure 19 below illustrates the expected effect on GDP of an increase in the stringency of carbon prices between 2023 and 2027. The shock is expected to negatively affect GDP in all the selected regions, except in China, where is projected to have a positive impact on GDP, reaching 0.60 per cent (relative to a baseline) in Year 5 (2027)—despite an initial 0.02-per-cent decrease in the first year (2023). The **United States of America, on the other hand, is projected to suffer from a lasting adverse impact, with GDP decreasing by 2.39 per cent in 2027**. By comparison, the expected impact on **GDP for Sweden, a less-carbon-intensive economy, is smaller; decreasing by 1.26 per cent in 2027**. Similarly, **equity valuations are slightly less impacted by the shock in Sweden (-8.27 per cent in 2027) compared to equity valuations in the USA (-11.31 per cent in 2027)**. This result illustrates the sensitivity of economies to carbon prices depending on the relative share of GDP issued from carbon-intensive sectors. While the GHG emissions per unit of GDP were 0.2 for the USA in 2020 (World Bank, 2024), it was half of this value in Sweden (World Bank, 2024).

There is a surprising disconnection between the effect of the shock on GDP and equity prices in South Africa as a relatively limited reduction in GDP is observed across the time horizon. The adverse impact being a bit smaller in 2027 compared to 2023, while there is a significant devaluation in equity prices, especially in 2027. This observation may be explained by an overrepresentation of carbon-intensive firms (e.g. active the industry or resources sector) on the Johannesburg Stock Exchange (JSE) (JSE, 2024), thus making indexes suffer disproportionally from an increase in carbon price. In addition, the less carbon-intensive service sector represented 70 per cent of South Africa's GDP in 2023 (ITA, 2024). It is, therefore, reasonable to assume that the larger service sector could absorb a substantial part of the shock.

In regards to inflation, projections show a limited impact initially in Year 1, followed by a significant increase across the board, with most jurisdictions expected to witness an increase of 1 to 3 percentage points in the inflation rate in Year 5 (2027). In Year 1 (2023), **Brazil and Türkiye are the only jurisdictions that experience a decrease in inflation rates**. Specifically, Brazil is expected to experience a 0.26 percentage-point decrease in the inflation rate in 2023, but the inflation rate is projected to increase by 1.12 percentage points in 2027. The initial decrease in the inflation rate experienced in Brazil may be linked to the shock on the country's output caused by the stringent carbon price. In comparison, the average increase in the inflation rate for the selected regions is 0.20 percentage points in 2023 and 0.99 in 2027. **An increase in the real interest rates is projected to be limited, ranging between 0.6 and 1.2 percentage points across Year 1 and 5. Real interest rates remain unchanged in China** across the five-year time horizon, while the country is projected to experience a relatively high inflation rate. This can be attributed to China's monetary policy, which, by default, is "pegged" to the monetary policy in the United States of America. As such, the monetary policy in China is unreactive to price developments in the country.

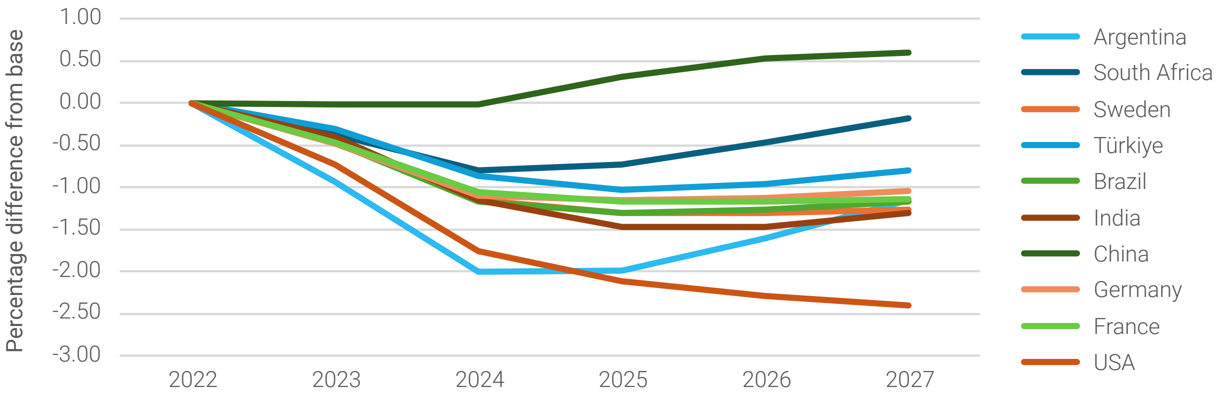

Figure 19: Impact of stringent carbon price shock on GDP, selected countries

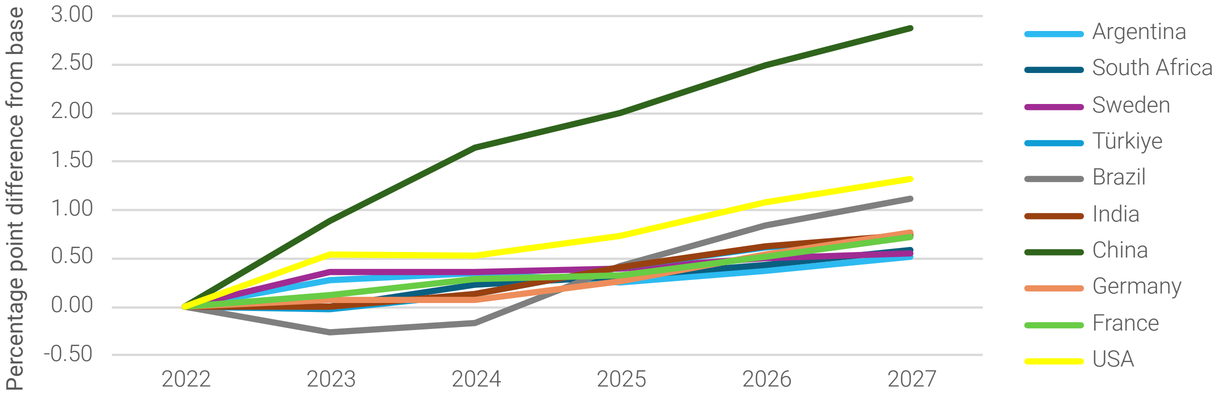

Figure 20: Impact of stringent carbon price shock on inflation rate, selected countries

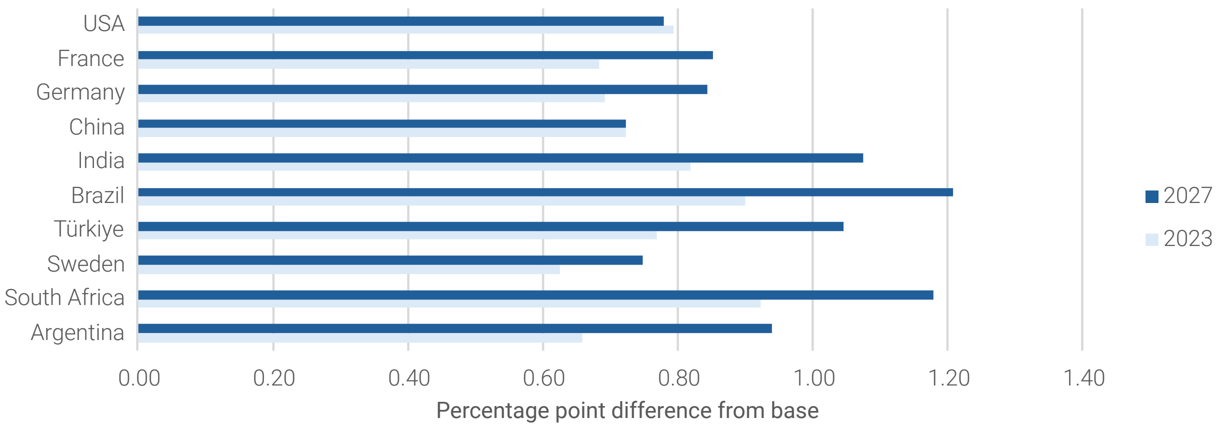

Figure 21: Impact of stringent carbon price shock on long-term real interest rate, selected countries

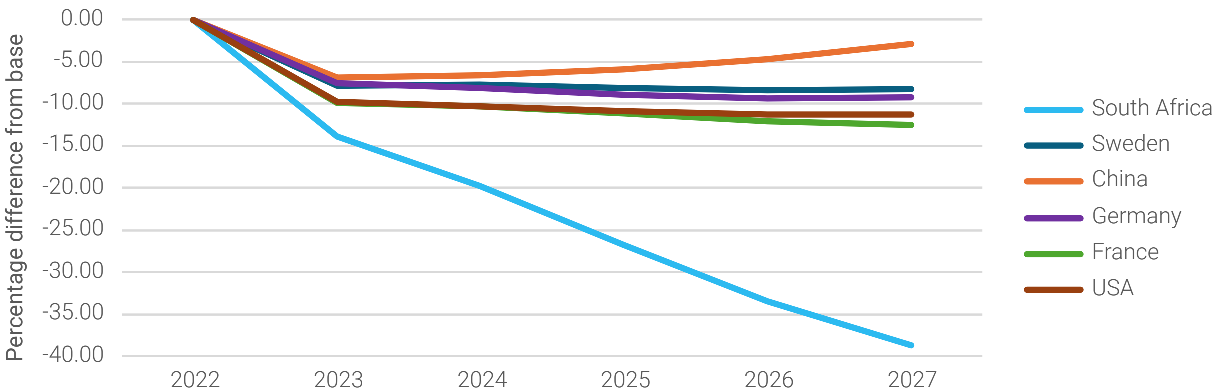

Figure 22: Impact of stringent carbon price shock on equity prices, selected countries

Green spending and technological innovation

Narrative

The IEA estimates that annual spending on clean energy will need to rise from USD 1.8 trillion in 2023 to USD 4.5 trillion globally by the early 2030s in order to limit warming to 1.5°C (IEA, 2023). This shock examines the potential consequences of a sudden and significant surge in green spending, likened to the levels estimated by the IEA.

Globally, there is a growing realisation of the urgent need to accelerate climate action and transition away from fossil fuels. Governments and investors worldwide significantly boost green spending to promote alternative low-carbon technologies. Many countries allocate a higher proportion of their GDP to research and development in green technologies. Furthermore, countries align their efforts to coordinate investments. This surge in investment leads to significant technological advancements across various green technologies over the span of five years, reaching a tipping point where such technologies become cheaper and more widely available for commercial use compared to their fossil fuel alternatives. In this way, they play a critical role in reducing CO_2 emissions. For instance, the share of renewables in the global energy mix experiences a rapid increase, and sales of electric vehicles (EVs) rise as costs decline due to these technological breakthroughs.

This shock assumes a rapid rise in green spending, accompanied by breakthroughs across green technologies over the next five years..

Source

The level of spending assumed in this shock was taken to be the average spending in terms of the percentage of GDP on research and development from 2010 to 2019. Spending figures were taken from both the OECD and the United Nations Conference on Trade and Development. The maximum average value reported in the literature was used to simulate the shock size.

Channels

This shock equates to both a productivity shock (through technology) and a direct demand shock through government investment. There is assumed to be no lag between investment and technological innovation.

Implementation

Three severity levels were explored for the shock: 150 per cent, 100 per cent, and 50 per cent of the maximum. These are categorised as high, medium, and low intensity, respectively.

Results and impact on countries

Table 8: Global expected impact (as percentage difference) of the green spending shock (high severity) for selected variables from 2023 to 2027

Variable	Year 1 (2023)	Year 2 (2024)	Year 3 (2025)	Year 4 (2026)	Year 5 (2027)
GDP	3.7	3.1	2.9	3.0	3.1
Inflation rate	1.1	1.4	0.9	0.5	0.1

Figures 23–26 display the results of a high-intensity green spending shock. As shown in Figure 23, GDP is expected to increase (relative to the baseline) in all the selected jurisdictions following the green spending shock. Among the selected countries, **Japan stands out with the largest impact on GDP in Year 1 (2023), at 7.01 per cent.** The fact that Japan has been in stagflation since the 1990s (IMD, 2023) could attribute for the strongest effect following the green spending shock as it is arguable that a sudden increase in (green) spending could push Japan's economy out of stagflation and cause it to experience solid growth again.

Initially, there is also a relatively large impact on GDP in the United Kingdom and the USA, measuring 4.76 per cent and 4.97 per cent, respectively. The "demand-driven" nature of the USA economy (CEPR, 2021) could explain, in part, the sensitivity of the country to a demand shock such as green spending. The United Kingdom currently has a low level of green spending compared to other large Western economies (Greenpeace, 2024). As a result, a sudden increase in green spending may enable the development of the sector, in turn boosting economic growth.

In Year 5 (2027), the impact on GDP in Germany is expected to be the largest amongst the selected jurisdictions, reaching 5.13 per cent. It is closely followed by the USA, Japan, and France, which will increase in 2027 by 4.94 per cent, 4.49 per cent, and 4.25 per cent, respectively. Most of the selected countries are projected to experience a similar level of percentage difference in GDP from the base across the time-horizon from 2023 to 2027, apart from Japan and the United Kingdom, which are set to experience a significant downward shift in GDP between 2023 and 2027.

Figure 24 illustrates the potential impact of the shock on inflation rates. **Germany, France, and Mexico are expected to experience a reduction in the inflation rate between 2023 and 2027**. For example, Germany is projected to witness an increase of 1.03 percentage points in 2023 and a decrease of 0.76 percentage points in 2027. Similarly, France and Mexico should see the inflation rate increase by 1.15 and 1.77 percentage points in 2023 and the inflation rate decrease by 0.23 and 0.09 percentage points. The difference in inflation rates can be attributed to the size of the shock and its impact on the trend capacity of output and monetary policy reaction, as shown in Figure 26 below.

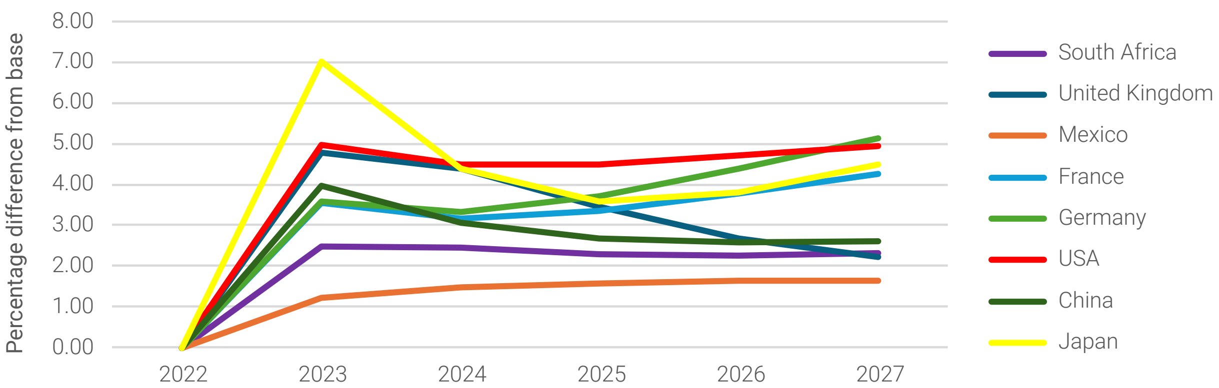

Figure 23: Impact of green spending shock on GDP, selected countries

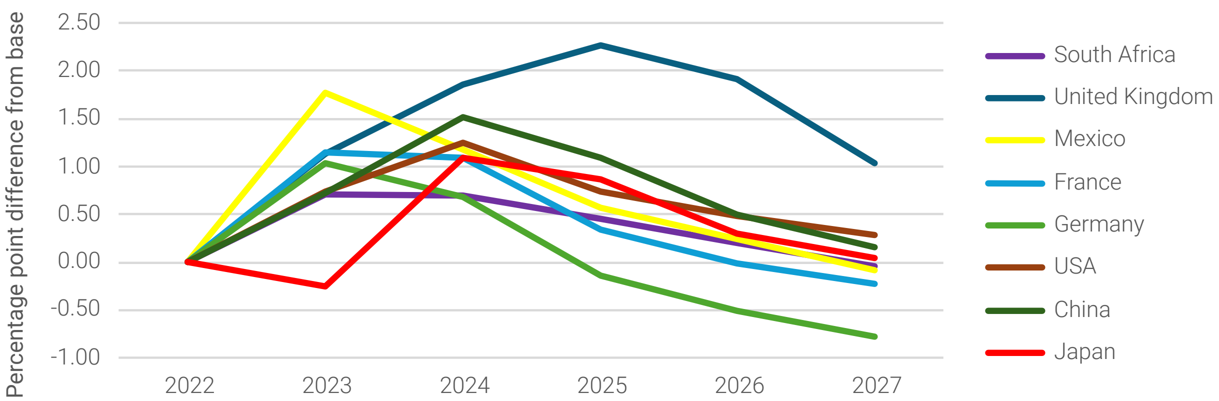

Figure 24: Impact of green spending shock on inflation rate, selected countries

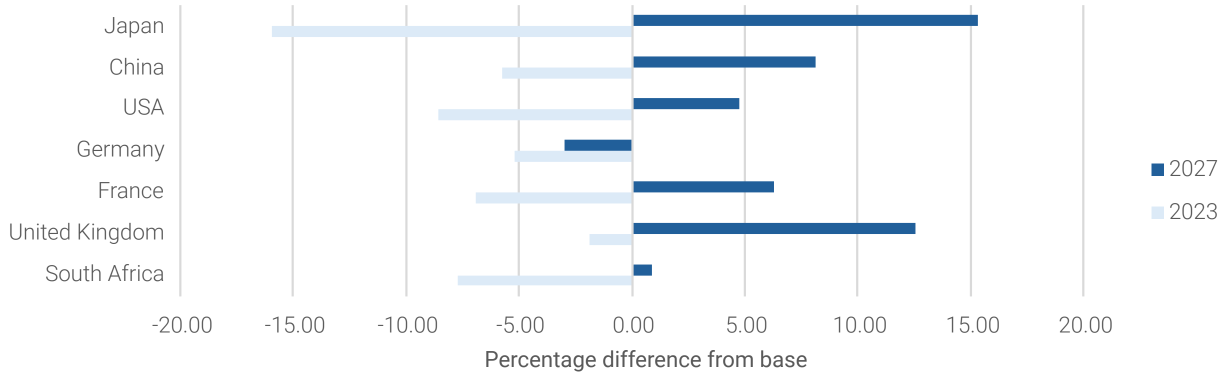

Figure 25: Impact of green spending shock on equity prices, selected countries

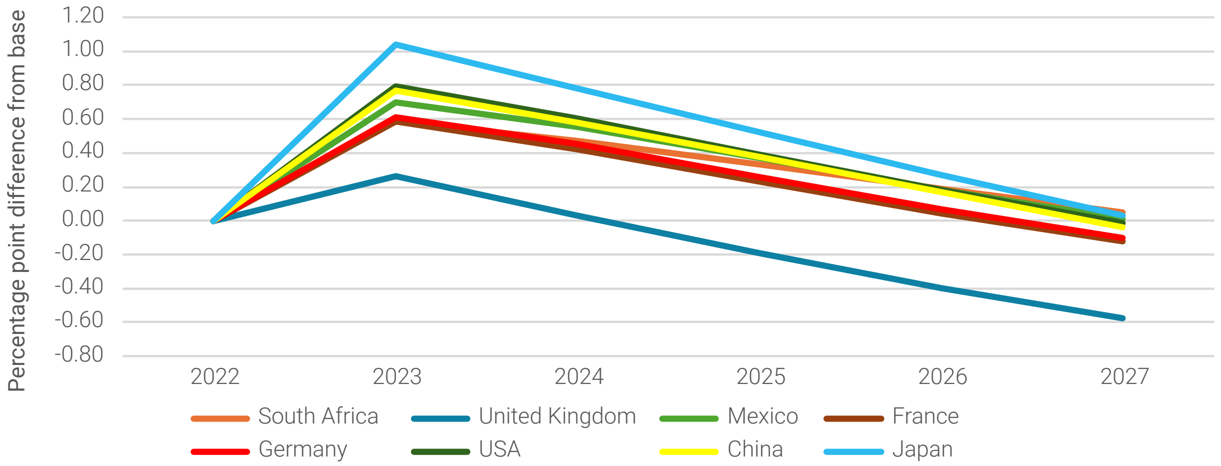

Figure 26: Impact of green spending shock evolution on long-term real interest rate, selected countries

Stranded fossil fuel assets

Narrative

A study by Welsby et al. (2021) determined that to limit warming to below 1.5°C, 60 per cent of oil and 90 per cent of global coal reserves would need to remain unextracted by 2050, respectively. Significant amounts of fossil fuel reserves remaining unextractable can result in asset stranding. Taking this into consideration, this narrative focuses on many countries suddenly refraining from burning oil reserves as economies transition to a low-carbon economy. Such action causes oil to face a rapid contraction in market value, resulting in the occurrence of stranded oil assets from 2023 to 2027.

For this shock, we consider the sudden occurrence of stranded fossil fuel assets from 2023 to 2027. As the price of carbon rises, fossil fuel consumers face a higher cost, which puts downward pressure on demand for fossil fuels and results in a drop in fuel prices.

Source

To capture the above narrative, it is assumed that oil-producing countries and regions (including Africa, Canada, Egypt, Latin America, Mexico, the Middle East, Norway, and Russian Federation) experience a 50 per-cent reduction in the price of oil. Negative terms of trade shock for fuel producer economies deliver demand adjustment as loss of export revenue hits investment and government spending (especially for those countries where the government is a major player in fossil fuel industry). In turn, this affects jobs, incomes, and household consumption. Existing capital stock depreciates as values of assets both under the ground and linked to fuel extraction will drop significantly, thus reducing the long-term potential of fuel exporting economies.

Channels

The developing economies among the above-mentioned group of oil producers experience further shocks to both domestic demand and trend capacity of output. Specifically, a 25 per-cent reduction in trend capacity output and an endogenous shock (of 4 per cent to domestic demand) is applied to deliver a reduction of 25–30 per cent in domestic demand (comparable to lower supply side).

Implementation

In order to capture the possible vicious cycle between rising climate risks and borrowing risk premia across the world (as per the spread of the risk and uncertainty observed during the financial crises), a global negative shock to equity prices and a positive shock to investment premia were added. The negative shock to equity prices is calibrated to deliver a 40-per-cent reduction, as was observed across the economies at the onset of the financial crisis. An additional shock to investment risk premia (4 percentage points) is applied to capture the impact from increased uncertainty.

Three severity levels are explored for this shock. Shocks are modified from historical values by 150 per cent (high severity), 100 per cent (medium severity), and 50 per cent (low severity).

Results and impact on countries

Table 9: Global expected impact (as percentage difference) of the stranded fossil fuel assets shock (high severity) for selected variables from 2023 to 2027

Variable	Year 1 (2023)	Year 2 (2024)	Year 3 (2025)	Year 4 (2026)	Year 5 (2027)
GDP	-3.2	-6.7	-8.4	-9.4	-10.1
Inflation rate	2.0	0.5	-1.7	-3.3	-4.1

Figures 27–29 below display the results of a medium-stress level stranded asset shock on selected regions. The stranded assets shocks illustrate in a rather explicit fashion how the concentration of economic activity in specific sectors (fossil fuels, in this case) may significantly affect the sensitivity of countries and regions to climate-related transition shocks. In the stranded asset shock, a large adverse impact on GDP is observed in the Middle East and Africa, two regions that are heavily reliant on the exportation of natural resources, including oil. For example, **GDP in the Middle East is expected to decline by 7.6 per cent in Year 1 (2023) and 27.4 per cent in Year 5 (2027).** In comparison, as Europe has a more diversified economy (ECB, 2024), it suffers less from the stranded assets shock, with an impact on GDP of -1.41 per cent in 2023 and -4.31 per cent in 2027. In addition, the Middle East region is expected to experience the largest increase in the inflation rate among the selected jurisdictions in Year 1 (2023). This is as a result of a deterioration in terms of trade and an increase in import prices resulting from the fall in demand for oil associated with the stranding of fossil fuel assets. **A severe downward**

shift in the inflation rate then follows, decreasing by 10 percentage points in Year 5 (2027). By comparison, the inflation rate in Europe is projected to experience only a slight increase of 0.55 per cent in 2023 and a decrease of 1.66 per cent in 2027.

The United Kingdom and China seem to be particularly resilient in the stranded asset shocks with a limited impact on GDP in 2027 of -0.98 per cent and -0.99 per cent, respectively. Among the least impacted regions, Norway, the USA, and Brazil also feature relatively smaller impacts on GDP—namely, 1.70 per cent, -1.35 per cent, and -2.07 per cent, respectively, in 2023; and -5.75 per cent, -3.17 per cent, and -5.46 per cent, respectively, in 2027. The resilience of these jurisdictions could be a result of their economies being relatively diversified and large.

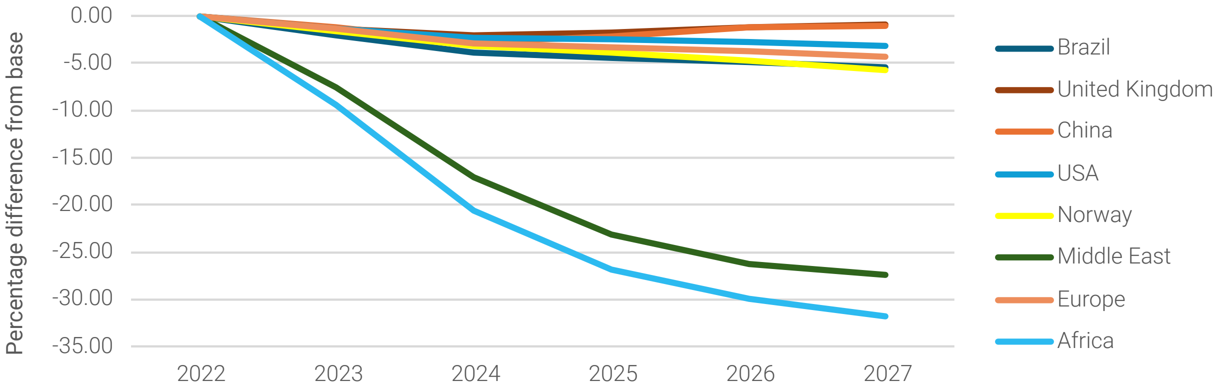

Figure 27: Impact of stranded assets shock on GDP, selected countries

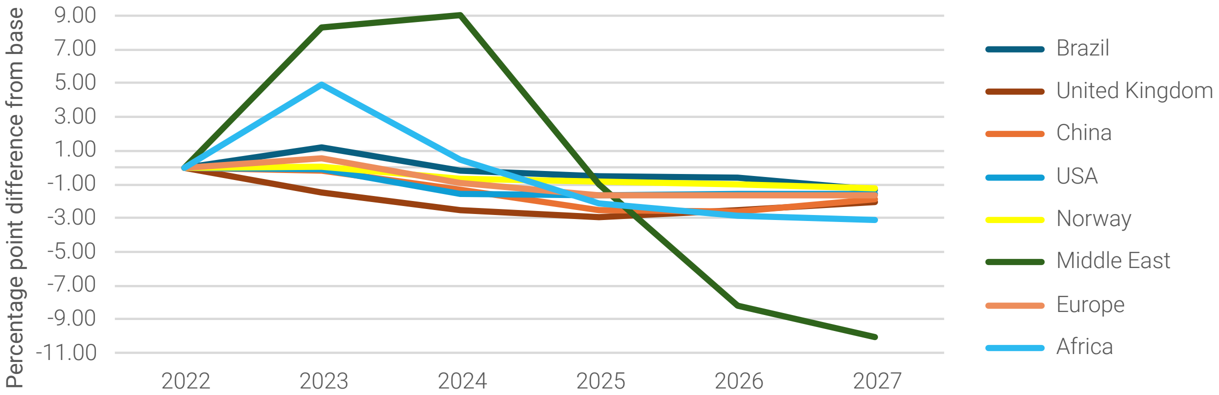

Figure 28: Impact of stranded assets shock on inflation rate, selected countries

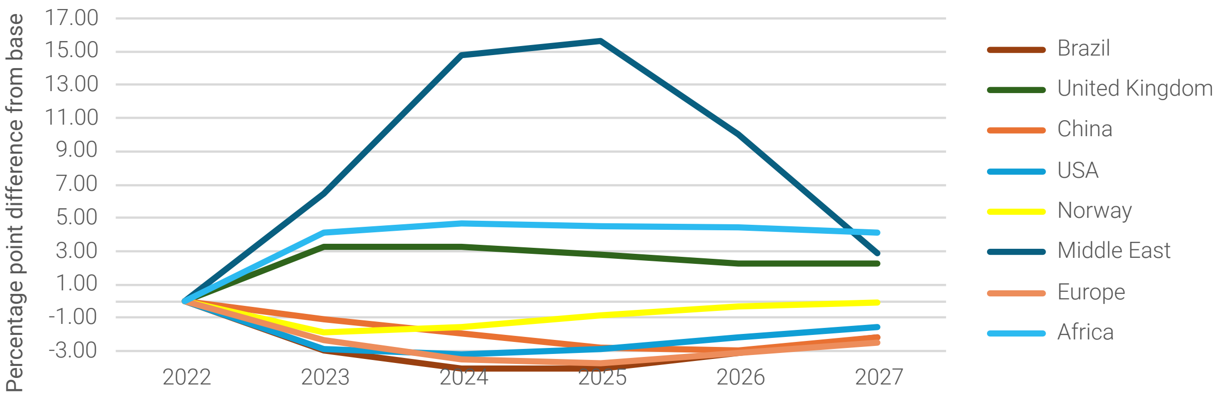

Figure 29: Impact of stranded assets shock on real effective exchange rate, selected countries

2.3.3 Physical shocks

Climate migration

Narrative

In this shock, extreme climate events such as drought and water stress drive climate migration from hotspots in Sub-Saharan Africa, East Asia and the Pacific, South Asia, North Africa, Latin America, and Eastern Europe and Central Asia. Lack of water availability acts as a main driver for internal climate migration in these areas, with populations migrating towards urban centres. Furthermore, Europe and North America are viewed as desired destinations by vulnerable populations, resulting in migration to these regions in large quantities. Areas with a large number of migrants could result in economic and political disruption (World Bank, 2021; European Parliament, 2022).

Source

This shock explores mismanaged climate migration brought forward from 2050 to 2023. The magnitude of this shock is determined by the total number of individuals anticipated to be relocated by 2050, as indicated by projections found in existing literature, including (World Bank, 2021):

- Sub-Saharan Africa could see as many as 85.7 million internal climate migrants (4.2 per cent of the total population)
- East Asia and the Pacific, 48.4 million (2.5 per cent of the total population)
- South Asia, 40.5 million (1.8 per cent of the total population)
- North Africa, 19.3 million (9.0 per cent of the total population)
- Latin America, 17.1 million (2.6 per cent of the total population)
- Eastern Europe and Central Asia, 5.1 million (2.3 per cent of the total population).

Channels

The relocation is distributed over a span of five years, from 2023 to 2027. Internal migration is assumed to have a negative population shock. External migration was modelled as an increase in total population but it was assumed that there is no effect on the labour force.

Implementation

Three levels of severity were modelled for the shock: high, medium, and low. Table 10 below summarises the key attributes for each severity level provided.

Table 10: Intensity levels provided for the shock and their descriptions

Severity level	Description
Low	Assumes significant impact on the economies only with internal migration.
Medium	Assumes impact on both countries with internal migration as well as those that are recipients of the migrants. Medium level of severity also includes an inflation shock, which is calibrated based on the inflation increase observed in Ukraine as a result of the Russian Federation invasion and scaled by the share of immigrants in the population.

High	Similar to the medium level severity, incorporates an inflation shock and assumes impact on countries with internal migration as well as those that are recipients of the migrants. Also includes economic and political disruption in countries suffering from the reallocation of population as well as asylum recipients, modelled via increased uncertainty through higher risk premia and their effect on business investment.

The inflation shock is considered to be temporary and has the largest impact in the first three years, after which adjustments in the economy (e.g. through monetary policy or other accompanying shocks that have a deflationary impact) ensure that inflation returns to the long-term target.

For the most severe case, the approach used to implement increased uncertainty through a higher risk premium is similar to that used in delayed NGFS scenarios, where higher investment risk premia aim to capture the impact of increased uncertainty as an inherent part of the delayed transition world. Investment premia are assumed to increase by 1 percentage point, which is modest in comparison to the levels seen during the financial crisis and is more comparable to the hikes seen in more recent periods associated with COVID-19 or the Russian Federation-Ukraine war impacting the advanced economies.

Results and impact on countries

Table 11: Global expected impact (as percentage difference) from the climate migration shock (high severity) for selected variables from 2023 to 2027

Variable	Year 1 (2023)	Year 2 (2024)	Year 3 (2025)	Year 4 (2026)	Year 5 (2027)
GDP	-0.5	-0.9	-1.1	-1.2	-1.1
Inflation rate	0.4	0.9	0.9	0.4	-0.3

The results of this shock (high severity) show the potential impacts of climate migration driven by the vulnerability of developing regions, such as Africa, the Middle East and Asia, to extreme physical events. Across the five-year horizon, all countries experience a reduction in GDP, with the decrease being much more significant in Year 5 (2027) than in Year 1 (2023). The decrease is more significant for Africa, the Middle East and Asia, as physical extreme events can cause significant damage to the livelihoods and living conditions of the populations of these countries, leaving them with little choice but to migrate elsewhere. As more and more of the population leave these regions, productivity levels decrease, with a significant impact on **GDP as well as on domestic demand. For example, as seen in Figure 30, GDP will decrease in Africa, the Middle East, and Asia by 0.67 per cent, 0.79 per cent, and 0.51 per cent in 2023, respectively, and by 1.95 per cent, 2.03 per cent, and 1.63 per cent in 2027, respectively.** The GDP of these countries is also expected to suffer due to economic and political disruption. Regions that experience an inflow of migrants, such as Canada and the USA, face increased uncertainty from this migratory inflow. As a result of a higher risk premia and their impact on business investment, GDP is expected to fall. For example, **the United States of America experiences a fall in GDP over the period 2023–2027; by 0.36 per cent in 2023, and by 1.08 per cent in 2027. A similar trend is observed for Canada, where there**

is a decrease in GDP of 0.32 per cent in 2023 and 0.79 per cent in 2027. Due to low demand and falling GDP in Year 5 (2027), deflation occurs in the selected regions. This is most significantly experienced by developing regions.

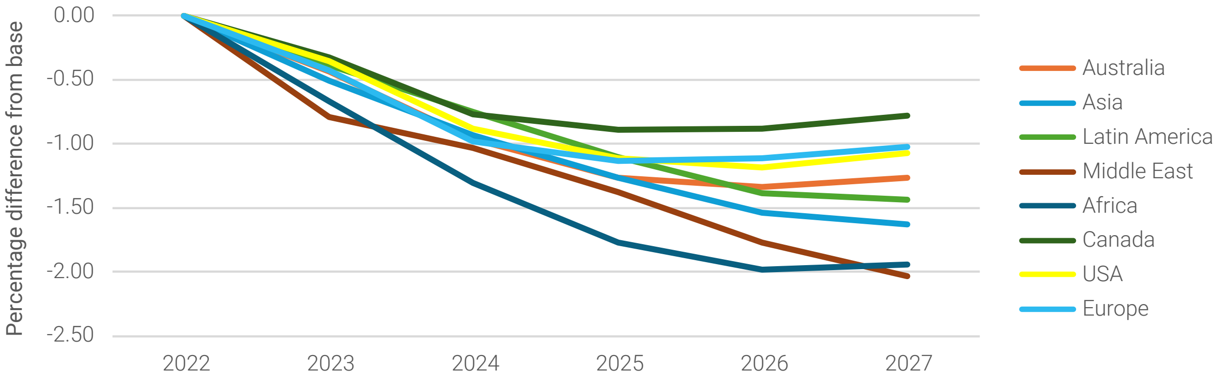

Figure 30: Impact of climate migration shock on GDP

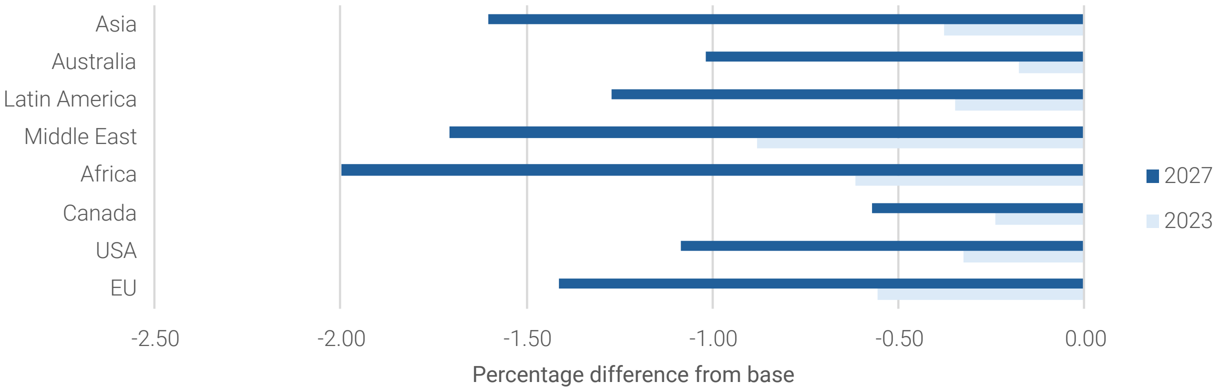

Figure 31: Impact of climate migration shock on domestic demand

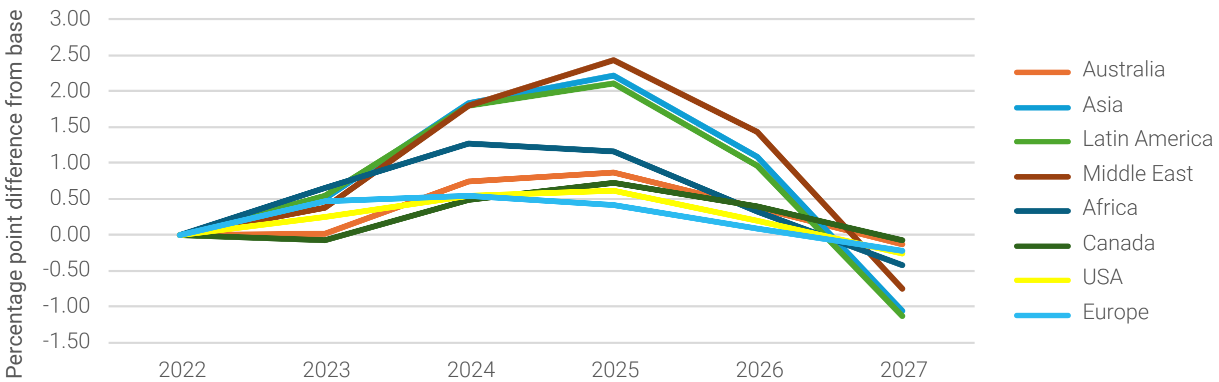

Figure 32: Impact of climate migration shock on inflation

2.3.4 Acute physical shocks

Narrative

This narrative explores the economic implications of severe drought, heatwave, flooding, and cyclone events, which are assumed to occur globally from 2023 to 2027. Future acute risk shocks, based on the scenarios by the NGFS, are frontloaded to occur in the near term as tail risks. Although the nature of the severe drought and heatwave events is more global, the impact of flooding and cyclones is expected to be more localised in nature.

Source

The acute physical shocks are modelled from the Phase 4 scenarios of the NGFS.

Cyclones, heatwaves, and droughts were modelled as stochastic shocks with 70, 80 and 90 per cent confidence bounds. The flood shock was modelled as a single shock based on annual data from Climate Analytics. Data for the cyclone shock are only available for countries that are susceptible to cyclones rather than all NiGEM countries.

Channels

Similar to the NGFS scenarios, the impact of heatwaves is calculated by estimating the population exposed to severe heat stress. These have been converted into productivity and demand shocks. A drought shock is estimated through the potential impact on national crop yield and its effects through shocks to productivity, exports, and prices. The flood shock is estimated through the impact on capital because of asset damages that affect the economy through investment premia shock. Similar to flooding, the cyclone shock is also estimated based on the direct impact on capital as a result of asset damages and investment premia shocks.

Implementation

Country-level projections have been provided for GDP losses for all four hazards.

Results and impact on countries

Table 12: Global expected GDP impact (as percentage difference) of the acute physical shocks (current policies scenario) from 2023 to 2027

Acute physical shock	Year 1 (2023)	Year 2 (2024)	Year 3 (2025)	Year 4 (2026)	Year 5 (2027)
Heatwave (90 per cent)	-1.2	-1.2	-1.3	-1.3	-1.3
Drought (90 per cent)	-1.4	-1.4	-1.7	-1.7	-1.8
Flooding	-0.3	-0.4	-0.4	-0.4	-0.4
Cyclone (90 per cent)	-0.2	-0.2	-0.2	-0.2	-0.2

Figures 33–36 illustrate the substantial negative effects of the acute physical shocks—from heatwaves, droughts, flooding, and cyclones—on the GDP of a selected set of countries.[4]

The heatwave shock can be seen to have an adverse impact on GDP. In all of the countries analysed, the impact of heatwaves is considerable and, therefore, has a hugely negative effect on productivity and demand, which impacts GDP. As we can see from Figure 33, in **India, South Korea, Singapore, and African countries, heatwaves have an adverse effect on GDP**—namely, 1.16 per cent, -8.83 per cent, -2.21 per cent, and -1.3, respectively, in 2023; and -1.26 per cent, -8.21 per cent, and -2.55 per cent, and -1.36 per cent, respectively, in 2027.

As seen in Figure 34, the drought shock is projected to significantly impact the economies of India and Africa, with GDP expected to decrease to 9.26 per cent and 7.46 per cent, respectively, **in Year 1 (2023)**. The detrimental impact of the drought shock on GDP

4 Shocks are based on the NGFS current policies scenario with 90 per cent confidence interval (where appropriate)

is likely due to these countries' reliance on primary sector activities such as agriculture, coupled with the limited availability of resources and mechanisms to adapt to a drought shock in the near term (e.g. via irrigation systems). Although drought also impacts GDP growth in Latin American countries and Australia, the effects are less severe. This could be attributed to these countries having more diversified economies.

The results from the flooding shock (Figure 35) show that flooding is also expected to have a greater impact on the GDP of emerging economies, such as **India (-0.6 per cent in 2023) and Viet Nam (-1.59 per cent in 2023)**. Although floods do cause setbacks to growth in more developed countries such as China and the United Kingdom, the impact on GDP is lower due to a more developed flood-resilient infrastructure. This results in lower costs of repair and losses in relation to the halt in exposed economic activities. For example, in 2027, the **impact of floods on GDP growth in the United Kingdom is expected to be -0.07 per cent**, compared to -1.72 per cent in Viet Nam in the same year.

As can be seen from Figure 36, the cyclone shock is expected to have a relatively small impact on GDP in the analysed countries, with only a small percentage difference existing between **Malaysia, which is most affected by this acute physical event (at -0.12 per cent in 2027)**, and China, which is least affected by this physical event (at -0.001 per cent in 2027).

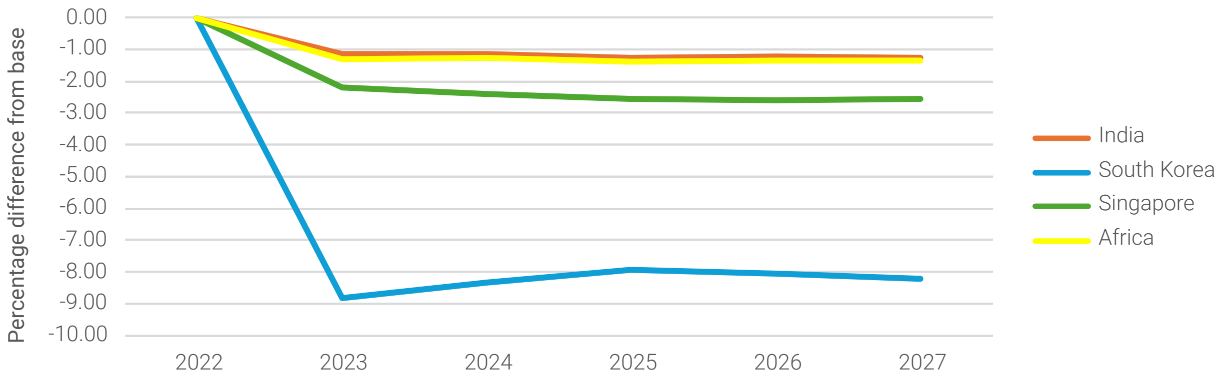

Figure 33: Impact of heatwaves on GDP, selected countries

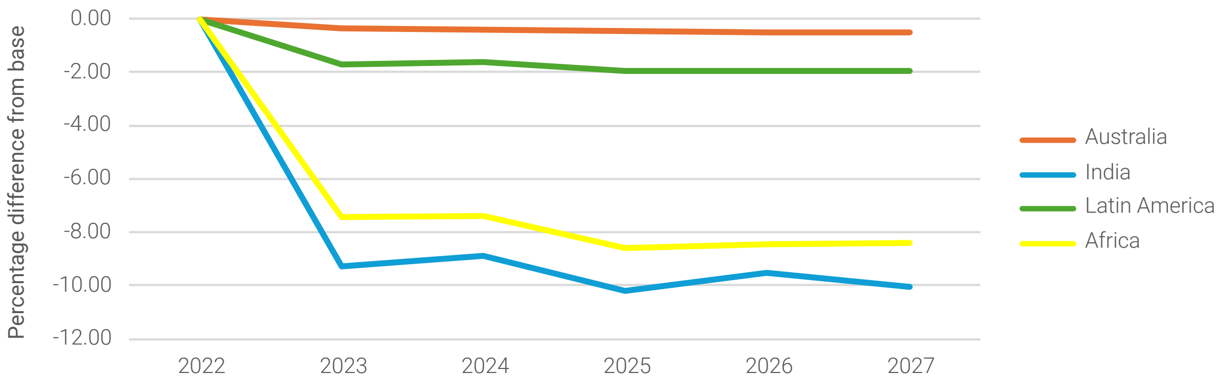

Figure 34: Impact of drought on GDP, selected countries

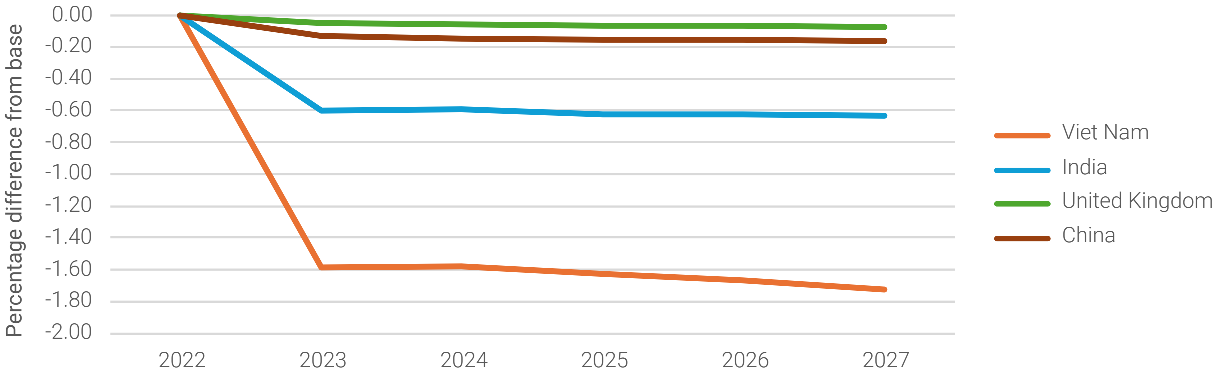

Figure 35: Impact of flooding on GDP, selected countries

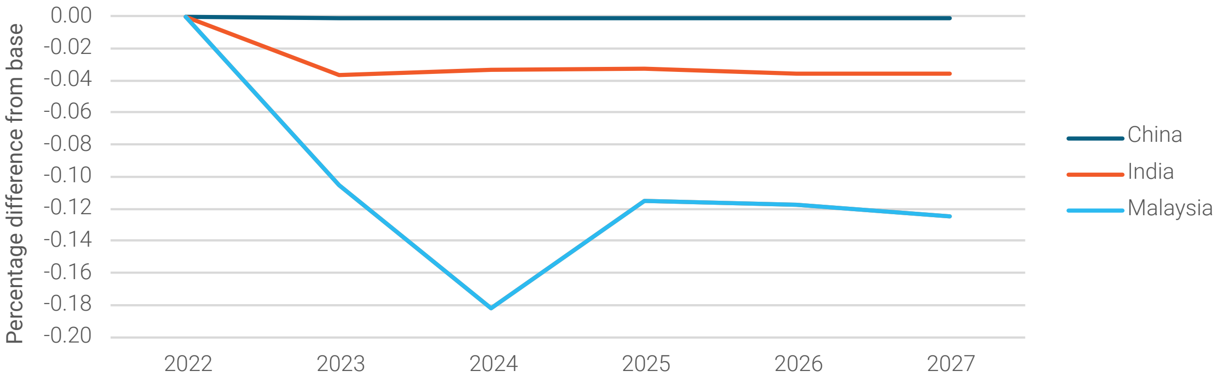

Figure 36: Impact of cyclones on GDP, selected countries

Country-level physical effects (chronic physical shock)

Narrative

Extreme chronic risks, such as high temperatures, rising sea levels, and changes in precipitation, are assumed to occur globally from 2023 to 2027. Such risks are expected to gradually increase in importance over time and have a severe impact on GDP in 20–30 years. However, for this scenario, these chronic risks are brought forward to the present.

Source

This shock models the chronic risks of the NGFS scenarios, with all physical risks starting in 2023.

Channels

Chronic physical risk shocks in NiGEM are implemented via demand-side and supply-side shocks. The combination of these shocks must mimic the GDP effects supplied by the damage functions by the NGFS.

Implementation

In the NGFS scenarios, the assessment of chronic risks is grounded in GDP impacts. The NGFS chose to use the High GDP impact version with the 95th temperature percentile for the Current Policies scenario and the 50th percentile for the delayed transition and net-zero scenarios.

Results and impact on countries

Table 13: Global expected impact (as percentage difference) of the chronic physical shock (current policies scenario) for selected variables from 2023 to 2027

Variable	Year 1 (2023)	Year 2 (2024)	Year 3 (2025)	Year 4 (2026)	Year 5 (2027)
GDP	-0.5	-0.7	-0.9	-1.0	-1.2
Inflation rate	-0.01	-0.01	0.02	0.05	0.06

The chronic physical risks shocks illustrate how events such as rising sea levels and increasing global temperatures can have significant impact on macro-economic indicators like GDP and inflation rates. The results show there is a significant adverse impact on GDP for the majority of countries analysed outside of Europe under the chronic physical shock, based on the NGFS Current Policies scenario.

Based on the selected group of countries for the analysis, chronic risks most significantly impact the GDP of India, South Africa and Mexico. As emerging economies, these countries have communities living in extremely vulnerable areas, with limited resources to adapt existing infrastructure to these risks. Out of the selected set of countries, **the largest adverse impact of the chronic physical shock on GDP can be seen in India, where GDP decreases from -0.89 per cent in 2023 to -2.03 per cent in 2027**. In regards to the other countries analysed, Australia, China, and the USA are projected to see a decrease in GDP over the five years. For example, the **USA GDP decreases from 0.45 per cent in 2023 and by 1.05 per cent in 2027** as a result of reduced productivity levels across industries that are key to driving economic growth. Initially, chronic physical risks have a **limited impact on inflation**. Although inflationary pressures rise over the five-year time-horizon, changes in the inflation rate remain low. For example, the United States of America in Year 1 (2023) is projected to experience an increase in the inflation rate of 0.055 per cent. China is expected to see the largest rise in the inflation rate in Year 5 (2027), at 0.12 per cent. This marks an increase from -0.018 per cent in 2023. The increase in inflation could be driven by increased adaptation costs and construction costs. Uncertainty and disruptions to productivity and supply chains will also impact the inflation rate over the five-year period.

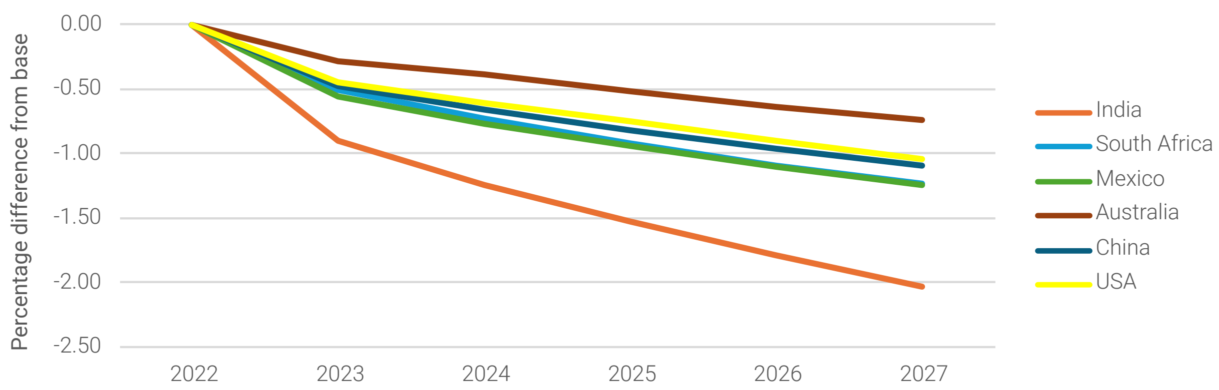

Figure 37: Impact of chronic physical risks on GDP

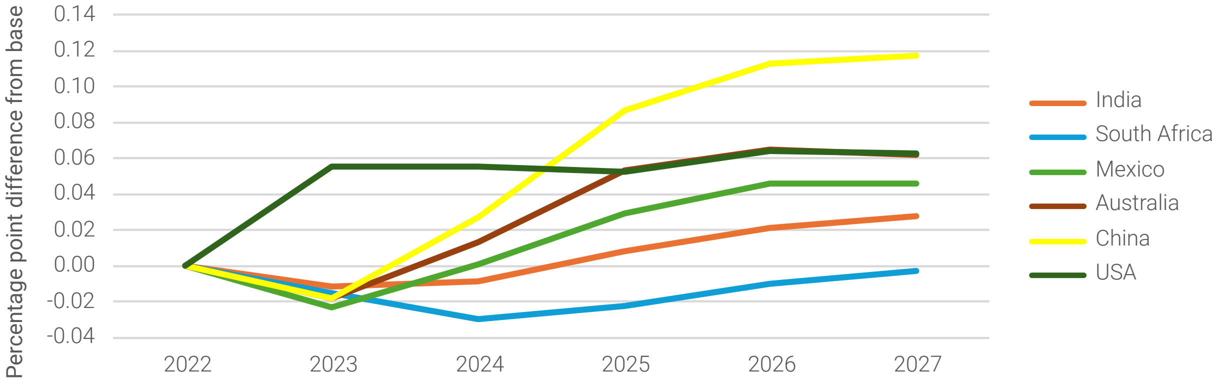

Figure 38: Impact of chronic physical risks on inflation

3. Exploring combined short-term shocks

The following section explores the potential impacts of a combination of shocks generated using the Excel-based tool. It is assumed that each shock occurs separately and unanticipated with regard to each other. For the scope of this report, we explore the following combinations:

	Shock 1 (macroeconomic shock)	Shock 2 (physical shock)	Shock 3 (transition shock)
Combination 1	Geo-political tension shock	Country-level physical effects (acute and chronic)	Imposition of a stricter carbon price
Combination 2	Greenflation	Climate migration	Green spending and technological innovation
Combination 3	Inflation	Acute physical shocks	Stranded fossil fuel assets

Combination 1:

The first combination of shocks explored in this section is a combination of geo-political tension, country-level physical effects (acute and chronic), and the imposition of a stricter carbon price. The following severity levels of the shocks were selected:

- Shock driven by geopolitical tension: high severity
- Stringent carbon price: based on the NGFS delayed transition scenario
- Country level physical effects
  - Chronic risks: NGFS current policies scenario
  - Acute risks: flood risk based on the NGFS current policies scenario

Table 14: Expected impact on global GDP (as percentage difference) for selected set of shocks and their combination from 2023 to 2027

Year	Shock driven by geopolitical tension	Stringent carbon price	Chronic physical risk shock	Acute flood risk shock	Combination of all shocks
Year 1 (2023)	-1.6	-0.4	-0.5	-0.3	-2.9
Year 2 (2024)	-3.5	-1.1	-0.7	-0.4	-5.6
Year 3 (2025)	-4.2	-1.2	-0.9	-0.4	-6.6
Year 4 (2026)	-4.6	-1.2	-1.0	-0.4	-7.2
Year 5 (2027)	-4.9	-1.1	-1.2	-0.4	-7.6

As the combination of shocks includes an acute physical risk shock, the only variable available to explore is GDP. Figure 39 illustrates the expected impacts if the three shocks occurred during the same five-year time-horizon for a selected set of countries.

For China, the combination of the three shocks is projected to have a limited impact on GDP, with most of the years deviating by 2 to 2.8 per cent for the five-year time-horizon. This can be attributed to the limited impact of a stringent carbon price shock and a flooding shock projected on the country (see sections 2.3.2 and 2.3.3). The combination of the three shocks is expected to have a much more significant impact on GDP for the remaining selected countries—namely, India, the USA, the United Kingdom, and Argentina. **Argentina's GDP is expected to be the most significantly impacted, with the maximum decline in GDP comprising 14 per cent in Year 5 (2027)**. This is attributed to the severe impact of the geopolitical tension shock projected on the Argentinian economy. The significant impact of this tension can be due to domestic economic conditions, which have resulted in Argentina defaulting on its sovereign debt payments and becoming reliant on funding from international institutions and countries such as China. The potential impact of the transition and physical shocks on Argentina's GDP range from a decrease of 0.5 to 2 percentage points across the five-year time-horizon. Similarly, the United Kingdom is expected to face a detrimental impact on GDP. This is less because of the transition and physical shocks and more due to the impact of the macroeconomic shock (geopolitical tension shock), which is high because of the United Kingdom's heavy reliance for trade on the European Union (of which it is no longer a member). **The United States of America is also expected to be impacted by the combination of the shocks, with its decrease in GDP reaching 11.4 per cent in Year 5 (2027)**. Finally, India is expected to experience a decrease in GDP as well due to the combination of shocks. Although the macroeconomic shock has the most severe impact (reaching a maximum 5-per-cent decrease in 2027), India is more resilient to this shock than others. Following the geopolitical tension shock, the chronic physical risk shock has the next largest impact on the country's GDP, contributing to a 2-per-cent difference in Year 5 (2027).

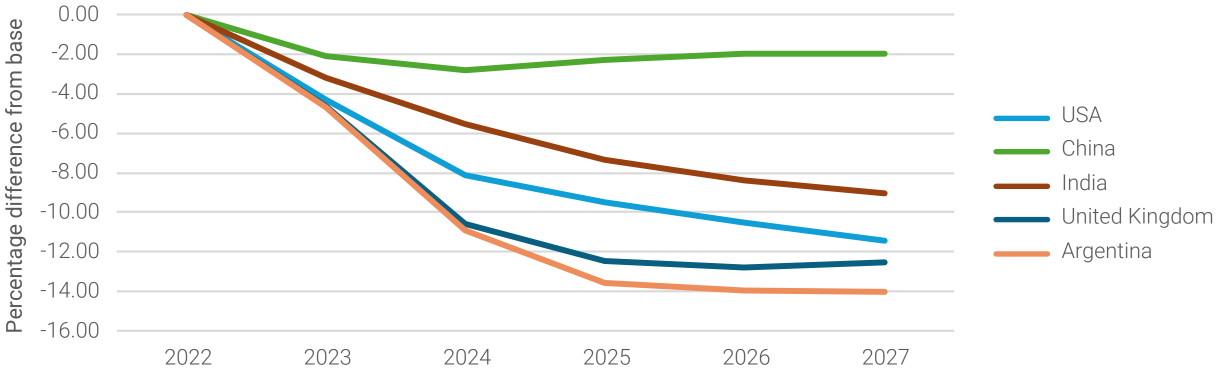

Figure 39: Impact of a combination of a geopolitical tension, stricter carbon price, and country-level physical effects on GDP, for select economies

Combination 2:

The second combination of shocks explored in this section is a combination of greenflation, climate migration, and green spending. The following severity levels of the shocks were selected:

- Greenflation: high severity
- Green spending: high severity
- Climate migration: high severity

Table 15: Expected global GDP and inflation impact (as percentage difference) for selected shocks and their combination from 2023 to 2027

Year	Greenflation	Green spending	Climate Migration	Combination of all shocks
Variable: GDP				
Year 1 (2023)	-0.4	3.7	-0.5	2.8
Year 2 (2024)	-1.0	3.1	-0.9	1.1
Year 3 (2025)	-1.3	2.9	-1.1	0.5
Year 4 (2026)	-1.4	3.0	-1.2	0.3
Year 5 (2027)	-1.6	3.1	-1.2	0.4
Variable: Inflation rate				
Year 1 (2023)	0.3	1.1	0.4	1.8
Year 2 (2024)	1.1	1.4	0.9	3.4
Year 3 (2025)	1.5	0.9	0.9	3.3
Year 4 (2026)	1.8	0.5	0.4	2.6
Year 5 (2027)	1.7	0.1	0.1	1.5

Figure 40 illustrates the expected GDP changes over a time-horizon of five years in the context of the combined greenflation, green spending, and climate migration shocks in selected regions. Figures 41 and Figure 42 display the impact of combined shocks on inflation and domestic demand respectively. Figure 43 plots the changes to the real exchange rates of selected regions as a result of the three combined shocks.

All selected regions are projected to experience a rapid increase in GDP in Year 1 (2023), mainly attributed to the green spending shock. However, between Year 2 and Year 5 (i.e. 2024 to 2027), most selected regions are expected to experience fall in GDP (level, relative to baseline). **On average, the shock resulting in the largest adverse impact on GDP among the selected regions is the greenflation shock, except for Latin America**, which is more impacted by the climate migration shock than the greenflation shock. For example, in 2027, climate migration is projected to cause a 1.5-per-cent decrease in GDP in Latin America, compared to a 1-per-cent decrease due to the greenflation shock. By comparison, the United States of America is expected to witness a 3-per-cent reduction in GDP in 2027 due to the greenflation shock, while the impact of the climate migration shock is projected to result in a reduction of 0.7 per cent. The difference in the contribution of these shocks to the implications on GDP can be attributed to the assumption that 2.6 per cent of the total population of Latin America migrates across the five-year time period under the climate migration shock. The outflow of the labour force can reduce economic productivity, adversely affecting GDP. The United States of America is expected to become a host country for climate migrants, but the inflow of migrants does not have an effect on the labour force (see Section 2.3.3). Furthermore, GDP in the United States of America is shown to be more vulnerable than in Latin America to fluctuations in metal prices for renewable technologies as part of the greenflation shock (see section 2.3.2.). This is likely to be due to the composition of the USA's output, which relies partly on resource-intensive industries, with manufacturing accounting for 14.5 per cent of GDP in 2023 (BEA, 2024). In Latin America, the exportation of raw materials represents a major part of output alongside agriculture. In Brazil, these carbon-intensive sectors accounted for 28.2 per cent of GDP in 2023 (IBGE, 2024). Figure 41 illustrates the impact of the combined shocks on domestic demand. The projections observed for domestic demand are in line with the trends of GDP for the selected countries and regions.

All the selected countries and regions experience an increase in the inflation rate across the five-year horizon, with this rise ranging from 0.2 to 4.4 percentage points, apart from Latin America. **In comparison, changes in the inflation rate of Latin America from 2023 to 2027 are much more significant, reaching 9 percentage points in 2025 (Year 3)** (Figure 42). Inflation is projected to be disproportionately impacted by the greenflation shock, reaching 7.6 per cent in 2026 (Year 4), compared to an average of 1.7 per cent in the other regions. The trajectory of GDP in Latin America could be linked to high inflation.

In terms of exchange rates, South Africa, India, and Latin America experience an appreciation of their exchange rates. **South Africa and India experience an appreciation of their exchange rate of 13.1 per cent and 5.9 per cent in 2027 (Year 5), respectively. In comparison, Europe, the USA, and China, and Europe experience a depreciation in their exchange rates, with a decrease of 4.6 per cent, 3.3 per cent, and 0.8 per cent in 2027 (Year 5), respectively**. Among the economies experiencing depreciation, the driving shock is greenflation. In 2027, most notably, the greenflation shock is expected to contribute a decrease of 2.5 percentage points and 2.7 percentage points for the USA and Europe, respectively. The decline in exchange rates across these three regions aligns with the expected GDP growth trends as weaker currencies might boost export levels. The greenflation shock also seems to be a major driver in the appreciation of the exchange, **particularly in Latin America, where it is projected to increase by 10.7 per**

cent in 2027. This significant appreciation may be resulting from shifts in commodity prices following the greenflation shock. Latin America may be particularly impacted since a significant share of output in this region is issued to carbon-intensive sectors such as agriculture and mining. In 2021, these two sectors accounted for 11 per cent of Argentina's GDP (World Bank, 2022).

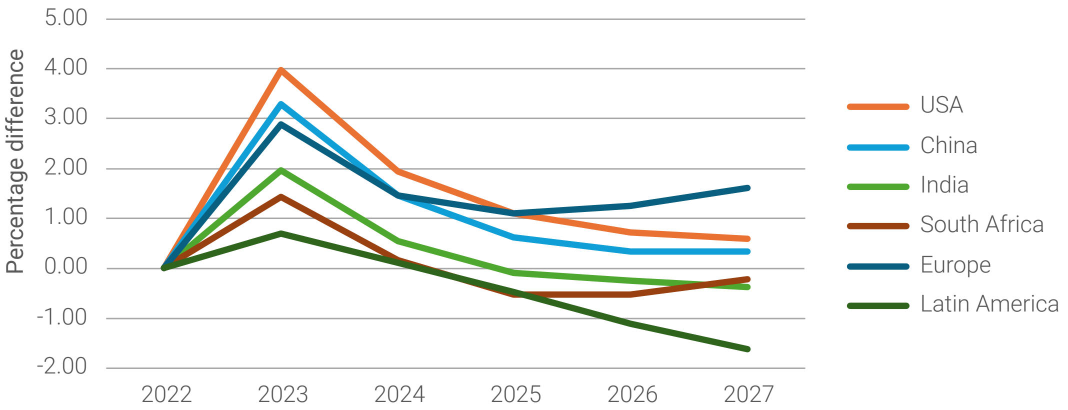

Figure 40: Impact of a combination of a greenflation, green spending, and climate migration on GDP, for select economies

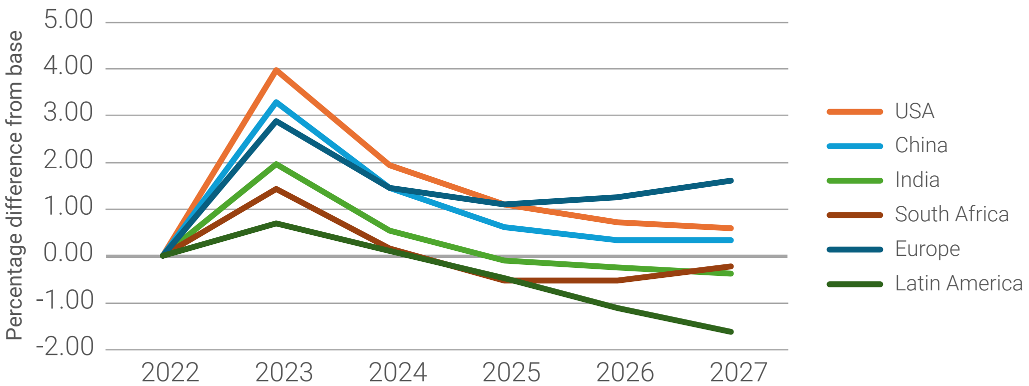

Figure 41: Impact of a combination of a greenflation, green spending, and climate migration on domestic demand, for select economies

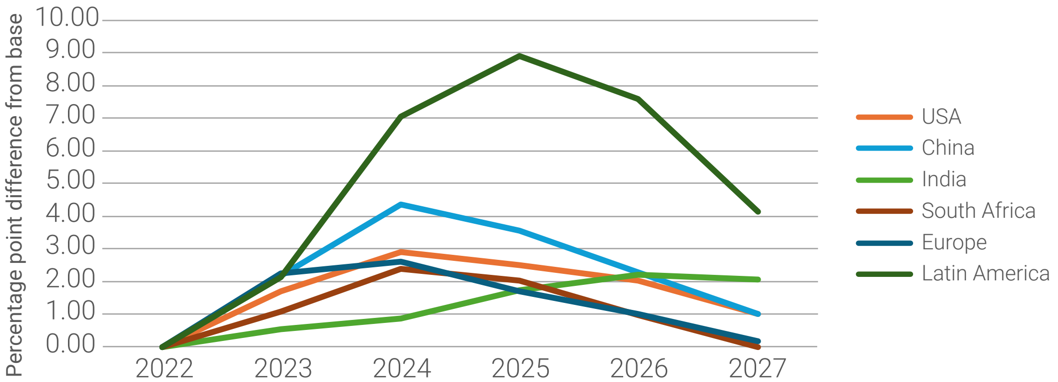

Figure 42: Impact of a combination of a greenflation, green spending, and climate migration on inflation rate, for select economies

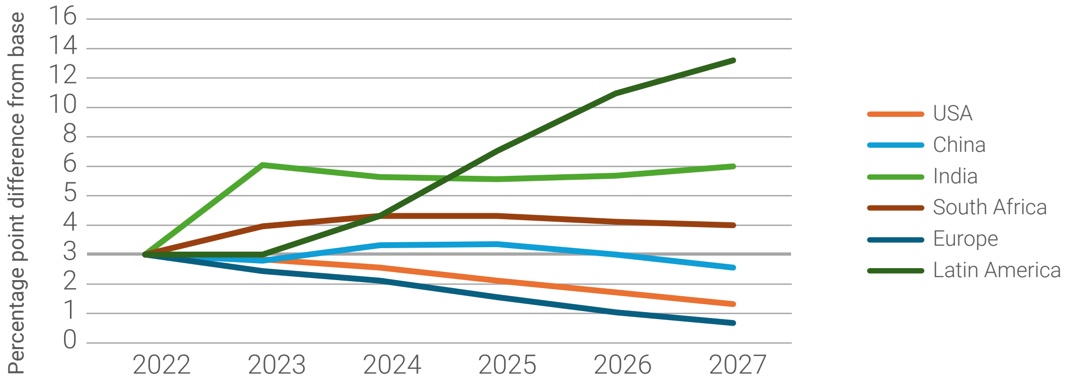

Figure 43: Impact of a combination of a greenflation, green spending, and climate migration on real effective exchange rate, for select economies

Combination 3:

The first combination of shocks explored in this section is a combination of geo-political tension, country-level physical effects (acute and chronic), and the imposition of a stricter carbon price. The following severity levels of the shocks were selected:

- Inflation: high severity
- Stranded fossil fuel assets: high severity
- Acute physical shocks: drought, NGFS current policies, 90 per cent confidence level

Table 16: Expect impact on global GDP (as percentage difference) for selected shocks and their combination from 2023 to 2027

Year	Inflation	Stranded fossil fuel assets	Acute drought risk shock	Combination of all shocks
Year 1 (2023)	-1.1	-3.2	-1.4	-5.7
Year 2 (2024)	-3.2	-6.7	-1.4	-11.3
Year 3 (2025)	-3.3	-8.4	-1.7	-13.4
Year 4 (2026)	-2.9	-9.4	-1.7	-14.0
Year 5 (2027)	-2.4	10.1	-1.8	-14.3

As the combination of shocks includes an acute physical risk shock, the only variable available to explore is GDP. Figure 44 illustrates the expected impacts if the three shocks occurred during the same five-year time-horizon for a selected set of countries.

Figure 44 shows the changes in GDP from 2022 to 2027 because of the combined inflation, stranded fossil fuel assets, and drought shocks in the selected countries and regions—namely, the USA, China, the United Kingdom, Norway, and the Middle East. This combination of shocks is projected to have a limited impact on the GDP of China, compared with other regions, **with GDP deviating by a maximum of 5 per cent over the five-year horizon**. This can be attributed to exposure from the inflation shock and the resilience of the country to the stranded asset and drought shocks. This combination of shocks will have a more significant impact on the other regions: the USA, the United Kingdom, Norway, and the Middle East. **The Middle East's GDP is projected to be most impacted by this combined shock, with GDP decreasing by 35 to 35.2 per cent across**

the time horizon. This is likely because of the severe impact of the stranded fossil fuel asset shock on the Middle Eastern region's economic growth (see section 2.3.2). Similar to the Middle East, Norway is also seen to suffer a huge decline in GDP from this combined shock. This decline is most significant between 2022 and 2024, which is likely due to the impact of the stranded fossil fuel asset shock for the oil-producing country. However, in comparison to some countries in the Middle East, Norway has a more diversified economy. This could explain why the impact of the stranded asset shock remains consistent on the GDP instead of intensifying after the initial decline from the shock in 2023 and 2024. This could be attributed to Norway being able to increase exports of other types of goods to offset a portion of the losses from oil exports. Unlike the other regions analysed, the impact of this shock on the United Kingdom's GDP is likely to be positive from 2025 onwards, after a steep decline of about 14 per cent initially from 2022. This positive upturn could be attributed to the limited impact of the drought shock on the region and the resilience of the country to the stranded asset shock. The decline in GDP to 2025 is likely a result of the severe inflation shock projected to impact the United Kingdom.

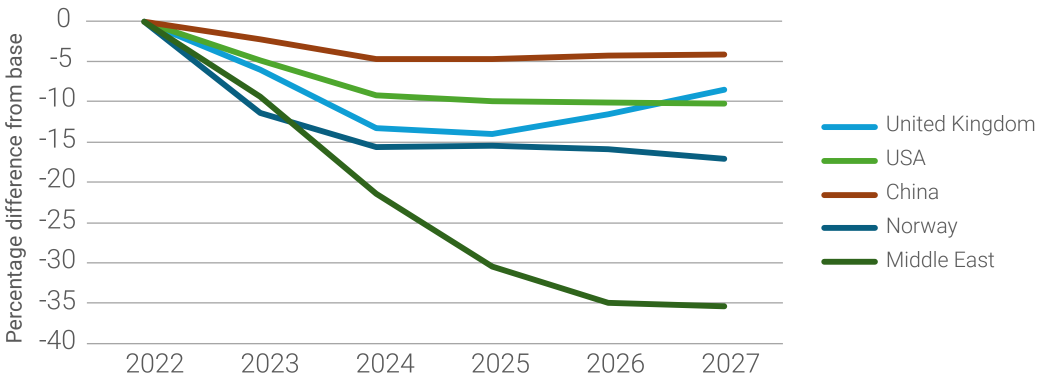

Figure 44: Impact of a combination of an inflation shock, stranded fossil fuel assets, and acute drought risk on GDP, for select economies

4. Severity of climate shocks in comparison to traditional shocks

Scenario users have typically criticised the severity and stressfulness of climate scenarios, particularly when compared to the adverse scenarios employed in traditional stress tests. This limited stressfulness is attributed to several factors, including the failure to adequately reflect worst-case (tail-risk) scenarios and the limited reflection of transition dynamics and volatilities. Climate scenarios have faced criticism for showing smooth trends that result in minimal variations in financial risk outcomes. For example, the NGFS scenarios depict diverse economic growth rates but lack significant fluctuations in long-term trends (Baer et al., 2023; Aguais and Forest Jr., 2023; Z-Risk Engine, 2023). Furthermore, the need to incorporate feedback loops and compound events to consider multiple risks materialising during the same time period has been emphasised to enhance the stressfulness of scenarios (Acharya et al., 2023).

To address these concerns, short-term climate scenarios are seen as a way to improve scenario severity for risk assessment. The various short-term shocks developed as part of this report (and the accompanying tool) are built to bridge the gap between current scenarios and scenarios with further enhanced severity for risk assessment purposes. To address the challenge of incorporating compound risk, the approach involves considering multiple shocks occurring simultaneously within the same time-horizon but are assumed to be independent of each other. Below is a comparison detailing the impact of combining these shocks against selected adverse scenarios from traditional stress tests (Examples 1–3).

Example 1: Comparison to the European Central Bank's 2023 stress test for Euro area banks (2023)

ECB's adverse scenario in the exercise: high and persistent inflation, with a significant decrease in economic activity.

Variable value reported for Year 1 (percentage points)	Adverse Scenario 2023 (high inflation and economic downturn)	Macro shock (geopolitical tension)	Transition risk shock (carbon price)	Physical risk shock (chronic physical effects)	Combination of all three UNEP FI and NIESR shocks
GDP	-4.8	-2.1	-0.5	-0.3	-2.9
Inflation	9.5	6.9	0.2	-0.0	7.1
Long-term interest rate	6.5	1.2	0.7	0.0	1.9

Example 2: Comparison to the USA Federal Reserve's 2023 stress test (2023)

The Federal Reserve's adverse scenario in the exercise: a severe global recession, with prolonged declines in both residential and commercial real estate prices (with spillover into the corporate sector), impacting investment sentiment.

Variable value reported for Year 1 (percent-age points)	Baseline Super-visory baseline scenario (Reference date: Q4 2023)	Adverse Supervisory severely adverse scenario (Reference data: Q4 2023)	Macro shock (Greenfla-tion, High)	Transition risk shock (Green spending, High)	Physical risk shock (Climate Migration, High)	Combi-nation of all three UNEP FI and NIESR shocks
GDP	0.9	-5.9	-0.6	4.9	-0.4	3.9
Forecasted Inflation (CPI)	2.4	1.3	0.7	0.7	0.4	1.8
Long-term interest rate	3.6	0.8	0.4	0.8	-0.1	1.1

Example 3: Comparison to the Reserve Bank of Australia's Statement on Monetary Policy (2020)

RBA's adverse scenario in the exercise: Australia encounters additional infection outbreaks and increased restrictions in certain areas following the initial COVID-19 outbreak. Furthermore, there is a global resurgence in infections in the near term. Recovery in service exports is further delayed and consumer spending continues to decline. Business investment also declines sharply. Domestic activity would take significantly longer to recover, resulting in the unemployment rate remaining close to its peak throughout 2021.

Variable value reported for Year 1 (percent-age points)	Baseline (Latest OECD fore-casts)	Adverse Downside Scenario (Reference data: 2020)	Macro shock (Geopoliti-cal tension, High)	Transition risk shock (Stranded assets, High)	Physical risk shock (Chronic physical effects, Current Policies)	Combi-nation of all three UNEP FI and NIESR shocks
Forecasted real GDP growth rate	1.9[5]	-3.09[6]	-1.5	-1.1	-0.3	-2.9
Forecasted inflation rates	5.6[7]	0.8[8]	3.5	0.8	-0.1	4.2

The comparison reveals that certain shocks developed as part of this report have resulted in similar percentage changes in the selected variables as observed by traditional adverse scenarios. Similarly, the combination of these shocks can result in substantial percentage changes in macroeconomic variables, such as GDP and inflation; similar to the types of stress levels measured using traditional adverse scenarios. However, certain climate shocks do project a limited impact on the variables. For instance, the physical risk shocks included showcase lower impacts on variables; this includes the chronic physical risk shock that is based on data from the NGFS scenarios.[9]

To enhance the severity of climate scenarios, one option is to integrate compound risks as part of climate scenarios by considering the occurrence of multiple risks due to the same underlying event or risk, increasing the probability of another risk. However, modelling compound events and feedback loops still remains in its infancy (Acharya et al., 2023). Another approach is the use of reverse stress tests, as this allows banks to identify potential scenarios that could cause a particular stress level. A reverse stress test allows banks to focus only on tail risk scenarios or extreme scenarios with low probability that would render the institution's business model unviable. Reverse stress testing can be a complex exercise, with only a handful of exercises so far having been conducted that incorporate climate.

5 ECD, 2024. Note that GDP given in constant prices and refers to the volume level of GDP.
6 RBA, 2020
7 OECD, 2024. Note that inflation forecast is measured in terms of the consumer price index (CPI).
8 RBA, 2020
9 It is important to note that as the combination of the short-term shocks presented in this report are additive, they can offer a limited insight into the systemic impact.

5. Conclusion

This report and the accompanying Short-term Climate Scenarios tool provide financial institutions with an additional resource for conducting short-term scenario analysis of climate risks to enhance their ability to measure potential exposures within a shorter time frame. Furthermore, it provides climate scenarios characterised by heightened severity (especially when compared to historical events) and considers the implications of multiple combined shocks. In this way, it provides insights into how such climate-related events may affect financial institutions and the global financial system. Overall, the work undertaken by UNEP FI and NIESR aims to provide a greater awareness for the finance sector of the nature and utility of short-term scenarios. The figure below highlights the key use cases of the tool for financial institutions.

Figure 45: Use cases of UNEP FI and NIESR's Short-term Climate Scenarios tool

Looking ahead, as the finance sector faces a rising need for a comprehensive scenario toolkit for risk assessment, the landscape of scenarios is expected to evolve, especially in regard to short-term scenarios. Notably, the forthcoming release of the NGFS short-term scenarios will mark a significant milestone in providing financial institutions with a resource to assess short-term climate risks. Furthermore, modellers and financial institutions continue to work on the development of nature risk scenarios, as well as on integrating nature risks into existing climate scenarios. Other sustainability risks are expected to follow suit soon and begin being considered for scenario analysis. Such advancements will not only broaden the scope of risk assessment but also underscore the growing importance of short-term scenarios as a pivotal component within banks' scenario toolkit (Table 17 and Figure 46).

Table 17: Overview of key scenario types available for use by financial institutions to address climate change

Types of scenarios available for use	**Long-term supervisory/ reference climate scenarios**	**Energy transition scenarios**	**Net-zero alignment scenarios**	**Short-term climate scenarios**	**Climate and other risk types integrated scenarios**
Description of scenario type	Scenarios that provide a range of potential future climate conditions based on different emission levels and their corresponding climate impacts across a 20-30-year time frame, extending to 2100.	Mitigation scenarios that consider how the overall energy system will transform (both supply and demand) by modelling its dynamics for a given warming outcome	Mitigation scenarios that are aligned with a science-based pathway to reach net zero around 2050 and limit warming to 1.5°C with no or low overshoot	Climate scenarios that explore the financial risks of climate changes across a time frame of 1 to 5 years, and even down to days and weeks in some instances	Integration of other sustainability risk types, such as nature risks, into existing climate scenario narratives
Currently Available Scenario Examples[10]	NGFS reference scenarios IPCC scenarios	IEA scenarios IRENA Long-Term Energy Scenarios (LTES) network	IEA Net Zero 2050 scenario NGFS Net Zero 2050 scenario One Earth Climate Model	UNEP FI & NIESR short-term scenarios ISDA's scenarios for the trading book Supervisory short-term scenarios	PRI's Forecast Policy Scenario (FPS) + Nature (Inevitable Policy Response)

10 Scenarios might overlap across the different types of scenarios that are available.

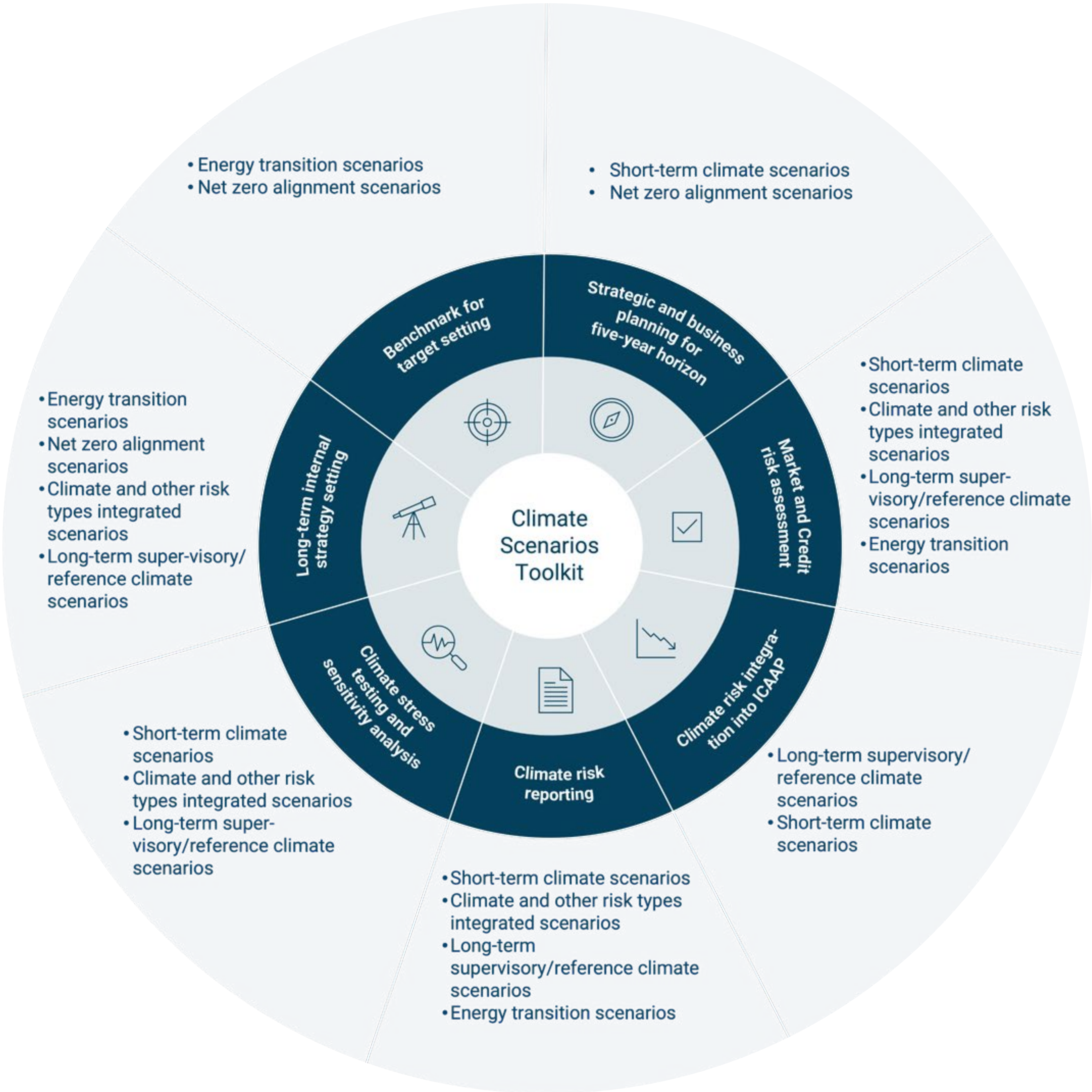

Figure 46: Illustration depicting the scenario types and their use cases of a financial user's toolkit of climate scenarios

Next steps for UNEP FI

In April 2024, UNEP FI launched its Risk Centre to provide risk professionals with a comprehensive approach to assessing sustainability risks. Through the Centre's technical programming, UNEP FI will continue to prioritise supporting the financial sector to advance its capabilities to use scenario analysis for risk assessment. This involves developing tools and methodologies for practical use, not only focusing on climate and nature scenarios but also supporting members in addressing other sustainability risks in their analyses.

Furthermore, UNEP FI will also continue to work with the financial sector with the aim of better understanding how to assess the consequences of multiple climate-related economic impacts occurring simultaneously in the short term. UNEP FI will also continue engaging with leading modellers and experts, bridging the modelling community and the finance sector.

Next steps for NIESR

NIESR is delighted to continue its partnership with NGFS in 2024 and 2025 in updating and developing climate risk scenarios, and providing macroeconomic indicators for various climate scenarios.

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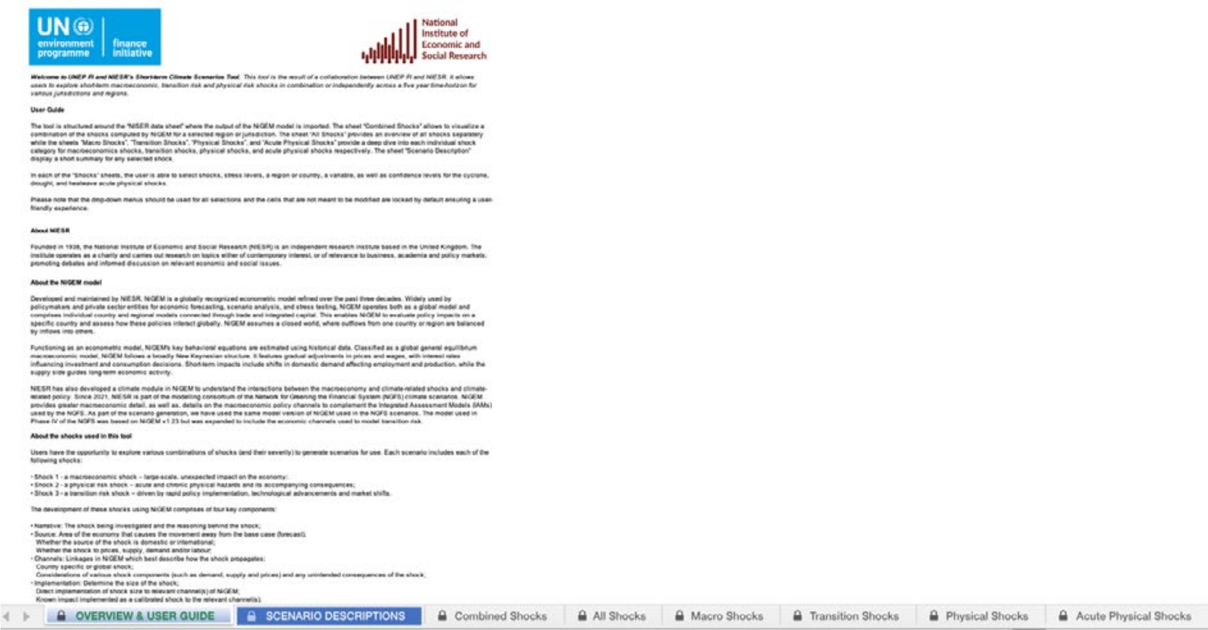
Appendix I—User Guide

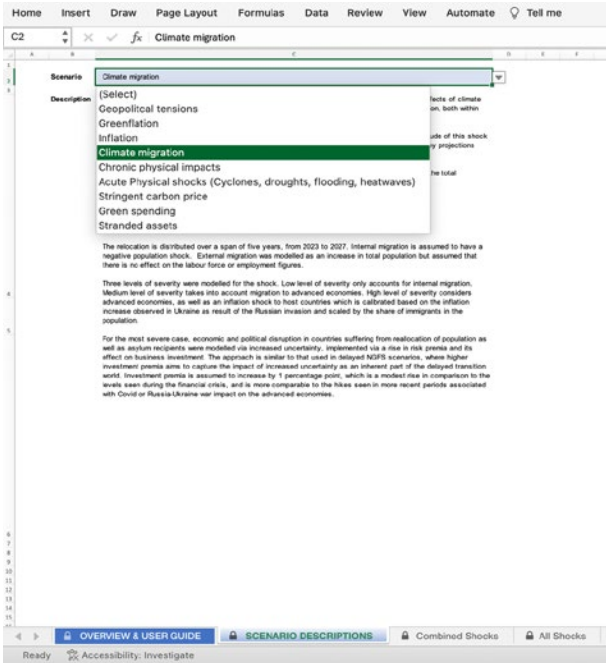
The tool is the result of a collaboration between UNEP FI and NIESR. It allows users to explore short-term macroeconomic, transition risk, and physical risk shocks in combination or independently across a five-year time-horizon for various jurisdictions and regions.

The tool is divided into the following eight sheets: Overview & User Guide, Scenarios Descriptions, Combined Shocks, All Shocks, Macro Shocks, Transition Shocks, Physical Shocks, and Acute Physical Shocks.



The *Overview & User Guide* sheet provides a short user guide as well as some background information about the NiGEM model.

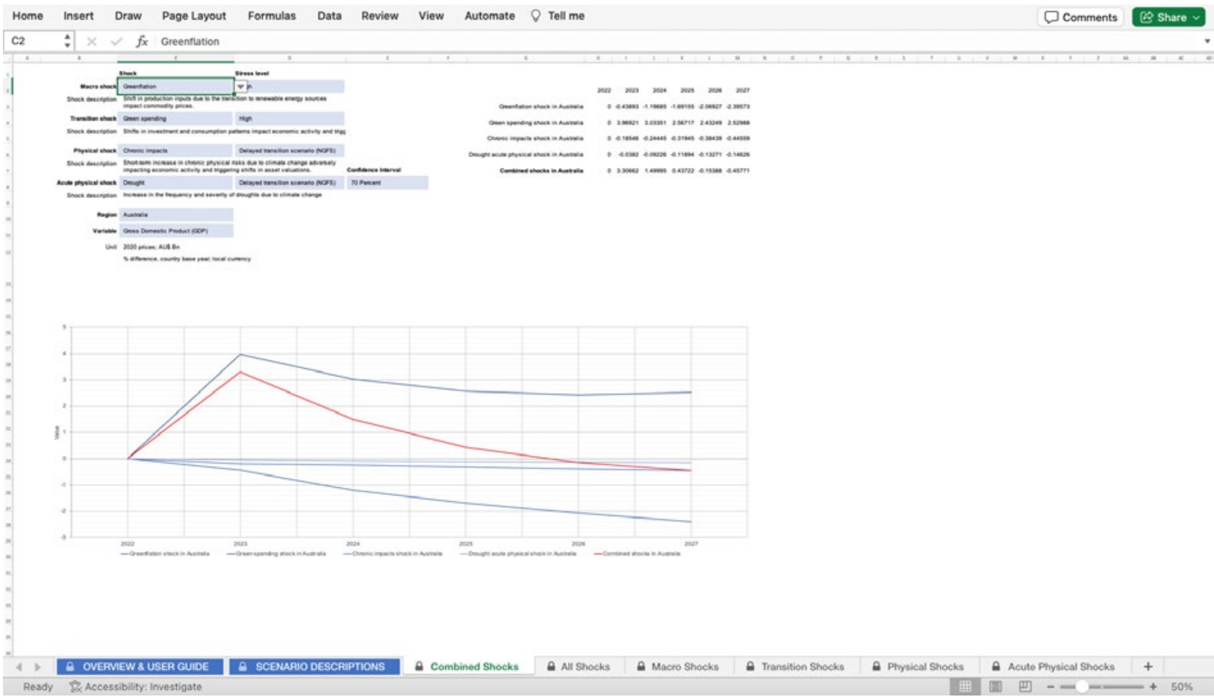
(A)



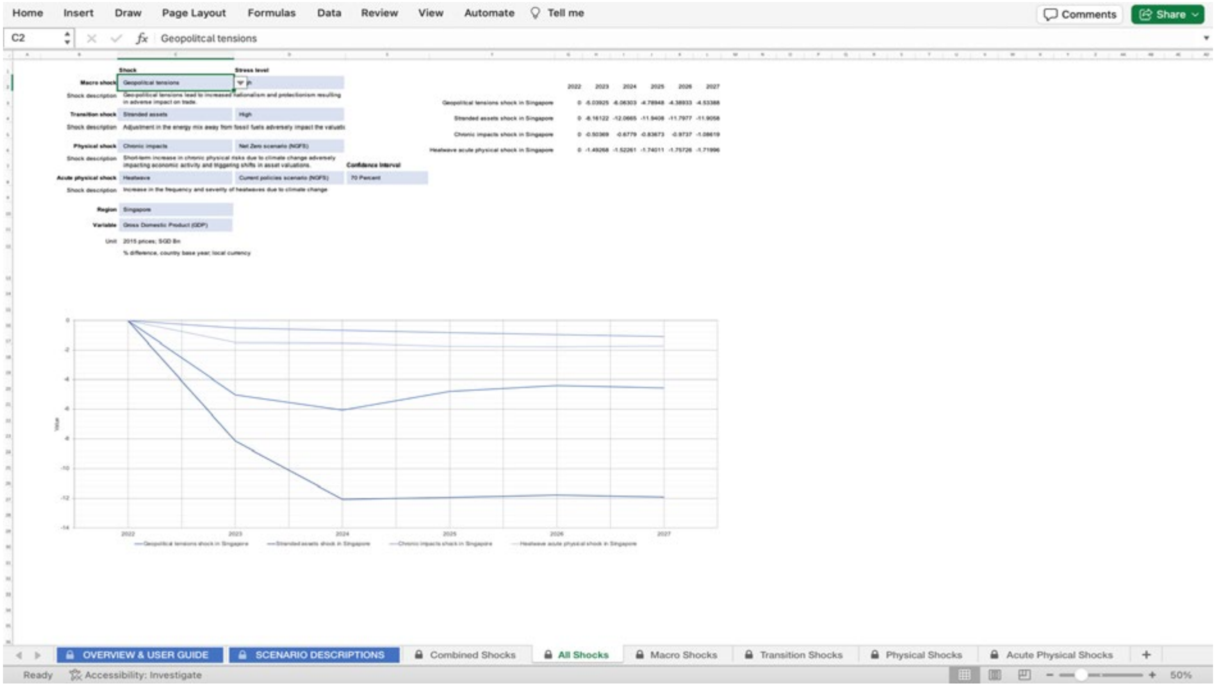
(B)

The *Scenario Description* sheet displays a short description of all the shocks available in the tool.

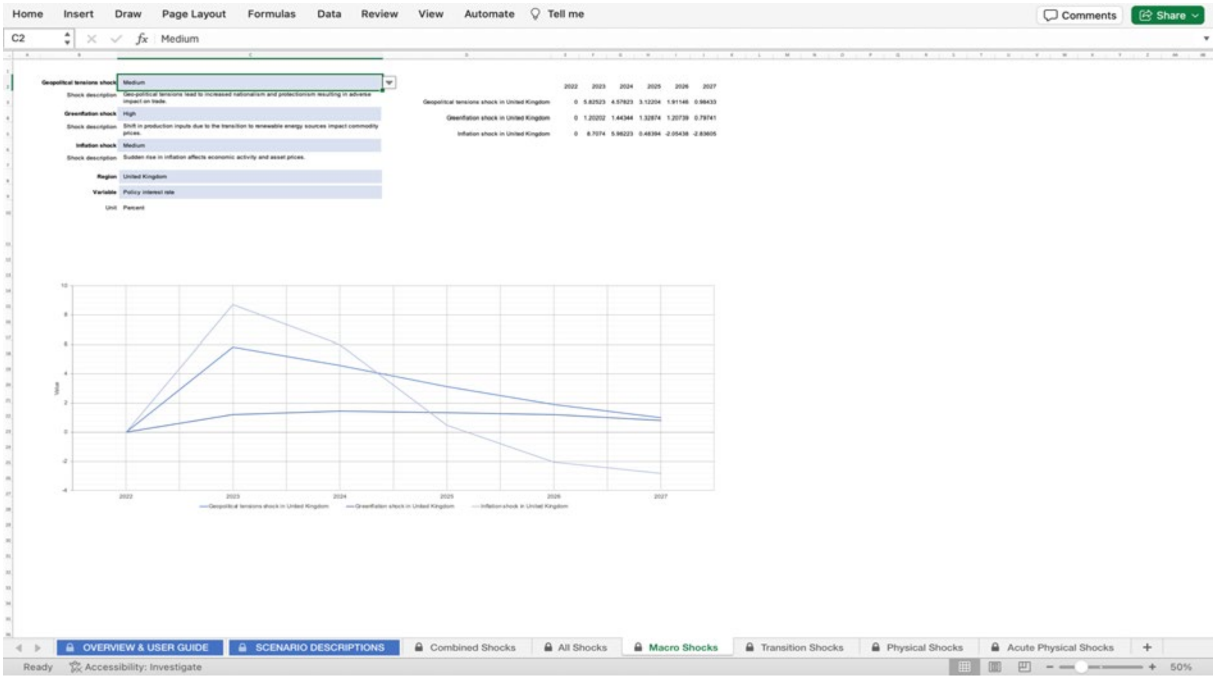
Each scenario can be selected in the "Scenario" drop down menu (A). The description of the selected scenario will then appear underneath (B).



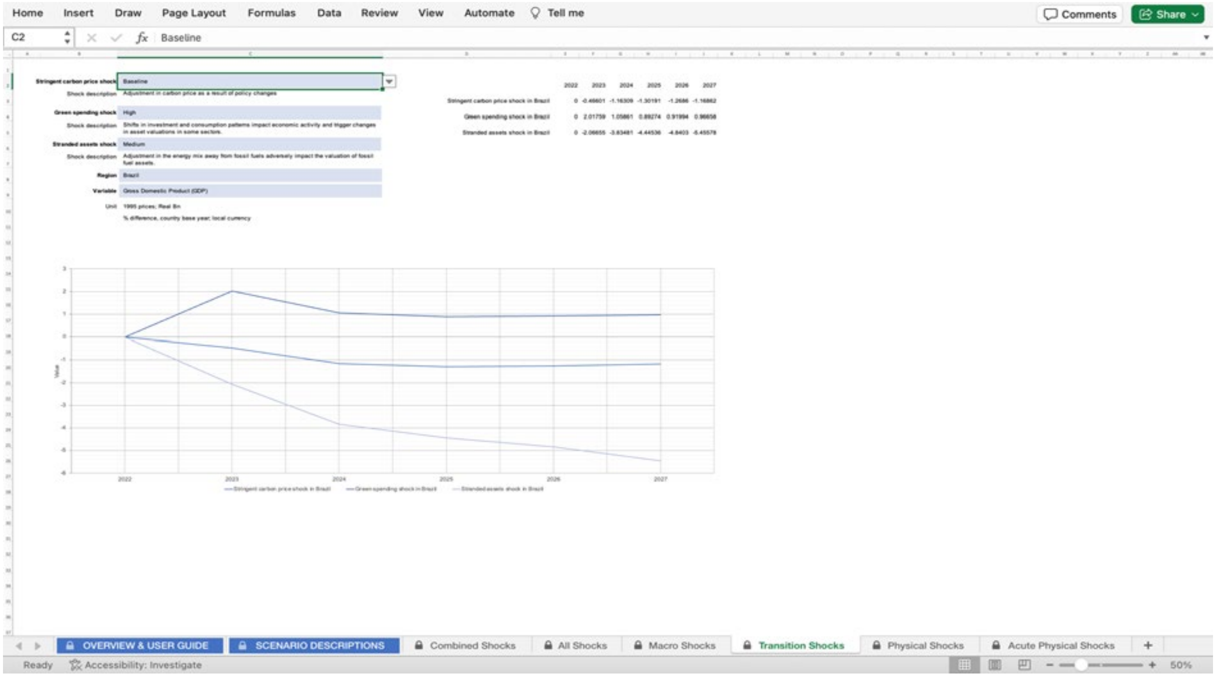
The sheet called *Combined Shocks* allows to visualise a combination of the shocks computed by NiGEM for a selected region or variable.



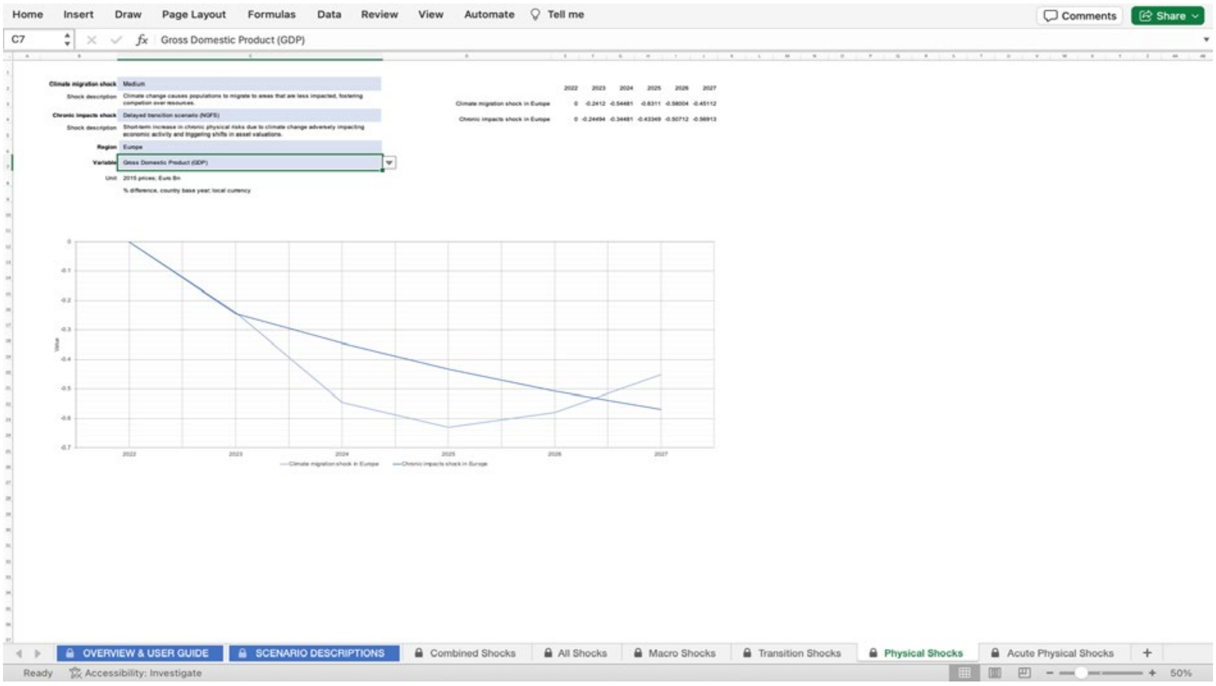
The *All Shocks* sheet allows the user to plot on the same graph one shock from every shock type (e.g. Macroeconomic, Transition, Physical, and Acute Physical). The user is able to select regions and variables.



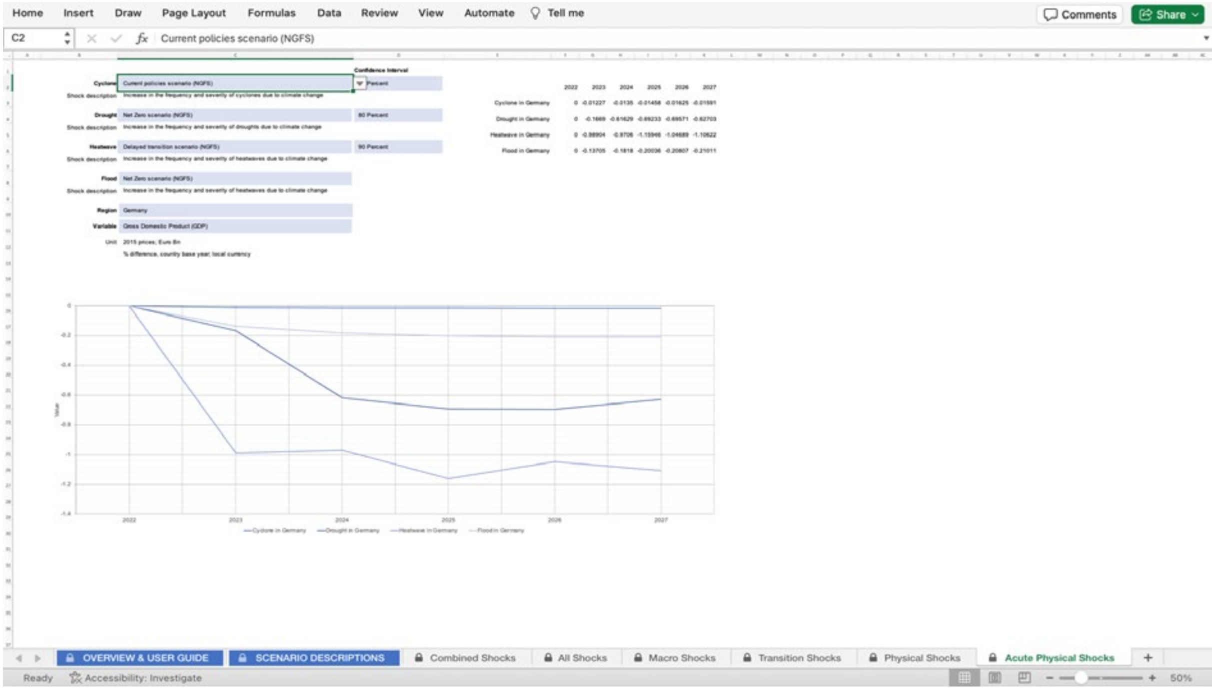
The *Macro Shocks* sheet enables the user to plot the three macroeconomic shocks calculated by NiGEM (e.g. Geopolitical tensions, Greenflation, and Inflation) for a selected region and variable.



The *Transition Shocks* sheet allows the user to plot the three transition shocks calculated by NiGEM (e.g. Stringent carbon price, Green spending, and Stranded assets) for a selected region and variable.



The *Physical Shocks* sheet enables the user to plot the two (non-acute) physical shocks calculated by NiGEM (e.g.Climate migration and Chronic impacts) for a selected region and variable.



Finally, the *Acute Physical Shocks* sheet allows the user to plot the impact all four acute physical shocks/extreme weather events on GDP calculated by NiGEM (e.g. Cyclones, Droughts Heatwaves, Floods) in a selected region.

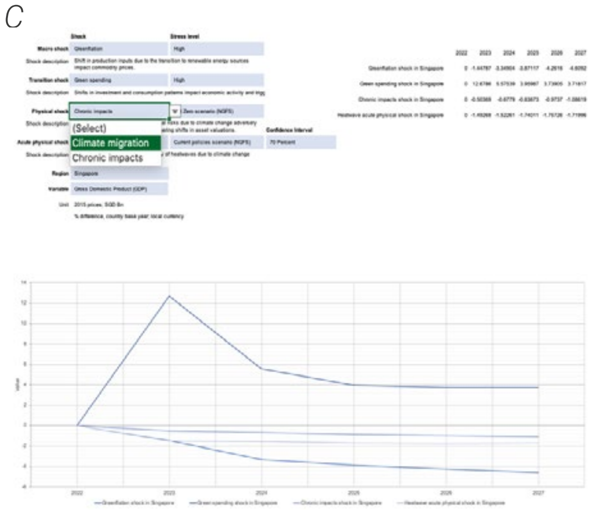
In addition to these eight "user-facing" sheets, the hidden "NISER data sheet" contains the output of the NiGEM model used as a basis by the tool.

In each of the "Shocks" sheets, the user is able to select shocks using drop-down menus. For instance, in the *All Shocks* sheet, the user can select a macroeconomic shock (A), a transition shock (B), a physical shock (C), and an acute physical shock (D).

A

B

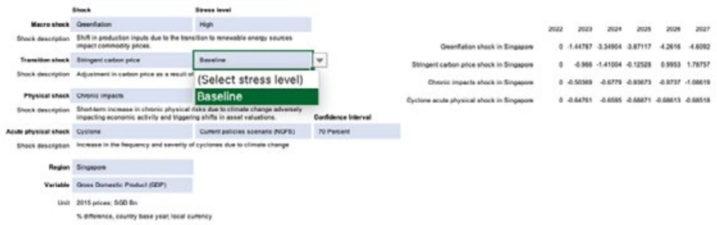
C

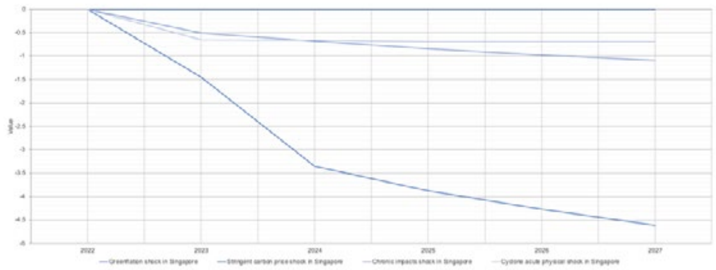


D

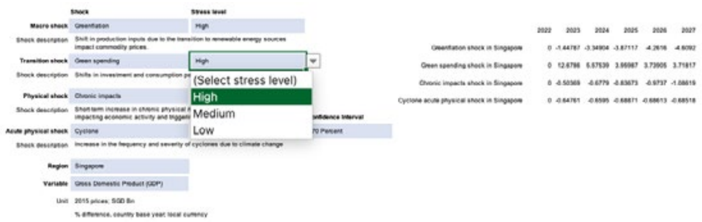
Once, the shock is selected, the user must choose a level of stress. The available levels and denomination of stress levels may differ across shocks as illustrated below.

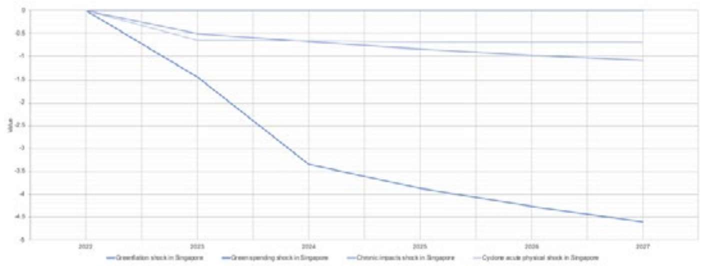
For all three macroeconomic shocks, three stress levels may be selected—namely, "High", "Medium", and "Low".



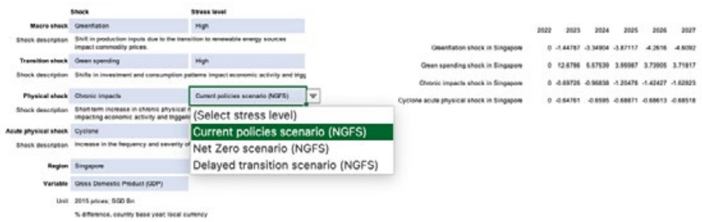


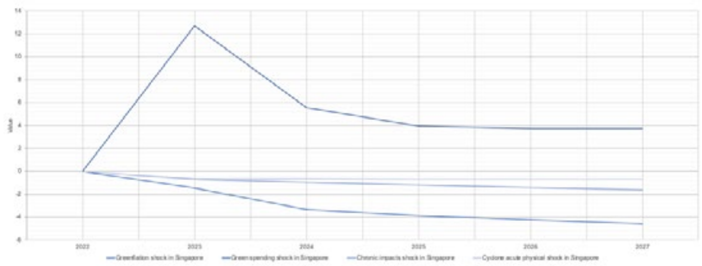
For the *Stringent Carbon Price* transition shock, only a "Baseline" stress level is available.



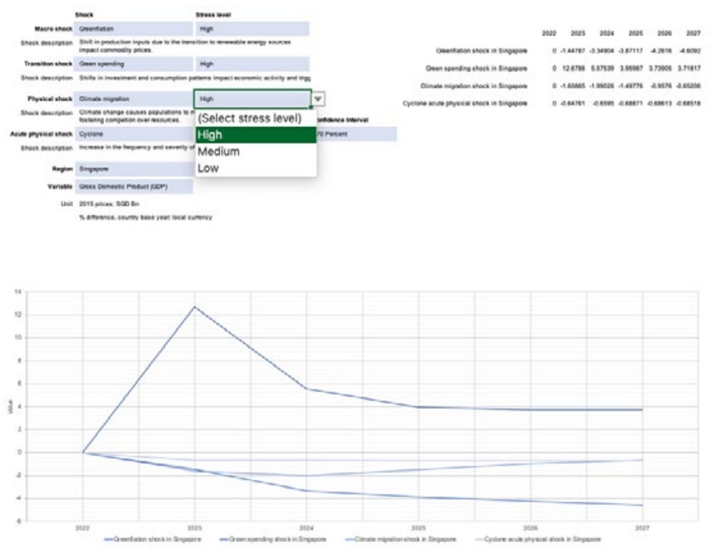


For the *Green spending* and *Stranded assets* shocks, the stress level may be set as "High", "Medium", or "Low", similar to Macroeconomics shocks.

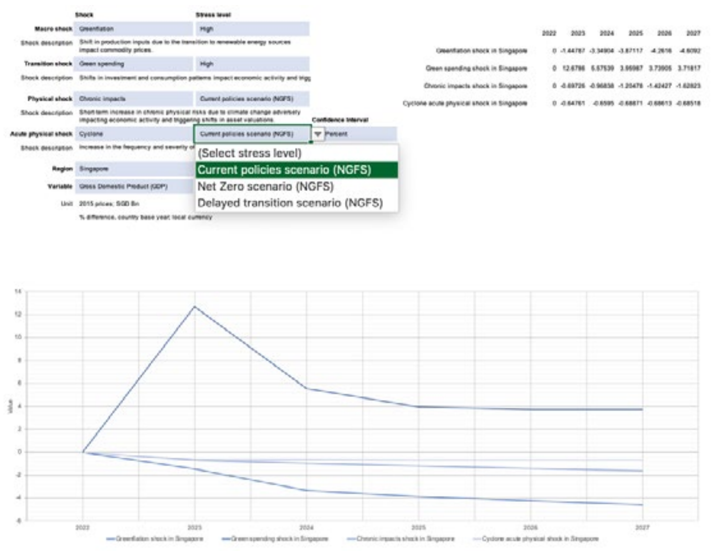




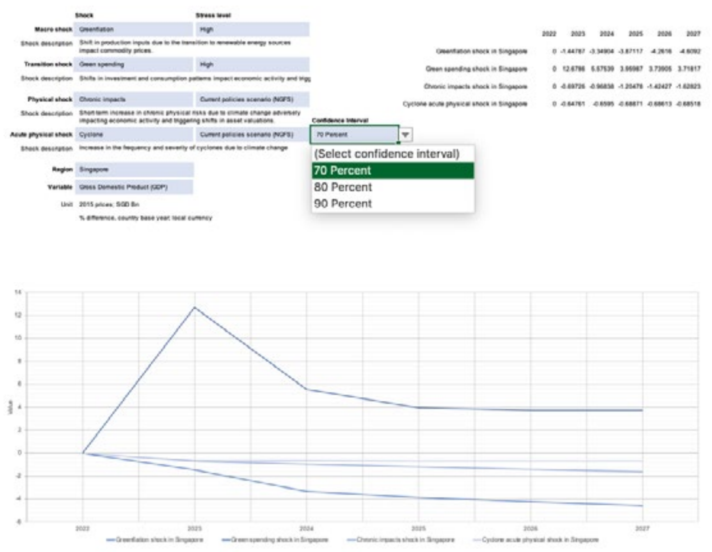
Regarding physical shocks, the available stress levels for the *Chronic impacts* shock are "Current policies scenario (NGFS)", "Delayed transition (NGFS)", and "Net-zero scenario (NGFS)". These scenarios are based on those provided by the [Network for Greening the Financial System (NGFS)](#).



For the *Climate migration* physical shock, the available stress levels are “High”, “Medium”, and “Low”.



Similarly to the *Chronic impacts* shock, the stress levels available for acute physical shocks are “Current policies scenario (NGFS)”, “Delayed transition scenario (NGFS)”, and “Net Zero scenario (NGFS)”, in line with the scenarios provided by the Network for Greening the Financial System (NGFS).



In addition to stress levels, the NiGEM model allows to compute the impacts of acute physical shocks for a confidence interval of 70 per cent, 80 per cent, and 90 per cent. These values must be selected for the “Cyclone”, “Drought”, and “Heatwave” shocks.

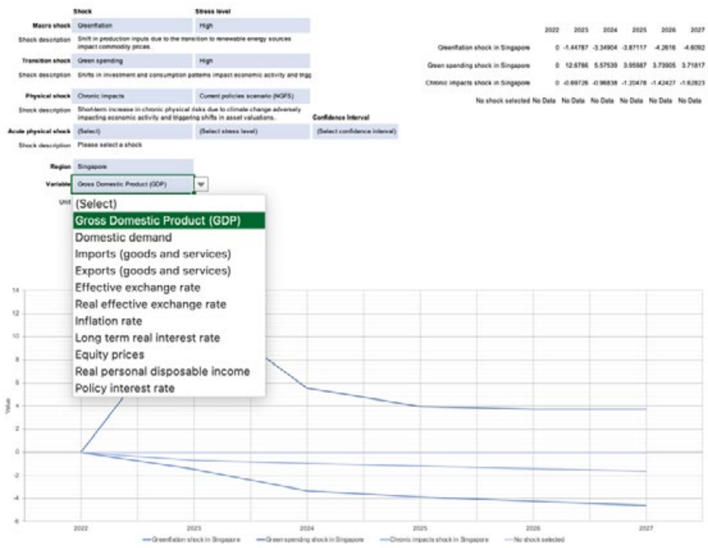
For "Floods", however, it is not possible to select the confidence interval, hence only the "none" option is available to the user.

After selecting shocks and associated stress levels (as well as confidence intervals for acute physical shocks), a region or country must be selected in the drop down menu.

At the moment, the following countries can be selected: Argentina, Australia, Austria, Belgium, Brazil, Bulgaria, Canada, Chile, Hong Kong China, Croatia, Czech Republic, Denmark, Egypt, Estonia, Finland, France, Germany, Greece, Hong Kong, Hungary, India, Indonesia, Ireland, Italy, Japan, Latvia, Lithuania, Malaysia, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Singapore, Slovakia, Slovenia, South Africa, South Korea, Spain, Sweden, Switzerland, Taiwan, Türkiye, United Kingdom, United States of America, and Viet Nam.

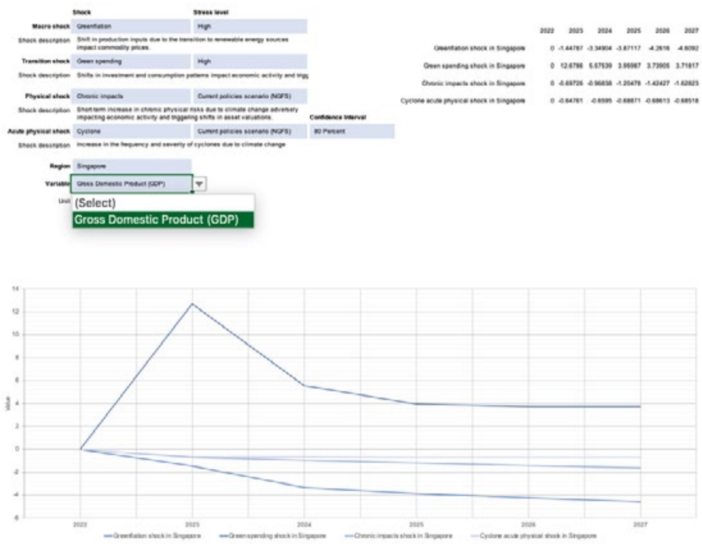
In addition, the Africa, Asia, Europe, Middle East, and Latin America regions can be selected. Aggregated data are also available globally.

Finally, the user must select a variable to be displayed. The unit used, as well as a short definition of each variable, is automatically provided underneath the selected variable.



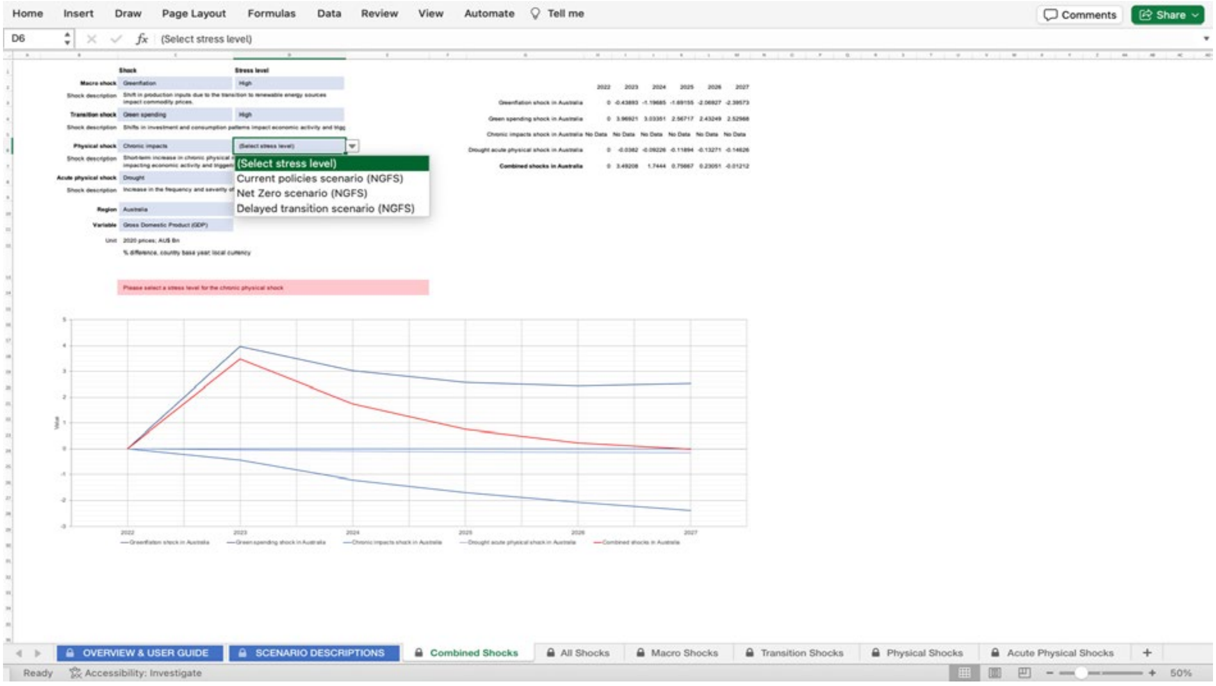
For all shocks in all regions, the impacts of the shocks on the following variables can be displayed: Gross Domestic Product (GDP), Domestic demand, Imports (goods and services), Exports (goods and services), Effective exchange rate, Real effect exchange rate, Inflation rate, Long term real interest rate, Policy rate, Equity prices, and Real personal disposable income.

Please note, however, that the long-term real interest rates as well as the policy rates for the chronic physical shock are unavailable.



NiGEM is only able to compute the GDP impact of acute physical shocks. As a result, when "Cyclone", "Drought", "Flood", or "Heatwave" shocks are selected, the only variable that the user is able to select is Gross Domestic Product (GDP).

While the layout may vary across the Shocks sheets, the choices of stress levels, regions, variables, and confidence level for acute physical shocks remain the same. All drop-down menus are located in light-blue coloured cells. An error message will appear in the cell below the unit description if there is an issue with the selected shocks, variables, regions, stress, or confidence levels.



For example, the stress level for the *Climate migration* shock has not been selected here as explained by the text in the red box above the graph—or below the unit description.

Please note that the drop-down menus should be used for all selections and the cells that are not meant to be modified are locked by default, thus ensuring a user-friendly experience. These cells may nonetheless be unlocked and modified using the password UnepFI24. Please note that modifying the locked cells may result in the tool breaking down.

UN environment programme

finance initiative

UNEP Finance Initiative brings together a large network of banks, insurers and investors that collectively catalyses action across the financial system to deliver more sustainable global economies. For more than 30 years the initiative has been connecting the UN with financial institutions from around the world to shape the sustainable finance agenda. It has established the world's foremost sustainability frameworks that help the finance industry address global environmental, social and governance (ESG) challenges. Convened by a Geneva, Switzerland-based secretariat, more than 500 banks and insurers with assets exceeding US$100 trillion work together to facilitate the implementation of UNEP FI's Principles for Responsible Banking and Principles for Sustainable Insurance. Financial institutions work with UNEP FI on a voluntary basis and the initiative helps them to apply the industry frameworks and develop practical guidance and tools to position their businesses for the transition to a sustainable and inclusive economy.

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