Strengthening the Capacity of Independent Fiscal Institutions

Deliverable 2A. Review of the existing long-term analytical tools

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Cover photo credit: Nuno Marques, "green grass field near the road during the day". Published on the 18th February 2021, via Unsplash.

LIST OF ABBREVIATIONS

AIReF	Spanish Independent Authority for Fiscal Responsibility
BMSA	Beneficiary Member State Authority
CE	Cambridge Econometrics
CGE	Computable General Equilibrium
CPAT	Climate Policy Assessment Tool
COACHH	CO-designing the Assessment of Climate Change Costs
DG ECFIN	Directorate-General for Economic and Financial Affairs
DG REFORM	Directorate-General for Structural Reform Support
DSA	Debt Sustainability Analysis
EM-DAT	Emergency Events Database
ESR	Effort Sharing Regulation
ETS	Emission Trading Systems
EU	European Union
GDP	Gross Domestic Product
GFCF	Gross Fixed Capital Formation
GHG	Greenhouse Gas
GNI	Gross National Income
GVA	Gross Value Added
HFISC	Hellenic Fiscal Council
IAM	Integrated Assessment Model
IFAC	Irish Fiscal Advisory Council
IFI	Independent Fiscal Institutions
IMF	International Monetary Fund
IPCC-WGI	Intergovernmental Panel on Climate Change – Working Group I
FDC	Latvian Fiscal Discipline council
LTFS	Long-Term Fiscal Sustainability
MOF	Ministries of Finance
MS	Member State
MTFS	Medium-Term Fiscal Strategy
MTP	Medium-Term Fiscal Structural Plan
NECPs	National Energy and Climate Plans
NEF	New Economic Foundation
OBR	Office for Budget Responsibility
OECD	Organisation for Economic Co-operation and Development
PM	Project Manager
QAM	Quality Assurance Manger
QPM	Quality Project Manger
RED	Renewable Energy Directive
RFS / ToR	Request for Service / Terms of Reference
RRF	Recovery and Resilience Facility
SC	Steering Committee
SFC	Slovenian Fiscal Council
SGP	Sustainability and Growth Pact
SSC	Social Security Contributions
UTM	Unprofitable Top Margins
VAT	Value Added Tax
VRT	Vehicle Registration Tax
WEM/WAM	With Existing Measures/With Additional Measures

1. Introduction to Pilar 2

1.1. Introduction

The aim of Pillar 2 is to focus on fiscal sustainability and climate transition. This report highlights the best practices for incorporating climate change considerations into standard government debt sustainability analysis. It aims to evaluate sustainability challenges that arise under different climate scenarios and the current capabilities of government debt sustainability analysis in the different IFIs.

This report follows the inception report circulated in March 2024 which revolved around a preliminary overview of IFI capabilities and requirements done between April-June 2024 for Cyprus, Spain, Latvia, and Slovenia. T The scoping phase for Greece ended in March 2025. Based on discussions with Pillar 2 IFIs and the assessment of their capacities and available modelling options, this report addresses the following aspects, consistent with the requirements set out in the Request for Service (RfS):

- An overview of the existing literature that is relevant to Pillar 2
- A proposed general framework outlining the:
    - different blocks that impact public finances in the context of climate change and transition
    - inputs, outputs and the interlinkages of each component to other blocks
- Scenarios of temperature warming and a framework measuring its impact
- Contextualising findings to specific IFIs: Cyprus, Spain, Latvia and Slovenia
- Workplan for the subsequent phases and timetable.

1.2. Pillar 2 Overview

The new EU fiscal framework proposed by the European Commission aims at strengthening public debt sustainability and promoting sustainable and inclusive growth in all Member States through structural reforms and investment, while subject to compliance with the Stability and Growth Pact (SGP) reference values for the budget deficit and public debt.

At its core the new framework is intended to encourage stronger national ownership (of Medium-term Fiscal-Structural Plans, MTPs), to provide a simplified operational rule (ceiling on net government expenditure path) taking account of different fiscal challenges (risk-based surveillance focused on public debt sustainability), to facilitate reforms and investment for EU priorities (through flexible fiscal adjustment based approved plans), and to support effective enforcement (ensuring delivery on commitments on MTPs). Independent Fiscal Institutions (IFIs) are envisioned to play an important role in supporting the EU in the application of the new fiscal framework, including as an important input in the assessment of the application of the framework in individual Member States. These steps build on the current role IFIs play in supporting fiscal sustainability and in promoting transparency, accountability, compliance, and unbiased public finance forecasts in EU Member States. In parallel, the IFIs will be required to expand their activities, in an enhanced role in fiscal surveillance, requiring unlimited and timely access to information on the public sector, adequate budgetary and human resources, and support in safeguarding independence. The startup for this evolution has not been uniform across IFIs, and the required enhancements may differ among Member States depending on the specific historical and institutional features of each Beneficiary Member State Authority (BMSA). This development occurs in tandem with the green transition which presents challenges to public finances and consequently for IFIs in coping with the ensuing implications and risks.

2. Review of Existing Analytical Tools and Methodologies

2.1. Introduction

Under the European Green Deal, the EU aims to become climate-neutral (net-zero greenhouse gas (GHG) emissions) by 2050. To achieve this, it proposes substantial cuts to GHG emissions including the amendment to the European Climate Law. Adhering to these targets would require public investment from Member States. However, the European Court of Auditors has expressed concerns about the EU's 2030 targets, stating that little action was taken to translate the targets into action and financing sources (European Court of Auditors, 2023). Concerns were raised about the budget sustainability to ensure the required financing amounts. The report by the New Economic Foundation (NEF) has found that only a few countries - Ireland, Sweden, Latvia, and Denmark - would be realistically able to increase public investment by 3% of GDP and stay within EU spending limits[1]. This would enable them to meet their Paris climate commitments. However, several countries, including France, Italy, Spain, and Belgium, would be unable to achieve even minimum increases in investment without significantly reducing other public spending or substantially increasing taxes to trigger the necessary climate spending.

The objective of Pillar 2 is to model the broad impact of climate change and transition on public finance. The objective of Deliverable 2A is evidence review, draft framework development, review of existing tools for each IFI, and develop and refine workplan for the rest of the Pillar 2 work.

The methodological framework consists in:

- A literature review of existing academic publications and those from other Independent Fiscal Institutions (IFIs) and international organisations that are relevant to Pillar 2. This gives us an overview of how the literature models physical risks, transition and compliance costs as well as impacts on public finances/debt.
- An overview of the proposed analytical framework and how to operationalise and integrate different aspects.
- Implementation of the analytical framework in each IFI.

The draft framework (Section **Error! Reference source not found.**) aims to define the i ntersection of climate change and macroeconomic-fiscal issues, including the fiscal representation of climate action, the assessment of climate investments and risks, and the macro-fiscal implications of various climate scenarios.

It also outlines the preferred sources of information on different climate scenarios and their impact on macroeconomic-fiscal development, along with guidance on incorporating relevant climate-scenarios information into macroeconomic-fiscal analysis. This general framework also establishes the practical implementation steps involving a combination of standardised tools and IFI-specific work to accommodate country-specific features and integrate the framework into existing IFI tools and models.

[1] neweconomics.org/uploads/files/Beyond-the-Bottom-Line-web-v1.pdf

2.2. Literature Review

Climate change could present significant challenges to economies and public finances, whether through:

- continued climate change, which may lead to more frequent and/or severe events (acute shocks), as well as longer-term (chronic) deterioration of physical and economic assets
- climate action, for which substantial investments and policy reforms may be needed for mitigation and/or adaptation (with costs but also potential benefits)
- transition of industries from fossil fuel to renewable energy sources.

In light of this, climate change considerations are being integrated into economic assessments such as Debt Sustainability Analysis (DSA), recognising the risks to economies, and in particular to countries' fiscal stability.

2.2.1. Overview

Although the effects are potentially substantial, climate-related fiscal risks have, until recently, often been overlooked in climate-economy models (European Commission, 2020). This is largely due to the inherent challenges in quantifying these risks and developing a comprehensive framework which incorporates the systemic implications of climate change and their impacts on public finances.

Recent efforts by public institutions to integrate climate change considerations into fiscal sustainability frameworks include those by the UK Office for Budget Responsibility (OBR), whose framework differentiates between short-term (physical) risks from extreme weather and cumulating longer-term (transition) risks associated with adaptation and mitigation policies. The US Congressional Budget Office (2019) has similarly been examining the fiscal consequences of extreme weather, as well as exploring the impacts on growth and public finances of emissions-reduction policies like carbon taxes and emissions trading. The IMF and World Bank, as well as countries like Australia, Japan, Mexico and New Zealand, have also been assessing the economic impacts of especially natural disasters in their fiscal analyses (OECD, 2019).

Table 1 presents a broad overview of approaches in the literature to integrating climate change considerations into macroeconomic/fiscal analysis. These include attempts by international organisations, such as the International Monetary Fund (IMF), World Bank, and the European Commission, as well as by IFIs and other relevant institutions in MSs. Table 1 highlights the variety of approaches, focus areas and degrees of analytical complexity. Modelling approaches range from spreadsheet models (Black et al., 2023) and adaptations of standard models (IMF, 2023; Office for Budget Responsibility, 2021) to the deployment of more complex energy-economy models to examine transitions in a more integrated manner (Irish Fiscal Advisory Council, 2023b). Some of these attempts are specifically focused on impacts on fiscal sustainability, while others are interested more broadly in the macroeconomic consequences of climate change/action. While there are similarities in the approaches, there is currently no strong consensus on the preferred framework or modelling approach, with regard to both the climate change-related aspects that are considered, or policy actions and impacts to be included in the frameworks or analyses.

In the literature, climate risks are broadly categorised into *physical risks*, i.e. those associated with climate disasters and sustained climate change, and *transition risks*, i.e. those stemming from climate policy action (E. Feyen et al., 2020; Gagliardi et al., 2022; Irish Fiscal Advisory Council, 2023b; Office for Budget Responsibility, 2021; Swedish Fiscal Policy Council, 2024). Physical risks could affect fiscal stability because natural disasters may lead to abrupt changes in asset values. Moreover, climate disasters may affect economies' productive capacity and, in turn, adversely impact debt sustainability depending on the effect on government revenues and/or expenditures relating to recovery. In contrast, transition risks are linked with the transition to a low-carbon economy. Effective climate policies may require balancing expenditures on adaptation and mitigation with potential revenues from carbon and other taxes to support a fiscally sustainable transition.

While many approaches draw this distinction between physical and transition risks in their frameworks, legal obligations may present a further consideration e.g. if there are repercussions of non-compliance with such obligations. Given that EU MSs are now legally bound to reach specific targets on emissions, potential *compliance costs* may need to be factored in should targets be missed. In some frameworks, this is thought of as a third consideration although with little work beyond that by IFAC (2023b) to estimate its potential impact on public finances.

Given the timeframe in question when assessing the impacts of climate change-related risks, it is critical to consider a longer-term horizon than in more routine fiscal analysis. Most approaches look to 2050 or beyond, in contrast to the typically shorter-term focus of macroeconomic/fiscal assessments.

Table 1: Overview of literature on macroeconomic/fiscal considerations of climate change

Organisation	Source	Type	Climate risks considered	Actions considered	Timespan	Focus
International analyses						
IMF	Black et al (2023)	Model application for climate policy assessment	Physical risks represented by continued GHG emissions; Transition risks	Many, e.g. emissions reductions based on NDCs, ETS, subsidies	15-year horizon	GDP impacts; government revenues
IMF	IMF – Fiscal Monitor (2023)	Model application for climate policy assessment	Transition risks	Carbon pricing, green public investment, subsidies, social transfers	2050	Public debt
IMF	IMF (2022)	Adjustment of DSA to include climate-resource spending	Acute physical risks; Transition risks	Recovery costs, Adaptation and mitigation spending	5 years	Public debt
European Commission	Gagliardi et al (2022)	Comparative analysis of acute extreme weather event risk on debt sustainability	Estimated economic losses from climate events; Transition risks	Recovery costs	10 years	Debt sustainability

European Commission	Zenios et al (2022)	Integration of Integrated Assessment Model into DSA to assess climate-adjusted debt dynamics	Physical risks (damages); Transition risks	Carbon taxes, ETS, Recovery costs, social transfers, subsidies	2080	Public debt
World Bank	Feyen et al (2020)	Theoretical framework of interaction between macro-financial and climate-related risks	Physical risks (damages); Transition risks	Carbon taxes, adaptation spending	N/A (theoretical framework only)	Public debt
World Bank	World Bank (2021)	Model application to integrate climate change module into existing macro-fiscal framework	Economic damages from heat; changed rainfall patterns	Carbon taxes, adaptation spending	2080	Economic impacts
OECD	OECD (2019)	Comparative study across countries of fiscal impacts of natural disasters	Acute damages from natural disasters	Disaster loss compensation	N/A (historical analysis only)	Public expenditure and revenues
IFI/country-specific analyses						
European Commission	Vousdoukas et al. (2020)	Estimation of annual damages by coastal floodings	Coastal flooding	Adaptation spending; recovery costs	2100	Economic impacts
IFAC	Irish Fiscal Advisory Council (2023b)	Model application to assess transition impacts on public finances	Damages from extreme weather events; Transition risks	ETS, carbon taxes, retrofits, Recovery costs	2050	Public finances
OBR	Office for Budget Responsibility (2021, 2023)	Model application to assess transition impacts on public finances	Extreme weather events (frequency, severity) ; Transition risks	Carbon taxes, ETS, public investment	2050	Public debt
CPB	Netherlands Bureau for Economic	Analysis to assess inter-generational	Climate damage costs; Transition	Subsidies, carbon prices, adaptation	2100	Inter-generational costs

	Policy Analysis (2023)	effect of climate costs	risks; non-compliance costs	spending, compensation spending		
CBO	US Congressional Budget Office (2019)	Estimation of budgetary costs from extreme weather events	Climate damage costs	Recovery costs	Long run expected annual costs	Public sector losses
IMF	Chen et al. (2023)	Evaluation of mitigation policies and hazards from weather shocks	Climate damage costs; Extreme weather events; Transition costs	Carbon taxes, ETS, tax reforms	2030	Economic impacts

2.2.2. International analysis

This section describes in more detail a selection of approaches at the international level, focusing specifically on work done by the IMF/World Bank and the European Commission.

IMF/World Bank

Considering transition risks linked to climate change, the Climate Policy Assessment Tool (CPAT), developed by the IMF and the World Bank, is a model designed to help countries mitigate climate change by integrating climate change considerations into their policy planning, including DSA (Black et al., 2023). CPAT allows for the rapid quantification of impacts of climate mitigation policies, including on energy demand, prices, emissions, government revenues, welfare, GDP, households and industries, local air pollution and health. The CPAT database covers a wide range of countries, supporting analysis of a diverse set of policies including taxes, subsidies, feed-in tariffs and green investments. As a 'model of models', CPAT integrates four components/modules: mitigation, to examine energy, emissions, revenue and GDP impacts; distribution, to estimate impacts on sectors/households; air pollution, to estimate health impacts; and transport, to estimate impacts on congestion and other externalities. There have been many applications of CPAT to conduct climate mitigation policy analysis, which vary in their geographic scope (e.g. country-level, regional or global analyses) or their thematic focus (e.g. comparisons between mitigation instruments or carbon price equivalence of policies).[2] As an example, De Mooij and Gaspar (2023) use the CPAT framework to assess the medium-term (2030) impacts on the government revenues of a global side agreement on carbon mitigation. With an efficient, uniform carbon price, i.e. one that will achieve agreed emission reduction in a 2°C decarbonization scenario, gross revenues from carbon taxes in 2030 are estimated to range between 0.5 and 3% of GDP. The analysis also incorporates revenue loss from base erosion of existing fuel taxes down the line, which is estimated to be within a range of 0.2 and 1.1% of GDP. Crucially, the results are dependent on the assumption that carbon prices are set at a level that achieves the targets.

[2] For a detailed list of applications, see Annex IV in (Black et al., 2023).

CPAT has a number of caveats. The model projects over a 15-year horizon, which limits its applicability for assessing longer-term policy impacts. Policy responses are assumed to be linear, whereas effects may well be non-linear in the face of large policy changes, such as those promoting large-scale technological development or adoption e.g. from higher carbon taxes. Also, while CPAT offers an extensive view on the effects of mitigation policies, it is less suited to assessing climate change-related physical risks (both acute and chronic) and integrating climate-economy interactions which might require a longer time horizon than CPAT allows for. However, CPAT is (increasingly) designed to allow linking with external models, such as macro-econometric, computable general equilibrium, or sectoral models, which may increase its future potential useability.

Using a different approach, in their Fiscal Monitor (2023), the IMF employs a New Keynesian dynamic general equilibrium model to simulate the change in public debt-to-GDP ratios stemming from the implementation of expenditure-based measures for achieving net zero emissions by 2050. The model is complemented by an energy input and a large set of fiscal policies. Fiscal policies in the model include carbon pricing, green subsidies, public investment, targeted transfers, and taxes on consumption, labour and capital income. Public investment amounts are calibrated to upper ranges provided by the International Energy Agency (2022) and carbon prices are aligned with those projected by the International Energy Agency (2021) for their net-zero-emission scenario. Emissions are assumed to be reduced by 80% by 2050. The findings indicate a sharp rise in debt ratios, putting debt sustainability at risk. Specifically, for a representative advanced economy, the debt-to-GDP ratio increases by up to 45 percentage points, depending on the simulated spending policy scenario, along with an uptick in government borrowing costs. The magnitude of rising debt levels would likely be unsustainable, with falling revenues from fuel taxes exacerbating the risk.

The analysis highlights that, on the one hand, there exists considerable uncertainty around projected debt levels, depending on assumptions around the magnitude of investment needs, substitution between energy sources, nonlinearity of sizeable climate policies, and the effect of emission reduction on climate change. On the other hand, incorporating climate change actions into debt sustainability analysis is essential, given the potentially large implications on public debt dynamics. It is also important to note that the assessment focuses on the climate risks stemming from transition costs, i.e. climate action, and neglects the risks arising from physical damages linked to climate change.

In an attempt to account for physical risks, the IMF (2022) has experimented with incorporating estimates of physical and transition risk-related spending required into its DSA methodology, to analyse countries' vulnerability to sovereign debt stress. By integrating scenarios of physical risks and/or transition spending into existing DSA frameworks, the analysis examined the impact on public debt in two countries, Colombia and Peru. The physical risk scenario assumed one climate-related shock, with short-term negative effects « real GDP and government revenues; and medium-term impacts in the form of increased public investment and spending to repair and/or adapt infrastructure post-shock, with positive direct and indirect GDP impacts. The estimated impact of the climate shock was assumed to be the same as that of the most recent climate-related disaster in each of the respective countries. The transition scenario assumed investments in key adaptation infrastructure and a change in the energy mix, towards renewables, with expenditures positively affecting real GDP and public revenues. Assumptions on the magnitude of public spending required were obtained from World Bank estimates for the region. These estimates were thought to be a likely lower bound (i.e. conservative), because they exclude spending needed to transition workers and, more broadly, social transfers to households and firms during the transition.

The research showed that climate shocks and transition spending can substantially impact countries' public debt trajectories, potentially increasing the probability of a stress event. Specifically, public debt in the two countries considered increased by 10-37 pp in the medium term compared to the baseline scenario, depending on the extent of the transition spending. However, in the case of the physical risks, as the calibration is based on data from the latest disaster to have taken place in the country, the results can only be taken as an indication of the potential impacts in the case of an extreme event of similar magnitude. In terms of costs linked to transition risks, no private sector involvement is assumed, which may overstate the public spending requirements, as private sector involvement is likely to be a certain share of total transition spending. To note is that public revenues are merely accounted for through indirect effects via GDP, while climate policies, such as carbon prices, which impact public revenues, are not included in the assessment. The researchers highlighted the need to improve official country-level data on the magnitude of investment required for transition pathways to enhance the assessment of climate change risk on public debt.

OECD

OECD has released in June 2024 the first version of the analytical tool to calculate the fiscal impact of climate change, called Edison. This tool is meant to help IFIs to providing a common methodology to calculate the impact of climate change on long-term fiscal sustainability.

Based on the OECD 2024 Survey on Climate Change and Long-Term Fiscal Sustainability, few IFIs have some done work linked to the impacts of climate on financial sustainability. Table 2 shows the IFIs that have included climate impacts in their assessment of long-term revenues, expenditure and/or macroeconomic forecasts.

Table 2 Summary of the results of the OECD 2024 Survey on Climate Change and Long-Term Fiscal Sustainability

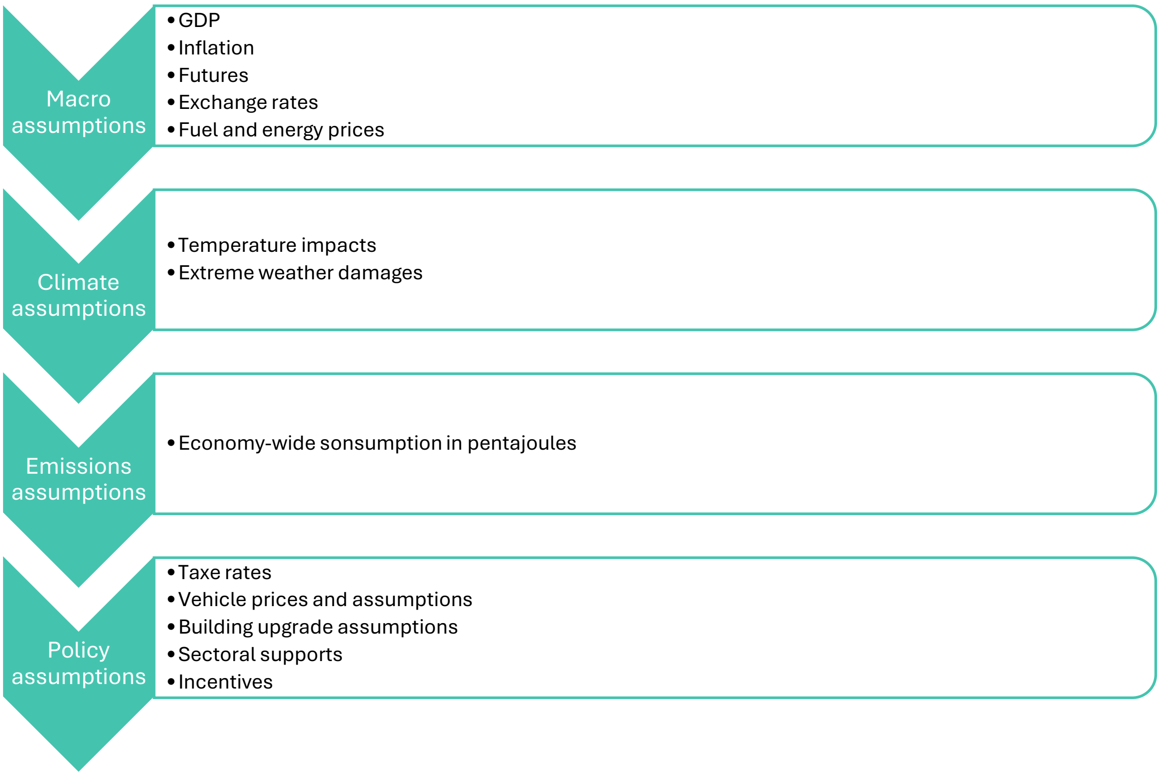
IFI	Revenue	Expenditure	Macro impacts
NLD CPB	Yes	Yes	Yes
IRL IFAC	Yes	Yes	
GBR OBR	Yes	Yes	
CAN PBO	Yes	Yes	Yes
USA CBO		Yes	Yes
ISR KNE	Yes		
SVN FC		Yes	
DNK DEC	Yes	Yes	

AUT PBO	Yes
BEL FPB	Yes

Source: OECD - Integrating climate into fiscal sustainability, 16th Meeting OECD Working Party of PBOs and IFIs.

Edison is an Excel-based model that builds projections based on assumed pathways for emissions, user judgements and on spending related to meeting climate targets, and macro-fiscal impacts of rising temperatures and climate events. Figure 1 shows the inputs that the user requires to add in order to get the results are transition revenues, transition expenditures and full results.

Figure 1 Inputs required by the Edison tool



EU

Focusing on the fiscal risks of extreme weather events in the European context, Gagliardi et al. (2022) explore the impact of climate change on EU countries' debt sustainability. They propose integrating acute physical risks and the accompanying fiscal implications into DSA using a series of stress tests implemented as shocks to public finances, drawing on a global natural disaster database[3] and projections of economic losses under different warming scenarios[4]. The scenarios examine impacts on debt-to-GDP ratios over a ten-year period, with direct impacts on government debt and deficit; and indirect impacts on GDP (climate damages). The results show Spain, Czechia and Hungary to be the MSs most exposed, with increases in debt-to-GDP ratios

[3] Emergency Event Database (EM-DAT): https://www.emdat.be/
[4] JRC PESETA IV: https://joint-research-centre.ec.europa.eu/peseta-projects/jrc-peseta-iv_en

of up to 5 pp by 2032, depending on the global warming scenario. The analysis confirms the macroeconomic relevance of climate change-related disasters and the risks to public finances.

The analysis also highlighted the challenges of linking climate change-related natural disasters to economic/fiscal impacts with a need to explore the role of tipping points more carefully, beyond which severity and frequency could increase markedly. Specifically, the disaster-related economic loss projections used do not capture the risk of passing tipping points. The authors acknowledge that these initial estimates are, therefore, considered to represent an underestimation of the potential impacts. The role of Integrated Assessment Models (IAMs) was also suggested as a way to better account for such phenomena (see more details in Section 2.3.3).

In a different study, Zenios et al. (2022) integrate climate change and climate policies into DSA, i.e. considering, both, physical and transition risks. Within their framework, physical risks (chronic and acute) are mediated by climate action, which involve costs, but bring potential benefits by increasing resilience and reducing economic damages. Therefore, the overall impacts of climate change on public finances depend on the effect of climate action on public finances as well as on climate change. The costs and benefits linked to physical and transition risks are estimated using historical data on impacts of disasters and existing climate policy plans. Subsequently, the estimates are transmitted to the DSA. Using scenarios consistent with the Paris Agreement targets developed by the Integrated Assessment Model Consortium,[5] and IAM to incorporate climate effects from GHG as well as the macroeconomic impact of rising temperatures, debt dynamics are assessed for example countries. The results of adjusting the DSA to climate change risks show an upward shift in debt-to-GDP over the projection period up to 2080. In the case of Italy, debt-to-GDP rises from slightly above 150% to 200% over the period, indicating potentially significant effects of climate risks on debt dynamics.

In a similar vein as in (Gagliardi et al., 2022), the authors acknowledge that shortcomings exist in estimating the number and severity of extreme weather events, as extrapolation from historical data risks underestimating future values. On the other hand, adaptation investments contribute to mitigating climate risks, possibly leading to overestimation of future impacts. Also to note is that two different IAMs are used to project debt dynamics with incorporated climate risks, which lead to debt trajectories of different magnitudes (though the overall development follows a similar trend), highlighting the importance of understanding the underlying parameters and how they may impact the results.

2.2.3. Discussion

Looking at the various analyses at the international level, by the IMF and in the European context, the impacts of climate change on public finances are of clear adverse nature and can be substantial. There are, however, substantial differences in approaches and frameworks for considering climate risks on public finances. While the incorporation of physical risks and risks linked to the transition (climate action) can be found across the different pieces, not all consider both to derive a comprehensive view. Moreover, public finance risks linked to non-compliance with legally agreed targets are not considered in any of the international analyses, although this aspect would necessarily be less relevant outside the EU, whereas Member States are bound by targets.

[5] https://www.iamconsortium.org/about-us/

Considering transition risks, the IMF/World Bank work on CPAT provides an extensive evidence base for assessing the effects of a large range of mitigation policies. However, in the context of assessing fiscal impacts, it seems to be more suited to provide estimates of government revenue projections, rather than a more holistic impact assessment on the fiscal balance including costs. In this sense, it's outputs can be used as inputs in further analyses, as exemplified in CPAT applications. The IMF's Fiscal Monitor scenario analysis offers a different approach, using a general equilibrium model to assess the impact of climate policies on public debt over a longer-term period. Here, public expenditure from climate action is considered, based on international estimates. Neither of these analyses consider the potential impact on public finances stemming from physical risks, either acute (disasters) or chronic (temperature increases). However, these impacts can be substantial, as shown in a separate IMF analysis, as well as in work done in the European context.

A recurring challenge across the work on physical risks relates to accurately assessing potential future impacts, which is hampered by both data availability and quality on the impact of past extreme events and uncertainty around how trends may shift in the future. Generally, the analyses which addressed physical risks concluded that the impacts on public finances are likely underestimated due to these reasons. IAMs may be a suitable way to account for long-run economy-climate linkages.

In assessing the impacts on public finances stemming from transition risks, the work discussed highlights uncertainties around the magnitude of investments needed to achieve the transition, potentially leading to underestimation of public spending. Accurately estimating transition risks requires more detailed and robust cost estimates of climate action.

2.2.4. IFI/country-specific analysis

According to a survey performed by the EU Independent Fiscal Institutions Network in 2021, not all IFIs are producing macroeconomic forecasts or debt sustainability analysis. Table 3 shows a summary of institutions that have reported having capabilities to either produce macroeconomic forecasts or DSA internally or obtain it from official sources.

Table 3: List of IFIs that have reported production of DSA or macroeconomic forecast in 2021

Institution	DSA production	Macroeconomic forecast production
Austrian Fiscal Advisory Council (FISK)	Official	No
Cyprus Fiscal Council	Internal	No
Czech Fiscal Council	Official	No
Economic Council of Denmark	Internal	Internal
Independent Authority for Fiscal Responsibility	Official	Internal
Irish Fiscal Advisory Council	Internal	Internal
Parliamentary Budget Office (PBO)	Internal	Internal

National Audit Office of Lithuania. Budget Policy Monitoring Department	Official	Internal
Fiscal Discipline Council of Republic of Latvia	Official	No
CPB (NL)	Official	Internal
Portuguese Public Finance Council	Official	Internal
Romanian Fiscal Council	Internal	No
Institute of Macroeconomic Analysis and Development	Internal	Official
Slovenian Fiscal Council	Internal	Internal
The Council for Budget Responsibility	Official	Internal
Office for Budget Responsibility of United Kingdom – OBR	Official	Official

Notes: DSA production refers to the nature of the mandate for DSA. Similar for macroeconomic forecast. Source: IFI Network.

Along with international and governmental organisations (such as the Swedish National Institute of Economic Research and the Netherlands' Centraal Planbureau), some IFIs have also incorporated climate change-related aspects into their fiscal sustainability analyses at the national level. In this respect, the UK and Ireland are relatively more advanced. This section presents their approaches in more detail.

Office for Budget Responsibility (UK)

The OBR has been integrating the fiscal implications of the transition to net zero into its fiscal analysis, as part of its fiscal risks series of reports (Office for Budget Responsibility, 2021). Components of the transition that are considered include the fiscal costs associated with rising take-up of electric vehicles and public investments needed for decarbonisation, as well as the risks of continued exposure to volatile gas prices.

The OBR uses the Climate Change Committee's Sixth Carbon Budget, which provides estimates of yearly decarbonisation costs by sector for different scenarios and over a period of 30 years. The share of costs borne by the government is estimated using various sector-specific assumptions. For example, 19% of costs related to vehicles are borne by public spending, mostly driven by infrastructure spending, while this share is assumed to be 45% in the buildings sector, based on simplifying assumptions on the government's share of costs for residential households across segments of the income distribution. Direct effects on public revenues and losses were derived from estimated reductions in fuel duty receipts and carbon tax revenues. Indirect effects were captured using the Bank of England's Climate Biennial Exploratory Scenario for GDP.

The OBR then developed a series of scenarios using its own macroeconomic model. The main ('early action') scenario saw a 21% increase in the debt-to-GDP ratio by 2050, with the loss of revenues from fuel duties being the most significant factor. In this scenario, the government takes early policy action, bearing one-quarter of total transition costs, while implementing a comprehensive carbon tax. The fiscal costs in this scenario can be seen as a lower bound, with alternative ('late action') scenarios indicating fiscal costs which are twice as large (in terms of the increase in the debt-to-GDP ratio) owing to the need to invest larger amounts over a shorter period. Another scenario considers the situation in which UK reliance on gas, as well as the government's fiscal response to shocks to global gas prices, remains unchanged, with results suggesting fiscal costs that are higher than those linked to completing the transition to net zero, as a result of increased energy security. This emphasises the importance of investing in renewable energy to reduce future terms-of-trade shocks and fiscal pressures.

Generally, the OBR's work on climate change-related consequences for public finances has been limited to mitigation risks, i.e. transition risks, and, so far, does not comprehensively integrate risks related to climate change-related adaptation and damage, i.e. physical risks. This contrasts with the more international work reviewed above.

Irish Fiscal Advisory Council (Ireland)

The Irish Fiscal Advisory Council (IFAC), the IFI in Ireland, increasingly considers climate change implications in its analyses of the long-term sustainability of public finances (Irish Fiscal Advisory Council, 2020, 2023b, 2023a). In line with other assessments described above, IFAC' framework identifies three channels through which public finances will be affected by climate change:

1. **Physical Risks**: A changing climate in Ireland and globally will impact the Irish economy and public finances. There will be some costs associated with facing up to more regular extreme weather events. More regular flooding and wildfires are a rising risk, with such events estimated to result in public costs of around 0.2% of GNI per event.
2. **Transition Costs**: In the situation in which Ireland's climate targets are fully achieved, there will be a range of impacts on public finances. On the revenue side, meeting Ireland's climate targets could result in tax revenues being reduced by 0.9% of GNI per annum by 2030, rising to 1.6% of GNI per annum by 2050. Most of this is due to factors such as a sharp decrease in tax on fuel and energy use, lower VAT rates on the electricity now consumed in place of fossil fuels and decreases in vehicle registration tax and motor tax revenues, both of which are linked to emissions. Moreover, on the spending side, depending on the type of policies chosen, the government may incur costs of 0.7-1.2% of GNI pa in the short-to-medium term and 0.4-0.7% of GNI between 2031 and 2050.
3. **Compliance Costs**: As is the case for all EU MSs, Ireland is legally bound to become a carbon-neutral economy by 2050 and to stay within three sequential carbon budgets between 2021 and 2035. This requires greenhouse gas emissions to fall by 51% by 2030 compared to 2018 levels. However, projections for Ireland based on existing plans suggest the country is currently on track to miss this trajectory. Failing to meet these targets would result in costs from non-compliance, which could be as high as 0.2% of GNI annually by 2030, as per (Walker et al., 2023).

Using TIMES-Ireland, an energy systems optimisation model, IFAC integrates climate change considerations into public revenue and spending estimates by assuming that Ireland's climate targets are met, i.e. disregarding potential non-compliance risks and associated costs. The model projections assume that the targets are met in a least-cost manner, identifying the optimal path under different scenarios which keeps costs at a minimum. Scenarios differ in their assumptions on factors such as technological improvements, shifts from private to public transport, and cost shares by sectors. Model outputs include projections, by scenario, on energy usage by fuel type, vehicle stocks, as well as investment costs, which are subsequently used to model public revenues and spending. In estimating revenues, no further tax policy changes over the projection horizon are assumed, with the exception being a continual rise in carbon taxes until 2050, based on legislation as well as official estimates.[6] Regarding revenues from ETS, IFAC assumes a reduction in the allowances auctioned by Ireland of 2.2% per annum until 2040, with allowance prices increasing annually. Regarding spending estimates, IFAC acknowledges uncertainties linked to the eventual policy choices made by the government. For this reason, scenarios are developed, which differ in the extent of state intervention. The majority share of expenditure is expected to relate to retrofitting homes and support for the agricultural sector – 80-90% of projected spending until 2050. Concerning the fiscal impacts stemming from physical risks, these are not explicitly modelled, but a separate analysis is provided, based on Ireland's historical experience (EM-DAT) and derived estimates of costs of extreme events.

Swedish National Institute of Economic Research and the Swedish Fiscal Policy Council

The Swedish National Institute of Economic Research (NIER) is a government agency accountable to the Ministry of Finance. NIER produces forecasts to support decisions on economic policy and analyse economic developments and conduct economic research. NIER has developed an Environmental Medium-Term Economic (EMEC) model to study interactions between the economy, energy use and emissions of several pollutants in Sweden and to support policymaking (National Institute of Economic Research, 2023).

EMEC is a computable general equilibrium (CGE) model of the Swedish economy. More specifically, the model allows for the analysis of the long-run impacts of several energy and environmental policies on the economy and emissions of several pollutants and can offer insights into how these policies can be designed effectively, cost-efficiently and equitably. These policies include the EU emission allowance under the EU Emission Trading System (ETS), the national energy and CO2 taxes, renewable fuel standards for vehicles ('Reduktionsplikten') and feebates for vehicles ('Bonus Malus'). The model is then calibrated to base-year data from the National Accounts and the Environmental Accounts, compiled by Statistics Sweden. However, it should be noted that a significant weakness of CGE is the poor empirical foundation of the calibration. Only observations from one year are used to calibrate shift parameters. The production and utility functions are constrained to constant elasticity of substitution (CES). The parameters for these functional forms come exogenously from the empirical estimation of elasticities and not from the calibration process. These "best guess" values add a large uncertainty into the model and the chosen elasticity has a significant effect on the results.

In addition, the Swedish Fiscal Policy Council, the IFI in Sweden, first reviewed the Riksdag's (Swedish Legislature's) net zero targets for 2045. An initial review by IFI indicates that substantial climate-related investments would be essential in the coming decades, particularly to boost electricity production and expand transmission networks within Sweden. Most of these investments are expected to be funded by businesses and households rather than public financing. The primary challenges identified are streamlining authorisation processes, ensuring stable and clear regulations, and enhancing national coordination. Public funding will still be required for building charging infrastructure for electric vehicles and hydrogen refuelling stations in non-market viable areas and investments in biogenetic carbon capture and storage systems. Existing reports suggest a need for 25-45 billion SEK annually in public financing for emission

[6] C.f.: Finance Act 2020: https://www.irishstatutebook.ie/eli/2020/act/26/enacted/en/html
And The Public Spending Code (2019): https://www.gov.ie/en/publication/public-spending-code/?lang=en

reduction, climate adaptation, and disaster aid, in addition to the 60 billion SEK per year already planned in the current twelve-year infrastructure plan, albeit with considerable uncertainty.

The models by both NIER and the Swedish IFI do not have considerations for physical risks and allied costs.

Centraal Planbureau or The Netherlands Bureau for Economic Policy Analysis

The Netherland's Centraal Planbureau (CPB) uses an applied general equilibrium model that is based on generational accounting principles named GAMMA (Generational Accounting Model with Maximizing Agents). The GAMMA can be used both for projections and simulations (Draper & Armstrong, 2007) and is developed to make projections of the costs and benefits of government policies for different generations.

Based on this GAMMA model, the CPB made projections of costs related to climate change and associated policies (CPB 2023). Three items are added to GAMMA model in this exercise: damage caused by climate change (climate damage), policies to guard against these damages (adaptation costs) and policies to combat global warming (mitigation costs). The purpose of the exercise is threefold. First to make a projection the fiscal cost of climate change for the government. Second to show how these fiscal costs translate into different costs for different generations given some assumption about budgetary policies. And third, to show the reduction in physical cost due to adaptation policies.

- **Climate damages:** To estimate the costs of climate-related physical damages and their impacting public finance, the CPB gathers data on the damage caused by drought, heat, waterlogging and flooding from various studies e.g. Klimaatschadeschatter[7], Stratelligence [8] and the PESETA IV (L. Feyen et al., 2020). For drought, heat, and waterlogging, the CPB assumes a linear increase from 2023 to 2050 inclusive, after which constant damage is assumed. In the case of river flooding and sea level rise, the CPB first assumes a linear increase from 2023 to 2050, bases on projections for the year 2050 and then a linear increase from 2050 to 2100bases on projections for the year 2050. Second, for the sake of simplification, the CPB assumes that no damage occurs until 2050 and that the 'accumulated' expected damage over the period from 2023 to 2050 occurs all at once in 2050. In addition, the CPB assumes that half of these damages are borne by the government and financed through an increase in taxes after 2051, with the government's debt level remaining constant. The same assumption is made for expected damages between 2050 and 2100.
- **Adaptation cost:** To estimate the costs and benefits of adaptation policies the CPB assumes a reduction in the damages due to adaptation policies for each of the different categories (drought, heat, waterlogging and flooding). In addition, the CPB makes an estimate for the costs of these policies, based on a small number of studies for such policies in the Dutch context.
- **Mitigation costs:** the CPB bases its estimate of mitigation costs on the Dutch government's current climate targets, which are: a 60% CO_2 reduction by 2030 (relative to 1990) and a 100% CO_2 reduction by 2050. The cost of these policies is based on a study (Hammingh, Van Soest, Menkveld, Daniels en Koutstaal, 2022), that estimates current

[7] https://klimaatadaptatienederland.nl/en/@258269/rapport-klimaatschadeschatter/
[8] https://stratelligence.nl/downloads/economische-analyse-zoetwater/

costs in 2030 at 7.2 billion euro and in 2050 between 18,4 and 32,7 euro. Again, the government is assumed to bear half of these costs.

Based on these estimates and assumptions, the CPB projects the costs of climate damages, adaptation policies and mitigation cost till 2100 for different generations. It concludes that, even though the government debt is kept constant, future generations still bear a relatively large part of these cost. In addition, the CPB stress the large uncertainties that are involved in this type of analysis, which are mainly due to large uncertainties surrounding the estimated cost of damaged far in the future.

Discussion

Comparing the frameworks for integrating climate change considerations into public finance assessments by the OBR, the IFAC and CPB, similarities are observable in that both consider the budgetary implications related to physical risks and transition risks. However, the IFAC framework also considers the potential cost of non-compliance with EU-set emissions and renewable energy targets.

There are various limitations to the approaches adopted by the OBR, the IFAC and CPB to assess the impacts of climate change on fiscal sustainability. These include the absence of:

- IFAC: indirect effects, e.g. the impact on economic activity from higher investment and lower taxes
- CPB: the cost of non-compliance with EU targets
- OBR: quantified fiscal costs resulting from climate damage, e.g. via damage functions
- OBR: economic and fiscal benefits from preventing climate warming

Moreover, the share of transition costs borne by the government is subject to uncertainty, with estimated shares based on possibly outdated analysis and likely subject to change over time (Office for Budget Responsibility, 2023).

2.2.5. Challenges

As touched upon in the description of approaches above, there are various challenges in the context of integrating climate change into fiscal analysis.

- **Estimating the costs from climate change related physical risks:** Comparable international country-level data on extreme weather events and their economic costs do not exist at a comprehensive level, with databases varying in geographical focus, framework for reporting disasters and economic implications considered/reported. Moreover, these data are inherently backward-looking, whereas the frequency and severity of future climate change-related disasters will likely increase. A suggested approach to evaluating the impact of extreme weather events on public finances could employ stress test-style scenarios (Gagliardi et al., 2022). These can be tailored to a country's historical weather events as well as implemented adaptation policies.
- **Estimating costs of climate action (transition costs):** Improvements in official data for estimating the scale of investments required for the transition are needed. Inadequate or insufficient analyses by governments in terms of cost estimates of transition measures

present an obstacle in developing robust projections of public finance impacts. This has been highlighted as a major challenge, particularly for some of the European IFIs (Network of EU Independent Fiscal Institutions, 2022).

- **Estimating the impacts of climate transition measures:** Enhanced availability of well-established and independent assessments of the impacts of climate policies on GHG emissions for individual countries would be useful. IFIs note that existing analyses of the effects of transition measures are frequently too vague and not updated at sufficiently regular intervals.
- **Model suitability:** A lack of sound macroeconomic models which consider sectoral or second-round impacts has been noted by IFIs as an obstacle to comprehensively assessing the climate impacts on public finances (Network of EU Independent Fiscal Institutions, 2022). For example, most CGE models do not account for positive feedback from national policies in a global transition context or potential productivity gains. Integrated Assessment Models (IAMs), frequently used to assess the costs and benefits of climate policies in a complex economy-climate system, also have various caveats to their results (Gagliardi et al., 2022). Limitations inherent to such approaches relate, for example, to setting adequate cost metrics across different elements or chosen discount rates. Alternative methods, using dynamic economic models, which exogenously set policies based on targets, provide another way to assess the impacts of mitigation policies. However, these approaches generally yield results with wide ranges of possible outcomes, which may make it challenging to base decisions on them (European Commission, 2020).

2.2.6. Summary

In conclusion, integrating climate change considerations into public finance analysis is essential for understanding related risks and impacts on a country's fiscal and economic stability, requiring new methodological approaches and forms of data collection so that more robust analyses are possible. Incorporating climate change considerations into DSA is a complex task, requiring a multi-faceted approach, involving robust data collection, a deep understanding of the potential impacts on public finances, and the integration of suitable models within a logical framework (Zenios, 2022). The literature provides a good overview of the types of climate change-related risks which have been considered in analytical frameworks to date, namely physical risks stemming from extreme weather events, transition risks linked to policy action to achieve net neutrality and adaptation, as well as, more specifically to the European context, risks relating to costs of non-compliance with legally set transition targets. However, there are various limitations in current applications. Comprehensive, international data to inform estimates of physical risks robustly are currently lacking. Moreover, improved estimates of required transition spending would be helpful. In addition, existing models generally do not incorporate non-linear responses to large policy packages. Most models that are used to assess macro-fiscal impacts of climate change and transition action also have limited or no linkages to climate variables or climate models to assess the physical risks of climate damage. Finally, an assessment of the benefits of preventing or mitigating global warming is lacking.

Based on the assessment of the literature, Table 4 presents an overview of existing frameworks for assessing the impact of climate change on debt sustainability. The selection focuses on the approaches adopted by the IMF and the IFIs, OBR and IFAC, which were assessed to be most relevant for informing the proposed framework and model inputs presented in Section 2.3. While not relying on one analytical approach in particular, the different approaches identified can be used to inform various elements within the overall framework. For example, the IMF work provides extensive analysis of the costs and impacts of climate action/policy, which is relevant for the estimation of transition costs/risks. The IFI work provides a more comprehensive analytical framework by attempting assessments of the climate change-related costs stemming from physical risks, next to transition costs arising from climate action. Their framework and analyses are, therefore, closely aligned with how climate change risks to public finances are discussed across the literature. From our review, the OBR and IFAC seem among the most advanced IFIs in terms of integrating these considerations into fiscal analysis at the national level. For this reason, they were assessed to be good examples to draw inspiration from when developing the proposed framework for European IFIs.

Table 4: Comparison of frameworks for assessing climate change impacts on debt sustainability

	Fiscal Monitor	IMF Climate Policy Assessment Tool	Office for Budget Responsibility	Irish Fiscal Advisory Council
Purpose	Assess fiscal implications of different climate mitigation scenarios	Assess impacts of climate mitigation policies, including on energy demand, prices, emissions, revenues, welfare, GDP, households and industries, local air pollution and health.	Estimate debt-to-GDP impact of net zero transition under different fiscal scenarios	Estimate public revenue and spending impacts associated with climate change and the climate transition
Model	New Keynesian dynamic general equilibrium model	Climate Policy Assessment Tool	In-house macroeconomic model	TIMES-Ireland model
Model type	Adaptation of standard general equilibrium model	Spreadsheet-based, simplified 'model of models'	Large-scale macro-econometric model	Complex energy systems optimisation model
Fiscal variables	Primary government balance, public debt	Fiscal balance	Debt-to-GDP, fiscal revenues, expenditures, borrowing, debt	Government revenue and spending, net debt to GNI
Climate-specific assumptions	80% emissions reduction by 2050; effective carbon pricing; CCS; fuel taxes; public infrastructure and subsidies; household compensation	Energy demand; Income elasticities of energy demand; cross price elasticities; carbon tax; ETS; fossil fuel subsidies	Carbon pricing and tax revenues; road-user charge. scenarios: global carbon prices; early action vs. late action	Mitigation targets met in a 'least-cost' approach; ETS; shift from cars to public transport; energy usage; vehicle stock; emission taxes; retrofitting and farming support; cost of repairing
Years	2030-2050	15-year horizon	2020-2050	2050
Physical risk	Not integrated	Climate damages, or physical risks, are only a representation of estimated greenhouse gas emissions, which is a limiting assumption.	Not modelled, but assumptions on the level of increase in adaptation costs (and spending) resulting from temperature increases. Size and frequency of climate shocks progressively increases with rising temperature to reach a two-fold increase by 2100 relative to historical baseline.	Does not model the climate damages on fiscal balances itself but summarises findings by other institutions. For example, they point out that major weather events may be associated with costs of 0.2% GNI.
Transition risk	The model accounts for various transition policy instruments and their impacts on revenues and spending: carbon pricing,	CPAT tool estimates revenues and costs associated with different policy scenarios. The policies packages included in the IMF scenarios were carbon pricing, green public	Global carbon prices are assumed to steadily increase, such that global emissions reach (close to) net zero by 2050, based on BoE. Public spending and receipt loss assumptions are based on scenarios produced by CCC.	Uses TIMES model to estimate government revenues and costs under high-cost scenario and low-cost scenario

	Fiscal Monitor	IMF Climate Policy Assessment Tool	Office for Budget Responsibility	Irish Fiscal Advisory Council
	green public investment, green production subsidies, and targeted transfers. Carbon prices increase in line with IEA net zero emission scenario.	investment, green subsidies, and targeted transfers		
Compliance cost	No compliance costs relating to missed EU-set climate transition targets	No compliance costs relating to missed EU-set climate transition targets	No compliance costs relating to missed EU-set climate transition targets	Considers emissions targets in line with EU
Scenarios	Compares debt-to-GDP impacts of scenarios on varying degrees of transition spending policies and timing of action.	CPAT tool is flexible to assess changes in various climate policies allowing for a multitude of scenarios	Global carbon prices (‘global deal scenario’). Early action vs. late action	Compares between high-cost and low-cost scenarios for transition costs

2.3. Scenarios

The above section discusses the existing models and some of their chosen scenarios. In this section, overview of the existing warming and policy scenario combinations is provided. These should be considered as examples of scenarios that the future tools will need to deliver.

2.3.1. Copernicus/IPCC

This year, the Copernicus Climate Change Service launched the Copernicus Interactive Climate Atlas, which visualises the most recent IPCC Assessment Report (A6) climate scenarios (Copernicus, 2024). The Copernicus atlas is similar to the IPCC WGI atlas tool (Iturbide et al., 2021) and additionally provides scenario's outcomes by European country, while the IPCC WGI shows scenario results by aggregate regions.

Both tools showcase four main warming scenarios: 1.5°C, 2°C, 3°C, and 4°C. The atlases include projections of mean temperature, days of heating and frost, precipitation, wind, sea-ice area, and other climate variables. The projections include both historical observations and forecasts for up to the year 2100. The climate scenarios in atlases are expected to be updated with future releases of IPCC Assessment Reports. While the tools do not provide the economic impacts of each climate scenario, the expected temperature increases can be inputted into the other tools and models that link the rise in temperature with GDP or other economic indicators.

2.3.2. European Green Deal scenarios

The economic and fiscal outcomes of the future climate scenarios do not only depend on the warming pathways but also the policies in place to mitigate them. Most EU Member States' national policies are driven by the EU targets, including the European Green Deal policy package. Therefore, it is useful to consider the European Green Deal policy scenarios in designing their own scenarios of fiscal climate impacts.

In July 2021, three core policy scenarios were published[9] to serve as tools for analysis across the impact assessments of the European Green Deal policy package. These are:

- REG - relies on very strong intensification of energy and transport policies in the absence of carbon pricing in road transport and buildings,
- MIX - relying on both carbon price signal extension to road transport and buildings and strong intensification of energy and transport policies, and
- MIX-CP - representing a more carbon price driven policy mix that illustrates a revision of the Energy Efficiency Directive and Renewable Energy Directive but limited to a lower intensification of current policies in addition to the carbon price signal applied to new sectors.

The scenarios do not represent climate or economic outcomes, however, they estimate the emissions from different sectors, as well as some air pollution measurements. These emissions

[9] https://energy.ec.europa.eu/data-and-analysis/energy-modelling/policy-scenarios-delivering-european-green-deal_en

scenarios are useful source of information to assess the potential revenues or costs associated with emissions reductions.

2.3.3. NGFS

The Network of Central Banks and Supervisors for Greening the Financial System (NGFS) have designed a set of hypothetical scenarios, that provide a reference point to understand both the physical and transition risks. The scenarios are updated every one to two years, and the newest version was published in March 2023. The seven scenarios are available, and they differ in policy ambition and reaction, technology change, carbon dioxide removal, and regional policy variation. The NGFS scenarios are built on the processed based IAMS discussed in section 0 thereby having a modicum of harmonisation in the scenario assumptions used and increasing comparability of scenario analysis being used in climate scenarios exercises. The NGFS scenarios are summarised in Table 5 below.

Table 5: NFGS scenarios summary

Scenario	Description	Policy ambition	Policy reaction	Technology change	Carbon dioxide removal	Regional policy variation
Net Zero 2050	Ambitious scenario that limits global warming to 1.5 °C, reaching net zero emissions around 2050	1.4 °C	Immediate and smooth	Fast change	Medium-high use	Medium variation
Low Demand	Assumes significant behavioural changes, and reduction of energy demand to reach global net zero CO2 emissions around 2050.	1.4 °C	Immediate and smooth	Fast change	Medium use	Medium variation
Below 2 °C	Climate policies are introduced immediately and become gradually more stringent. Net-zero emissions are achieved after 2070.	1.6 °C	Immediate and smooth	Moderate change	Medium-high use	Low variation
Delayed Transition	Global annual emissions do not decrease, and new climate policies are not introduced until 2030.	1.6 °C	Delayed	Slow/Fast change	Low-medium use	High variation
Nationally Determined Contributions	Includes all pledged policies. Climate ambitions reflected in NDCs continues over the 21st century.	2.6 °C	NDCs	Slow change	Low-medium use	Medium variation
Current Policies	Only currently implemented policies are preserved.	3 °C+	None – current policies	Slow change	Low use	Low variation

Scenario	Description	Policy ambition	Policy reaction	Technology change	Carbon dioxide removal	Regional policy variation
Fragmented World	Delayed and divergent climate policy ambition globally. Countries without zero targets follow current policies, while other countries achieves theirs partially.	2.3 °C	Delayed and fragmented	First slow, then fragmented	Low-medium use	High variation

Source: NGFS (2024)

The seven scenarios have been generated by three different integrated assessment models to key transition variables available to explore in the interactive tool on the NGFS website. Some of the transition variables include electricity generation by energy type, energy demand, fuel production, emissions, and energy efficiency. However, the results are only available by aggregated regions (i.e. EU, or OECD countries).

The physical risks outcomes of the scenarios are available to explore on the Climate Analytics website[10]. Usefully, it shows results not only by country but also by country's provinces. The variables relate to economic damages (although only from floods and cyclones), risks of wildfires, and heatwaves, agricultural yields of some crops, the usual climate and temperature variables, as well as loss of labour productivity, which can be useful to estimate the scenarios' impact on GDP.

2.3.4. European Environment Agency and NECPs

Emissions estimations by the European Environment Agency (EEA), as well as the National energy and climate plans (NECPs) also employ two policy scenarios within the EU: *with existing measures* (WEM), and *with additional measures* (WAM). The WEM scenario reflects existing policies and measures, while the WAM scenario takes into account the additional effects of planned measures reported by Member States. More details can be found in Sections **Error! Reference source not found.** and **Error! Reference source not found.**.

2.3.5. Scenarios used in DSA analysis

In the Fiscal Monitor report (2023), IMF included number of global climate policy scenarios analysed in the context of debt stability and fiscal balances. Their analysis mostly include comparing the impact on fiscal balances of lower and higher investments for reaching net zero. For example, one of the sections of the report considers a policy package that achieves net zero emissions by 2050. The package combines revenue and expenditure measures, including carbon pricing, green public investment, green subsidies, and targeted transfers. The report also describes a model for scenarios of fossil fuel extraction. The model used International Energy Agency's transition policies scenarios: a stated-policies scenario, an announced-pledges scenario, and a net zero scenario. In the stated-policies scenario, only current policies and those under development are implemented; in the announced-pledges scenario, governments achieve

[10] https://climateanalytics.org/

their mitigation targets; in the net zero scenario, global warming is limited to 1.5 degrees Celsius, and there is no new development in the area of fossil fuels.

The UK's Office for Budget Responsibility (OBR) used an 'early action' as their main ('early action') scenario in their fiscal risk report (Office for Budget Responsibility, 2021). The scenario assumes that the government bear one quarter of all £1.4 trillion (in 2019 prices) investments towards Net zero until 2050. Additional assumptions include, all emissions taxed from 2026 onwards, and receipts from fuel duty falling to almost zero by 2050. OBR then developed alternative scenarios to test as sensitivity: 'unmitigated climate change', which assumes the UK temperatures to rise around 4°C by the end of this century; 'delayed action', which assumes climate action delay until 2030; 'uncertain consequences for productivity', which assumes decarbonisation boosting productivity; 'high versus low public sector share of net zero investment', which assumes in which the state bears around an eighth of the whole economy costs instead of one quarter; and 'potential for offsetting fiscal policy adjustments' in which the government re-allocates its public investment from within its existing spending envelope rather than go into further deficit to fund climate policies.

The Irish Fiscal Advisory Council (2023b) proposed a baseline, and two scenarios – 'low cost', and 'high cost'. The baseline projections are based on CO2 emissions by sector from UC MaREI. The 'low cost' scenario can be seen as a lower bound on potential State involvement whereas the "high cost" scenario can be seen as a reasonable upper estimate, recognising that costs could still end up higher. The costs differ in such policies as incentives for vehicle scrappage, retrofitting homes, farmers compensation, and carbon capture installation.

2.3.6. Summary

The above-discussed scenarios can inform the scenario design for the individual IFIs' needs. The IFIs may be interested in analysing the warming and policy pathways combinations found in the other examples. The above sources for climate scenarios are also useful to extract input data, to determine temperature and emissions pathways which would inform on fiscal expenditure needed to mitigate economic damages from physical risks, as well as costs and revenues associated with transition risks.

3. Proposed Framework

3.1. Introduction

In this section, the proposed general framework is defined, based on the literature reviewed in Section **Error! Reference source not found.**. The framework is split into three types of r isks/blocks that are then included in the public finance assessment. The blocks considered include:

1. the physical risks of climate change: This encompasses the direct impacts of climate change, such as extreme weather events and long-term shifts in climate patterns.
2. transition costs incurred in achieving emission targets: These are the costs associated with achieving emission targets and transitioning to a low-carbon economy.
3. compliance costs inferred from potential non-compliance to binding climate neutrality commitments.

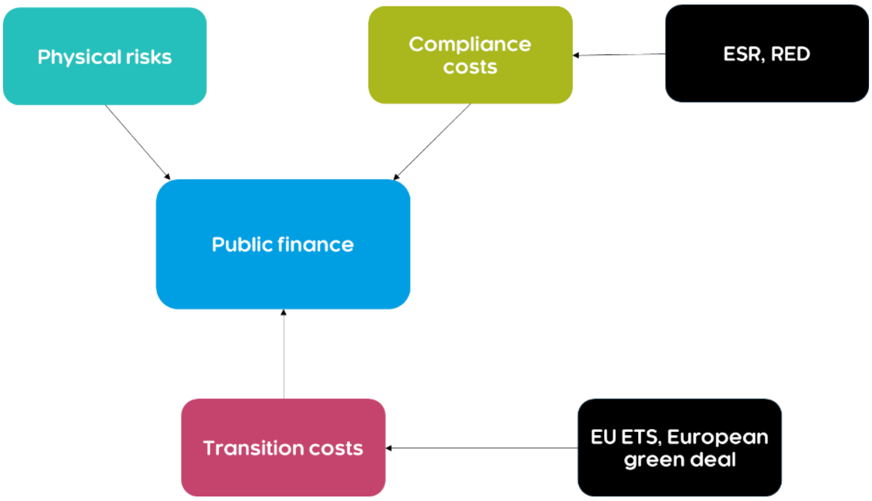
The public finance bloc represents the model used in public debt sustainability assessment by the different IFIs. Under the next Deliverable, the workplan will include a review of the current model used by each IFI. If the model is deemed appropriate, it will be modified to include the three climate-related blocks. In the absence of any existing model/ framework to assess debt sustainability, under Deliverable 2B, the research team will propose a model to which the three climate-related blocks will be added.

The framework, along with its public finance components, is structured around an introduction, a European and methodological context, required inputs, expected outputs, and linkages with other blocks. The physical risks block takes into account both short-term (intensive margin) and long-term (extensive margin) adaptation and mitigation measures, particularly under the block discussing the impacts.

Beyond the costs of restoration and damages due to physical risks, this section also details the costs and benefits associated with transition and compliance. Transition costs relate to the re-valuation of carbon-intensive activities as a result of costs associated with the transition to a low-carbon economy. Following this, the channels through which these blocks impact public finance are identified and a framework for considering various warming scenarios is proposed.

Figure 2 illustrates the broad structure of the proposed framework. The main benefit of this framework (with add-ons blocks) is that the IFIs can decide to include or not in the climate change scenario, depending on the assumptions present in the long-term macroeconomic baseline. For example, transition costs might be already part of the assumptions that drive the long-term GDP and components forecast.

Figure 2: Proposed broad framework



Source: Cambridge Econometrics.

Each of these blocks is described in detail in the subsequent sections. Finally, in Section **Error! Reference source not found.**, the findings are conceptualised by identifying how the general framework can be integrated into existing IFI capacity. This section is illustrative of the plan for Deliverables 2B and 2C.

3.2. Physical Risks

3.2.1. Introduction

In light of climate change, governments are expected to provide additional support and funds in response to more frequent and more adverse weather events, and other negative impacts of climate change, such as rising temperature and sea levels.

The frequency of droughts, forest fires, heatwaves, storms, and heavy rain has been increasing in Europe over the past decades. The EU adaptation strategy, which is a part of the European Green Deal, sets out how the EU can adapt to the unavoidable impacts of climate change and become climate resilient by 2050 (European Commission, 2021a). However, there are other costs to be considered when it comes to physical risks, such as impacts of and responses to unpredicted weather disasters.

In addition, temperature rises, and increased frequency of extreme weather events will cause medium and long-term impacts on GDP. These in turn will affect the fiscal balances of the Member States, as with lower output, the debt-to-GDP ratio increases.

This model framework block considers two types of impacts caused by physical damage: acute, and chronic. Acute damage relates to short-term immediate damage caused by extreme weather events. Such damages create costs for governments, in the form of both instant disaster relief efforts, and medium-term capital restoration costs, such as public investments to rebuild any infrastructure affected by the extreme weather event. Chronic physical risks occur from the long-term effects of temperature increases, such as productivity loss, reduced tax revenue, financial uncertainty, agricultural yield loss, and other gradual, often irreversible transformations of the environment due to global warming.

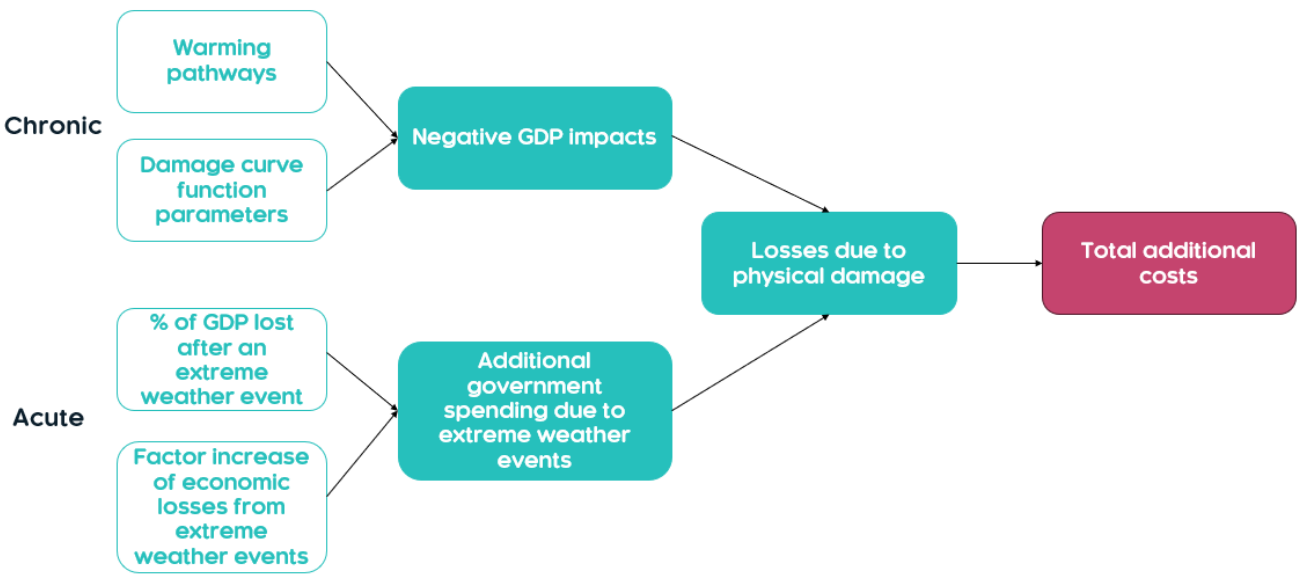
There is no established method in the literature to calculate how much of the cost from physical damage incurred from climate change effects, both acute and chronic, is borne by the public bodies in comparison to the private sector. Some attempts involve the estimation of the public costs from climate damages based on past country-specific experience, calibrated to different warming scenarios (Gagliardi et al., 2022). Other attempts consider that all costs are borne by the state (IMF, 2022). Our proposed framework follows the European Commission's discussion paper on the fiscal impact of extreme weather events (Gagliardi et al., 2022) to calculate how much of the cost from physical damage incurred from climate change effects, both acute and chronic, is borne by the public bodies in comparison to the private sector.

Both acute and chronic physical risks will reduce the capital stock and increase the expenditures included in the fiscal/debt sustainability models. In the case of some EU Member States, global warming will lead to better economic outcomes (e.g. increase agriculture production) and minimal climate change damages.

3.2.2. Description

The framework can be divided into chronic effects that affect GDP over the longer term, and acute effects that affect shorter-term government spending. This is reflected in the Figure 3 below.

Figure 3: Physical risks framework



Source: Cambridge Econometrics.

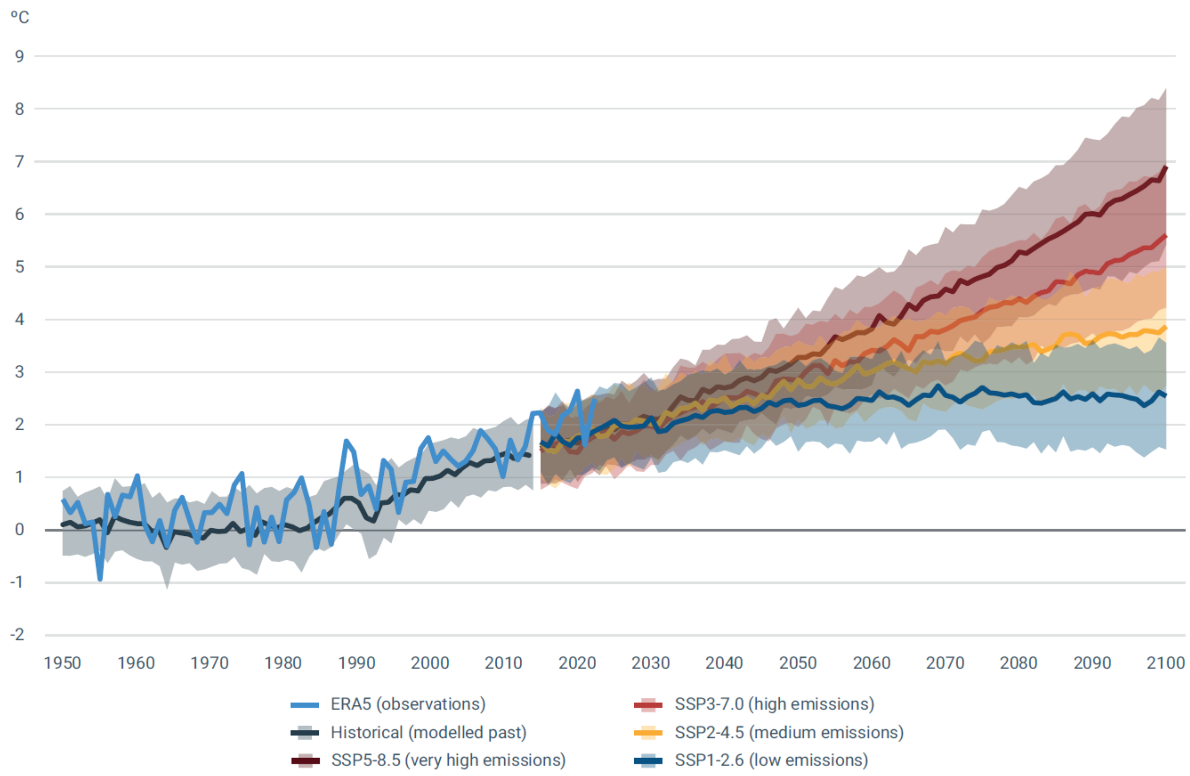
Chronic impacts

To assess the chronic impact on GDP, different global warming pathway scenarios are available to choose from. The Copernicus Interactive Climate Atlas[11] indicates four main trajectories,

[11] https://atlas.climate.copernicus.eu/atlas

associated with different emissions pathways: low emissions, medium emissions, high emissions, and very high emissions. The projected temperature increase for these scenarios for the whole European land area are presented in Figure 4.

Figure 4: Observed and projected temperature increase over European land area



Source: Copernicus Climate Change Service; Graph taken from EEA (2024).

Once a warming pathway is chosen, corresponding chronic warming impacts on GDP can be assessed, given a damage function. Currently, the literature on damage functions estimation differs vastly. Summary of some of the literature is presented in Table 6: Damage function literature below.

Table 6: Damage function literature

Document	Model/approach	Scenario	Global GDP impact in 2100
Burke, M., and Tanutama, V. (2019). "Climatic Constraints on Aggregate Economic Output," *NBER Working Papers 25779*	Econometric study (subnational-level data)	4˚C 1.5˚C	~60% *[12] ~10% *
Kalkuhl, M., & Wenz, L. (2020).The impact of climate conditions on economic production. Evidence from a global panel of regions, *Journal of Environmental Economics and Management*, 103	Econometric study (subnational-level data)	4˚C 1.5˚C	~10% * ~0.7% *

[12] *Note that damage values are calculated by CE based on the damage function parametrisation of the core specification run as part of a project for the International Renewable Energy Agency (IRENA)

Document	Model/approach	Scenario	Global GDP impact in 2100
Burke, M., Hsiang, S.M. and Miguel, E., (2015). Global non-linear effect of temperature on economic production. *Nature, 527(7577), p.235*.	Econometric study (national-level data)	5-6˚C	-23%
Burke, M., Davis, W. M., & Diffenbaugh, N. S. (2018). Large potential reduction in economic damages under UN mitigation targets. *Nature, 557(7706), p.549*.	Econometric study (national-level data)	1.5˚C 2˚C 3˚C	-11% -16% -25%
OECD (2015), The Economic Consequences of Climate Change, OECD Publishing, Paris.	IAM (DICE)	1.5˚C 4.5˚C	-2% -10%
Nordhaus, W. D., & Moffat, A. (2017). A survey of global impacts of climate change: Replication, survey methods, and a statistical analysis *(No. w23646). National Bureau of Economic Research*.	IAM (DICE)	6˚C	-8.16%
Hsiang, S.et al. (2017). Estimating economic damage from climate change in the United States. *Science, 356(6345), p.1362-1369.*	Spatial Empirical Adaptive Global-to-Local Assessment System (SEAGLAS)	1.5˚C 4.5˚C 8˚C	-1 to -1.7% -6.4% to -15.7% -1.5% to -5.6%
Kahn, M. E., Mohaddes, K., Ng, C., Ryan, N., Pesaran, M. H., Raissi, M., & Yang, J. C. (2019). Long-term macroeconomic effects of climate change: A cross-country analysis.	Econometric analysis	1.5˚C 4˚C	-1.07% -7.22%
Zenghelis, D. (2006). Stern Review: The economics of climate change. *London, England: HM Treasury*.	IAM (PAGE)	5-6˚C	-5% to -20%

However, the econometric approach does not fully capture acute climate damage risks, with acute climate events (such as wildfires, floods, and tropical storms) increasing in frequency and severity as temperatures rise over the projection period.

It is also possible to use a predetermined economic impact analysis, rather than choose a damage function for individual modelling, in which case the COACCH Climate Change Impact Scenario Explorer research project[13] presents impacts on GDP, and various other macroeconomic variables under nine different scenarios. The project is a synthesis of multiple scientific researches over the last century, and its methodology is primarily based on general equilibrium integrated assessment models (IAMs). The datasets are available for download on their website for each Member State (COACCH, 2024).

Acute impacts

The second part of this model block focuses on acute impacts of weather events on fiscal spending. It is difficult to assess how much of the costs of a natural disaster falls onto governments, not to mention the uncertainty of damages estimations. However, some assumptions might help to build an understanding of future fiscal costs associated with acute climate risks.

[13] https://www.coacch.eu/interactive-tool/

The proposed methodology of the acute climate impact assessment follows Gagliardi et al. (2022):

- Historical economic damages of each climate disaster type are extracted from the EM-DAT (Centre for Research on the Epidemiology of Disasters, 2024) dataset.
- Specifically, only the uninsured economic losses as a percentage of GDP are extracted to find a proxy estimation of costs for public finance.
- The uncertainty around estimating the number of future extreme events due to non-linearity is approached by identifying the maximum value of historic economic losses and scaling by a factor increase derived by Gagliardi et al. from the JRC PESETA IV project research. The factor increase in projected economic losses was derived for 1.5°C degree and 2°C degree scenarios for regional aggregates.

To assess and analyse the future impacts of various climate disasters, the JCR PESETA IV project might be further beneficial. While limited in its analysis, the project estimates economic losses under high and moderate emissions scenarios by disaster type (L. Feyen et al., 2020).

3.2.3. Inputs

Chronic and acute impacts

Chronic impacts of physical risks from climate change can be assessed using global warming pathways from sources like the Copernicus (2024), IPCC (2023), or NGFS (2024). GDP impacts can be extracted from the COACCH database, and IFIs can calculate GDP impacts of chosen scenarios. Damage functions should be chosen based on a country's vulnerability. Acute climate risks involve costs related to damaged assets and infrastructure, social transfers, and relief aid. These costs can be estimated using the EM-DAT dataset and the methodology of Gagliardi et al. (2022). However, as was noted by the national IFIs of Pillar 2, EM-DAT dataset might only reflect a part of the recent climate disasters. Therefore, the IFIs should consult the national statistical agencies to extract the most recent data for climate disasters damages. The main model inputs are summarised in Table 7.

Table 7: Physical Risks block inputs

Variable type	Variable	Source
Chronic	Warming pathways	Copernicus Climate Service; COACCH
	GDP losses	COACCH
		Damage functions from literature; Recommended: Burke, M., and Tanutama, V. (2019)
Acute	% of GDP lost after an extreme weather event	EM-DAT; National statistics agencies
	Factor increase of economic losses after extreme weather events	Gagliardi et al. (2022)

The sources in the table are all international or European analysis that aggregate evidence on different countries. This provides a consistent starting point for developing a standardise tool. Nevertheless, during phase 2B, there may be a need to a draw on national data to supplement the data above, based on the availability of the data from national sources. This will be explored with individual IFIs.

3.2.4. Outputs and links with other blocks

The outputs of this model block will enter the main Public Finance model block through the impact of physical risks on GDP, and the impact of physical risks on public spending. The decrease of GDP may result in weaker financial stability, as the debt-to-GDP ratio will increase. Additional government spending to mitigate the effects of acute extreme weather disasters will also require more debt and resources.

To make sure that the scenarios chosen to test are consistent throughout all the model blocks, the same emissions, and thus warming pathways, should be chosen accordingly for all of the blocks.

It is possible to link the Physical Risks to Transition Costs: e.g. the emissions input of the Physical Risks model could be extracted from the Transition Costs model block.

3.3. Transition Costs

3.3.1. Introduction

This framework block measures the costs and benefits of the transition towards net zero. It estimates the revenues collected from the planned climate-related taxes, and costs from any transfers and public investments made to achieve the emissions targets (set for 2030, 2040 and 2050) from the European Green Deal.

This model block can involve multiple policy scenarios and is dependent both on climate trends and policy variations. Some of the climate policies, such as tax on new vehicles requires stock model estimations, which in turn requires macroeconomic modelling outputs. To inform transition costs and revenues, some IFIs such as UK's OBR, Ireland's IFAC, and IMF use macroeconomic modelling outputs to estimate demand in the economy.

In Ireland's IFAC, the different scenarios considered included varying assumptions such as a more optimistic outlook for improvements in technology and a lower burden of adjustment falling on specific sectors. A general equilibrium TIMES model was used by IFAC to extract the scenario inputs. For example, the estimated number of additional cars are added to Ireland's overall car stock, and are, in turn, used to estimate revenues from VAT on new vehicles and Vehicle Registration Tax.

In the case of transport green transition, Slovenia might be negatively impacted by the reduction in the revenues generated by the fuel tax from the high transit activity. So, this module will be country-specific development and will lead to further development of the current debt sustainability model.

The IMF uses a New Keynesian model to estimate transition costs by country. They ran a Net Zero scenario of two groups of country averages: advanced, and emerging economies, and the results are publicly available. Some variables, such as fuel elasticity projections, may be used in designing individual countries' models. However, the IMF's CPAT tool, based on the same model, is also available for individual countries to estimate revenues and costs associated with different policy scenarios. The policy packages included in the IMF scenarios were carbon pricing, green public investment, green subsidies, and targeted transfers.

3.3.2. Description

Figure 5 presents the relationship between inputs and outputs of this block. Revenues and costs accrued from transition policies will be calculated separately, and the total change in fiscal balance will be calculated by subtracting costs from the revenues.

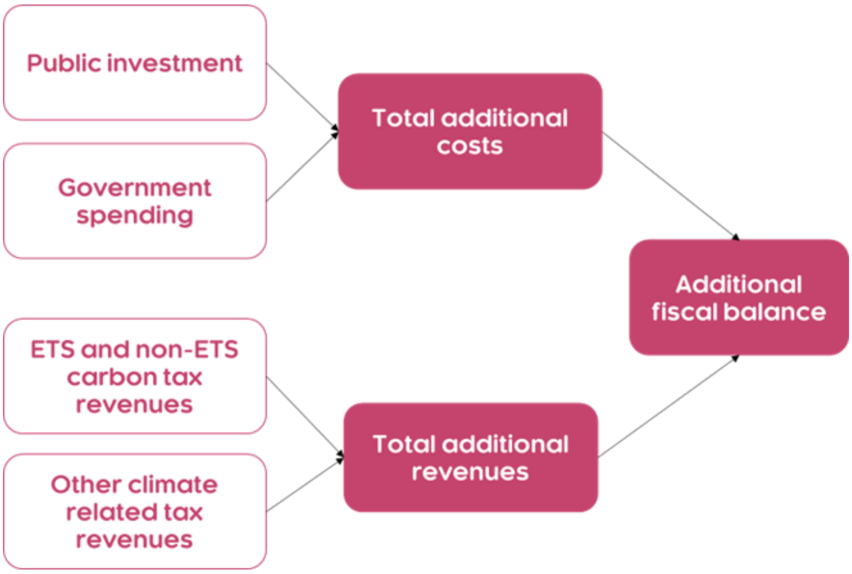
The costs associated with the climate transition are uncertain, but the inputs for public investment and government spending associated with the climate transition can be estimated by analysing national policy strategies.

Additional revenues from EU ETS scheme and other climate taxes are more complicated to estimate. While the tax rate is available, the amount generated from applying the tax is uncertain – macroeconomic modelling scenarios might be able to inform about it.

Lastly, the EU is pushing Member States to recycle revenues received from the EU ETS, meaning that the planned public investment might be part-funded by the revenues gained from EU ETS scheme.

One possible loop within the broader model is also the estimated projected emissions under various transition policy scenarios. These could then be used to inform inputs in the compliance costs and physical costs model blocks.

Figure 5: Transition Costs block framework



Source: Cambridge Econometrics

3.3.3. Inputs

The inputs are divided by sectors linked to policies. It is recommended that sectors are disaggregated by manufacturing, electricity, transport, buildings and residential, and agriculture, in line with the European Green Deal. The model design allows the user to change the inputs and see the outcomes under various policy assumptions. The input description below provides the sources and information.

Public Investments

The Member States have indicated the total amount of investment planned towards the Net Zero targets in their National Energy and Climate Plans (NECPs). Two pathways are assessed: with existing measures (WEM), and with additional measures (WAM).

The difficulty is in determining how much of the sustainable investments will be borne by the public finances in comparison to the private ones. Some of the NECPs are quite clear about it. For example, Cyprus clearly defines that under WEM the total investment is €17,575bn, of which only €1,988bn relates to public expenditure. The Cypriot NECP also identifies the funding sources (Directorate-General for Communication, 2023a).

Other Member States have indicated the planned sustainable investment in their NECPs, but some might have further plans outlined in national documents in the language of the country – these could be national Sustainable Development Strategies to achieve climate neutrality by 2050, climate change adaptation plans, etc. Each IFI will provide the necessary sources of planned sustainable investment for their country which should be included in this block.

Government Spending

Climate policies also require industrial subsidies as defined in the Green Deal Industrial Plan (European Commission, 2024g), and household transfers to support transitioning to energy efficient technologies[14]. The Social Climate Fund (European Commission, n.d.) is part of the Fit for 55 package, providing Member States with funds for social transfers, however, additional specific plans for household and businesses subsidies can also be found in NECPs.

ETS revenues

One of the main revenue sources related to transition for the Member States will remain the EU-ETS scheme. In estimating the future revenues from the scheme, price projections, as well as cap and free allowance trajectories should be considered. On the one hand, the prices are set to increase (differently under WEM and WAM), but, on the other hand, the cap is set to decrease by an annual linear factor of 2.2% (European Commission, 2024c) by 2030. The 2022 EU-ETS revenues from which future revenues can be calculated from are available from EEA (European Environment Agency, 2024b).

However, there is a certain level of free emissions allowances that will not generate revenues for the governments. More information, and the current free allowances for each Member State can be found on the European Commission website (European Commission, 2024e).

[14] Residential retrofitting is estimated to be one of the largest cost factors in Ireland, according to IFAC results.

Other climate tax revenues

Individual Member States might be imposing additional taxes on vehicles, or certain fuels and collecting additional revenues. The excise tax, and plans for future years, may be declared in the NECPs, such as in the case of Greece (Directorate-General for Communication, 2023b). The Irish IFI used the TIMES model to estimate the future demand for vehicles, and fuels, to estimate the amount of tax collected.

Revenues from ESR and RED

If Member States exceed their targets set in the Effort Sharing Regulation, or Renewable Energy Directive (more about these below in Section **Error! Reference source not found.**), they may be a ble to gain revenue from selling the excess emissions allowances, or statistical transfers of renewable energy[15]. More information on how to estimate the costs of non-compliance to ESR and RED are in the section below. The same estimation procedure can apply to estimated potential revenues from over-exceeding the targets.

Alternative to NECPs – “Fit for 55”core policy scenarios

It was expressed by the Pillar 2 IFIs that the NECPs might contain unrealistic and unachievable targets. Another alternative to policy scenarios are the European Green Deal core policy model scenarios[16]. These are: REG - relying on very strong intensification of energy and transport policies in absence of carbon pricing in road transport and buildings, MIX - relying on both carbon price signal extension to road transport and buildings and strong intensification of energy and transport policies, and MIX-CP - representing a more carbon price driven policy mix that illustrates a revision of the Energy Efficiency Directive and Renewable Energy Directive but limited to a lower intensification of current policies in addition to the carbon price signal applied to new sectors.

The specificities of each policy scenarios are outlined in Climate Target Plan impact assessment (SWD/2020/176 final)[17] page 46. They differ in the targets chosen from different EU policy directives, as well as the role played by the ETS revenues. While the policies from scenarios could be plugged in this model framework itself, conveniently, part of the Referee 2020 project, the three scenarios have already been modelled using PRIMES, and the excel files for the three-scenario output can be found linked in the webpage referenced above. The outputs include population, energy consumption by sector and fuel, energy demand by fuel type, production and imports by energy type, and energy costs. All of these can already be used to estimate tax revenues. However, were the IFIs to check the outputs for a chosen policy inputs of their own, they can also use the Referee tool online[18].

A summary of aggregated variable groups as inputs to this model block are provided in Table 8 below.

---

[15] “Statistical transfers are agreements between Member States to transfer the statistical value of a quantity of renewable energy produced in one Member State to another to meet their 2020 renewable energy targets or for contribution to the 2030 EU target compliance purposes” (European Commission, 2021b)

[16] European Commission. ‘EU Reference Scenario 2020’

[17] European Commission ‘COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS. Stepping up Europe’s 2030 climate ambition’ (2020)

[18] Referee (2024). https://refereetool.eu/presentation-referee-tool/

Table 8: Transition Costs block inputs

Variable type	Variable	Source
Costs	Investment in sustainable policies	NECPs; European Green Deal Scenarios
	Subsidies	NECPs; European Green Deal Industrial Plan Scenarios
	Transfers	NECPs; European Green Deal Scenarios
Revenues	ETS and auction revenues	European Green Deal Scenarios EEA NECPs
	Non-ETS carbon taxes	NECPs, European Green Deal Scenarios
	Other tax revenues : VAT, VRT	NECPs, European Green Deal Scenarios
	ESR, RED	Refer to Compliance Costs model block to estimate possible revenue if the targets for ESR and RED are exceeded in a modelled scenario

3.3.4. Outputs and links with other blocks

The outputs of the model under different policy scenarios will enter in the final public finance model block to estimate the future fiscal balance. The two types of outputs of this block are total costs incurred from transition policies, and total revenues received from climate-related taxes.

Costs: Total additional public costs would be calculated as the sum of any transition investment planned, as well as subsidies, and transfers.

Revenues: Total additional revenues would be calculated as a sum of EU-ETS revenues, non-ETS taxes, and any potential revenues from ESR and RED.

Emissions: Additionally, different emissions trajectories are estimated by the EEA under WEM and WAM spending. If the transition model block calculations are based on either one of them, then the corresponding emissions

3.4. Compliance Costs

3.4.1. Introduction

EU Member States are legally obliged to become climate neutral by 2050 (European Commission & Council of the European Union, 2021). This also includes reaching an intermediate target, which binds the EU to reduce greenhouse gas emissions by at least 55% by 2030 and 90% by 2040 in relative to 1990. The compliance cost block estimates the costs inferred from the Member States not complying with the climate neutrality commitments, specifically, Effort Sharing Regulation (ESR) and Renewable Energy Directive (RED) targets.

The ESR recognises the different capabilities of Member States to reduce GHG emissions and thus assigns different national targets for each of them by 2030. These targets relate only to non-EU ETS sectors. The current targets of ESR emissions reductions in 2030 in relation to that of 2005 as defined in the regulation as following: Latvia -17%, Cyprus -32%, Spain -37.7%, Slovenia -27%, Greece -22.7 % (European Commission, 2024b). If countries fail to meet these targets, there are two ways in which they can offset the excess emissions.

1. If they fail to meet a target one year, but they have surplus annual emissions allocations (AEAs) from previous years, they may use them to cover the excess emissions.
2. If they do not have any surplus AEAs from previous years, they may buy some from other Member States who have surplus and are willing to sell them. For example, in 2020, Germany bought them from three different countries (Bulgaria, Czechia and Hungary)[19].

Therefore, if a Member State does not comply with the ESR targets, additional costs will be incurred by the government. **This will be country-specific estimation and would require further development of the current debt sustainability assessment model.**

Similarly, the RED is a legal framework binding renewable energy target for 2030 to a minimum of 42.5% across the EU in the industry, transport, and building sectors. The latest revised version – RED III, requires that the Member States achieves:

- 1.6% annual increase in renewable energy usage in industry,
- at least 29% renewables in the final energy consumption in the transport sector by 2030,
- at least 49% share of renewable energy in buildings by 2030 (European Parliament & Council of the European Union, 2023).

If a Member State does not reach the target, it may buy a statistical transfer from a Member State which overachieved its targets. A statistical transfer involves an amount of renewable energy being deducted from one country's progress towards its target and added to another's. This is simply an accounting procedure, as no actual energy changes hands. So far, these transfers have not been common, and their prices are always bilaterally agreed by the two Member States engaging in the transfer.

The design of this framework block is partially derived from in the design in the Irish Fiscal Advisory Council's report (Irish Fiscal Advisory Council, 2023b).

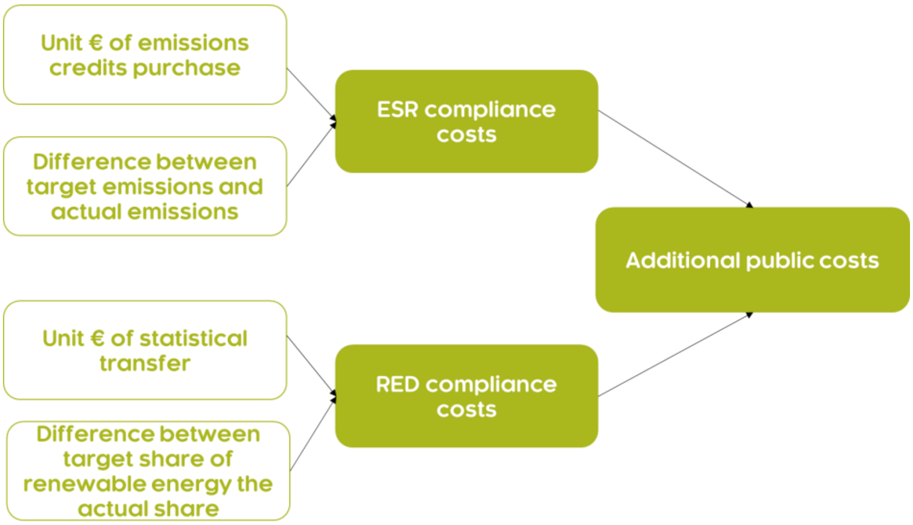
3.4.2. Description

This model block estimates and combines the compliance costs that may arise from ESR and RED as shown in the conceptual framework in

[19] European Commission, 'Climate Action Progress Report 2023 Shifting Gears: Increasing the Pace of Progress towards a Green and Prosperous Future'.

Figure 6.

Figure 6: Compliance Costs block framework



Source: Cambridge Econometrics

To estimate the total compliance costs for each of the commitments, the model uses a simple equation outlined by (Walker et al., 2023) for compliance costs calculations for Ireland:

*Total ESR compliance costs = (projected emissions – emissions targets) * unit € of emissions credits purchase* (1)

*Total RED compliance costs = (projected renewable energy share – renewable energy share targets) * unit € of statistical transfer* (2)

Inputs and outputs of this equation are described in the sections below.

3.4.3. Inputs

The inputs are summarised in Table 9. The block will allow to adjust the inputs, i.e. the price of unit costs, and the differences between targets and actual emissions, or renewable energy shares. In the text below it is described how to estimate the inputs.

Table 9: Compliance Costs block inputs

Output	Input	Source
ESR compliance cost	Unit € of emissions credits purchase	EU Reference Scenario 2020 IEA
	Difference between target emissions and actual emissions	Fit For 55 target emissions Emission projections from macroeconomic modelling outputs/external WEM and WAM projections from EEA

RED compliance costs	Unit € of statistical transfer	See section above to inform the estimation.
	Difference between target share of renewable energy the actual share	Renewable Energy Directive share targets IEA for estimations

Difference between target and estimated ERS emissions

ESR emissions targets are easily accessible on the EU website. Across official EU statistics websites as well as National energy and climate plans (NECPs) (European Commission, 2024f), emissions and costs are estimated under two main scenarios: With Existent Measures (WEM), and With Additional Measures (WAM). Official projections of the non-EU ETS emissions under both WEM and WAM scenarios are available from the European Environment Agency website (European Environment Agency, 2024a). The projected emissions under different policy scenarios can also be derived endogenously from the transition costs block, or extracted from the IMF's CPAT tool, which allows for customised climate policy inputs.

Based on the latest reports of GHG emissions in ERS sectors, the European Commission estimates shortfalls (or surpluses) from ESR targets under both WAM and WEM scenarios. The estimates from the 'Progress Report 2023 Climate Action' (European Commission, 2023b) for the pillar 2 countries are presented in Table 10. Here positive values suggest that a country is on track to overachieve its 2030 targets, while negative values indicate a shortfall or underachievement relative to the targets.

Table 10: GHG emissions estimates

Country	WEM	WAM
Greece	+13%	+13%
Spain	+7%	- 6%
Slovenia	-1%	-17%
Latvia	-9%	-10%
Cyprus	-23%	-23%

Source: European Commission (2022).

As of June 2023, Greece is projected to exceed its 2030 ESR targets by 13% under both the WEM and WAM scenarios. Spain shows a 6% shortfall under WAM but is expected to exceed its target by 7% under WEM. Slovenia is projected to slightly fall short of its target by 1% under WEM and significantly by 17% under WAM. Latvia is expected to have a shortfall of its target by 10% under WEM and 9% under WAM. Cyprus is on track to achieve a substantial 23% overachievement of its target under both scenarios.

Unit cost ESR

Unit costs of emissions credits purchases are difficult to estimate since there is no established market for trading AEAs. In the Walker et al. (2023) study for Ireland, the unit cost of ETS credits is used as proxy, but there is no official indication that Member States will use ETS prices as a reference for ESR transactions.

Suggested sources for ETS price estimations are the EU Reference Scenario 2020 (European Commission, 2024d),, and the IEA Net Zero Emissions model data (International Energy Agency, 2023). Member States also often include the ETS price estimation data they used in projecting future climate and energy trends in their NECPs.

Difference between target and estimated renewable energy shares

Several reports conclude that EU as a whole should not struggle to reach the current RED goal (Cremona et al., 2023). Targets of individual Member States renewable energy shares can be found in the individual NECPs.

Some estimated projections, as well as information about the current shares are available from EEA or IEA, although these are not sector specific.

Unit cost RED

As stated above, the RED transfers' prices are always bilaterally agreed by the two Member States engaging in the transfer deal. As noted in the European Commission's guidance (European Commission, 2021b) some of the factors indicating the price might be:

- Supply and demand of the statistical transfers across the EU.
- Incurred support costs and other indirect costs incurred by the selling Member State.
- Outside options, such as Renewable Energy Directive share targets.

As an example, statistical transfer agreements between different Member States in 2020 have included prices of: €12/MWh, €15/MWh, and €20/MWh (European Commission, 2021b).

3.4.4. Outputs and links with other blocks

Using equations (1) and (2), and the inputs described above, total costs incurred from non-compliance with RED and ESR can be calculated.

These numbers would then be added to the central Public Finance model block and treated as additional costs. This would then help to estimate how much more of a budget deficit a Member State might face under different renewable energy policy scenarios, and different emissions projections.

3.5. Public Finances

3.5.1. Introduction

The framework allows the estimation of the climate change impact on public finances. Therefore, the Public Finance module is the central block in the proposed framework. It incorporates outputs from the other three blocks: physical risks, transition costs, and compliance costs.

This block is essentially the current debt sustainability model used by the IFIs. The outputs of these block will be future debt sustainability, including how much additional costs will the government bear due to climate change and climate policy impacts, as well as the possible revenues from climate-related tax under different chosen scenarios. Our block's framework is partly based on the IMF's description of fiscal policy's role in the green transition, published in the 2023 Fiscal Monitor report (IMF, 2023).

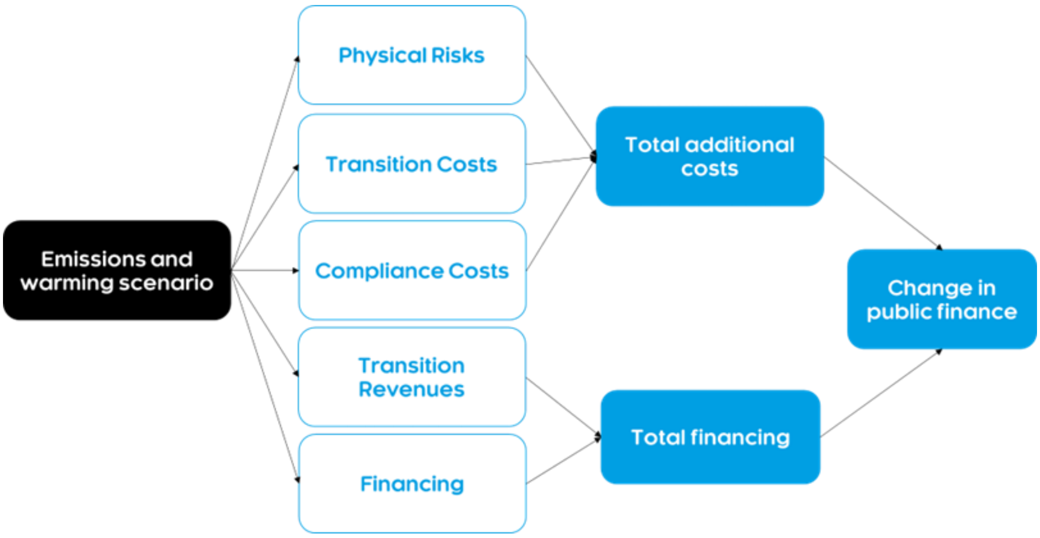
3.5.2. Description

The inputs are taken from the outputs of the previous model blocks. It is recommended for simplicity that one emissions and warming scenario is chosen for all of the input model blocks.

The Public Finance block combines the costs and revenue outputs from the other model blocks. The model block also concerns the future sources of financing. Some of the financing will be partly covered by the EU ETS revenues and other tax revenues. Some of the investments and transfers expenses might also be covered by EU funding, or other multilateral support. The rest would need to be financed by public debt.

Figure 7 illustrates the conceptual framework of the model block. Depending on the current model used by the IFI, this model block will need to be adapted to include the feedback loops from the other different modules. Moreover, further disaggregation will be required since both transition and compliance costs require sectoral breakdowns for both investment and revenues (tax basis). In the absence of an existing public finance block, the IFI will be equipped with a tool that will allow integration with the other modules.

Figure 7: Public Finance block framework



Source: Cambridge Econometrics

3.5.3. Inputs

The inputs of the Public Finance block are indicated in Table 11.

Table 11: Public Finance block inputs

Type of variable	Variable	Source
Macroeconomic projections	GDP	Physical risks block National projections
Costs	Government expenditure incurred after acute weather events	Physical risks block
	Public Investment	Transition costs block
	Adaptation Subsidies	Transition costs block
	Targeted transfers	Transition costs block
	ERS and RED compliance costs	Compliance costs block
Revenues	Carbon pricing (ETS)	Transition costs block, compliance cost block
	Other climate related tax and revenues	Transition costs block
Financing	Public Debt	Calculated
	EU support	EU Commission ; National development strategies

In general, it is expected that the future costs relating to climate change will be higher than any positive revenues, meaning that the governments will need to find additional ways to finance it. Financing sources for climate change related risks are something that the Member States do not report on to a proper level at the moment as noted by much of the literature. Therefore, it should be one of the main concerns for the IFI's debt sustainability analyses. Part of the transition costs, such as investments, and household transfers can be funded through EU climate financing schemes, including the Social Climate Fund. The brief overview of such schemes are presented in Table 12. However, a lot of these schemes are funded by ETS. Revenues from the EU ETS are already accounted for in the inputs of the Transition Costs, so the total revenue recycling from the scheme should be approached with care.

The additional costs not covered by support from the EU will have to be covered by public debt, or any other funding sources.

Table 12: Summary of EU climate change-related financing

EU climate financing	Description
Innovation Fund	The fund is financed from ETS, it finances highly innovative technologies and flagship projects within Europe that can bring about significant emission reductions. The fund awards grants through calls for proposals and through competitive bidding procedures.
Modernisation Fund	The Modernisation Fund supports the modernisation of energy systems and the improvement of energy efficiency in 13 lower-income EU Member States. Greece, Slovenia, and Latvia fall within the 13 Member States.
LIFE Climate Change Mitigation and Adaptation	The LIFE Climate Change Mitigation and Adaptation sub-programme manages about € 905 million to develop and implement innovative ways to respond to climate challenges. It finances policies relating to nature and biodiversity, circular economy, climate change mitigation and adaptation, and clean energy transition in a form of grants.
Social Climate Fund	Social Climate Fund is funded from ETS. It will provide Member States with dedicated funding so that the most affected vulnerable groups, such

	as households in energy or transport poverty, are directly supported, and not left behind during the green transition.

Additionally, Table 13 below summarises and links the data source to all of the inputs mentioned in the framework for the convenience of the use.

Table 13: Summary of inputs for the different model blocks

Model block	Variable	Data Source	Timeframe	Comments
Physical Risks	Warming pathways	Copernicus Climate Service	1950-2100	4 different warming pathways, results based on World Climate Research Programme (WCRP)
		COACCH	2015-2070	9 different scenarios
	GDP losses	COACCH	2015-2070	9 different scenarios; Created in 2018, unclear whether updated regularly; Based on CGE models
		Damage functions from literature; Recommended: Burke, M., and Tanutama, V. (2019)	Up to 2010	Historical analysis, not updated; Two warming scenarios
	% of GDP lost after an extreme weather event	EM-DAT	From 1900	Might not include smaller scale or more recent disasters; Updated regularly
		National statistics agencies	IFI specific	IFI specific
	Factor increase of economic losses after extreme weather events	Gagliardi et al.	Factor increases are built with respect to the climate baseline (1981-2010)	European Commission computations, based on the PESETA IV project (Feyen et al., 2020).
Transition Costs	Investment in sustainable policies	NECPs	2021-2030	National strategy
		European Green Deal Scenarios	Up to 2030	3 scenarios: REG. MIX. MIX-CP
	ETS and auction revenues	European Green Deal Scenarios	Up to 2030	3 scenarios: REG. MIX. MIX-CP
		IEA	Up to 2050	Observations for years 2030, 2040, and 2050
		EEA	2013-2022	Historical observations

		NECPs	2021-2030	National strategy
	Non-ETS carbon taxes	European Green Deal Scenarios	Up to 2030	3 scenarios: REG. MIX. MIX-CP
		NECPs	2021-2030	National strategy
	Other tax revenues: VAT; VRT	European Green Deal Scenarios	Up to 2030	3 scenarios: REG. MIX. MIX-CP
		NECPs	2021-2030	National strategy
Compliance costs	Unit € of emissions credits purchase	European Green Deal Scenarios	Up to 2030	3 scenarios: REG. MIX. MIX-CP
		IEA	2030; 2040; 2050	Global Energy and Climate Model updated each year
	Difference between target emissions and actual emissions	Fit For 55 (target emissions)	Up to 2030	
		EEA (real emission projections)	1990 - 2050	Based on historical data up to 2015 only
		Policy scenarios for delivering the European Green Deal - European Commission (europa.eu) (real emission projections)	Up to 2030	3 scenarios: REG. MIX. MIX-CP
	Difference between target share of renewable energy the actual share	RED share targets	Up to 2030	
		IEA (real share estimations)	Up to 2028	

3.5.4. Outputs

The outputs of this block will be the final output of the modelling framework. These will be the variables that can report on the projections of debt sustainability in the future. For example, having inputs of expected revenues and costs from climate policies can reveal the expected impact on fiscal balance. This, in turn, can indicate how much a government needs to go further into debt to cover the fiscal balance gap.

Knowing the projected GDP under different scenarios, the debt sustainability variables – metrics such as the debt-to-GDP ratio – can be derived.

If the share of each financing source to cover this debt is known or can be predicted too, the amount of debt, including interest can be calculated for each financing source.

4. Individual IFIs' Frameworks

This section focuses on four out of five IFIs and includes the review to date of the current capabilities and how further development work might proceed.

4.1. Long-term Macroeconomic and Fiscal Forecasting Tools

As part of the review on existing long-term analytical tools, the five IFIs were reviewed for the existing capabilities.

IFI	Long-term macroeconomic forecast	Long-term fiscal sustainability
Cyprus Fiscal Council	None	None
Hellenic Fiscal Council	None	None
Latvian Fiscal Discipline Council	Uses external macroeconomic forecasts (from National Bank of Latvia)	Fiscal sustainability analysis using the Ageing assumptions.
Slovenia Fiscal Council	SVAR macroeconomic model for the medium term. Mostly relying on DG ECFIN Ageing report on GDP projections	SFC uses the EC DSA with inflation rates, and long-term GDP projections from DG ECFIN Ageing report
Spain AIReF	Diverse suit of models ranging from nowcasting to long-term projections Macroeconomic forecast to 2070 driven by demographic projections	Estimation of revenues and expenditures separately.

4.2. Cyprus Fiscal Council

The Cyprus Fiscal Council is currently using only the deterministic EC-compliant DSA model in Excel as used in DG ECFIN Debt Sustainability Monitor reports[20];. Before discussing the relevant climate risk to be include in debt sustainability assessment, Cyprus needs to be equipped with a long-term debt sustainability model.

There are two options, the details of which:

1. Develop a suitable model structure tailored to the national context based on the EC methodologyor
2. Adopt the IMF public debt sustainability analyses (DSAs) tool.

[20] https://economy-finance.ec.europa.eu/publications/debt-sustainability-monitor-2023_en

Options	Advantages	Disadvantages
Adapt the European Commission long-term fiscal sustainability analysis[21] to the national context	• DG ECFIN will hold a workshop in September to explain the methodology (under the IFI Network project) • Simpler assumptions than the IMF's DSA • Scenarios analysis using Indicators • Long-term projections reflecting the Ageing Report	• Does not incorporate climate risk into the model, but this is easily mitigated since we will add it withing this project
IMF public debt sustainability analyses (DSAs) tool	• The DSA tools are user-friendly • Provides rapid quantification of impacts • Scenarios analysis • IMF provides training	• DSA does not show climate change impacts and mitigation on public finances • DSA requires arbitrary assumptions depending on the indicator being used • There are no feedback loops

The climate change risks will then be added to one of the two options. There is also the possibility to adopt also the IMF CPAT tool (and adapt it to match the European Green Deal requirements in terms of compliance costs).

4.3. Hellenic Fiscal Council

The Hellenic Fiscal Council does currently not have a useable model to assess debt sustainability. Some recent attempts involve developing a Matlab tool for Stochastic DSA, following the European Commission's framework (stipulated in the recent Debt Sustainability Monitor 2023, European Commission 2024h). Hence, before adding any climate components to the model, first HFISC welcomes support in improving the above model following the tender specification and the inception report. In addition, given that the new EU fiscal framework places large emphasis on the debt trajectory from a particular EU DSA methodology, HFISC is especially interested in acquiring a DSA model that is able to replicate the EU methodology, fine-tuned for the Greek economy

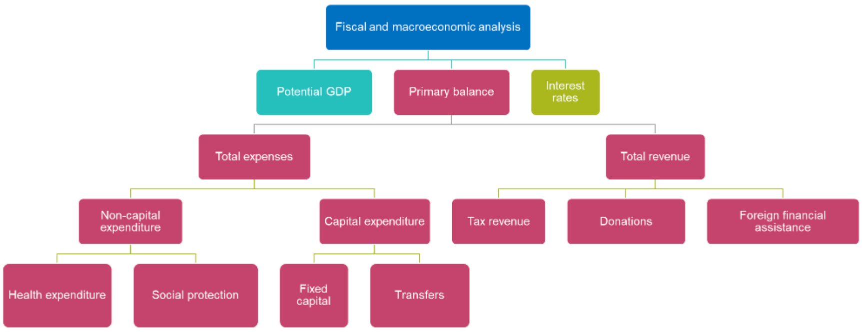
Important inputs in such a model are macroeconomic projections (of GDP and the government budget). Since there are currently official Ministry of Finance projections for GDP growth, government budget, interest rates etc. the DSA model could run in parallel with Pillar I. In a next phase the outcome from pillar I could be embedded in the DSA analysis.

[21] Based on: https://economy-finance.ec.europa.eu/system/files/2023-06/ip199_en_UPD.pdf

4.4. Latvian Fiscal Discipline Council

The Latvian Fiscal Discipline Council (FDC) produces fiscal projections for components of primary balance – public revenue and expenditure, and GDP projections (taken from AMECO). The FDC's revenue forecasting tool has four key input blocks to project revenues and expenditures accurately: realised government revenues and expenditures, current macroeconomic projections, tax-to-macro base elasticities, and the expected budgetary impact of policy measures. Realised revenues and expenditures are based on historical data for national and local government, while macroeconomic projections are used as proxies for tax bases. Tax-to-macro base elasticities, sourced mainly from the OECD and adjusted for national reforms, are inputs to the revenue forecasts. The FDC also maintains a basic long-term sustainability model. This model also includes data from DG ECFIN's Ageing Report and macroeconomic projections into the fiscal framework. The overall modelling framework is illustrated below:

Figure 8: Latvian FDC's current modelling capacity

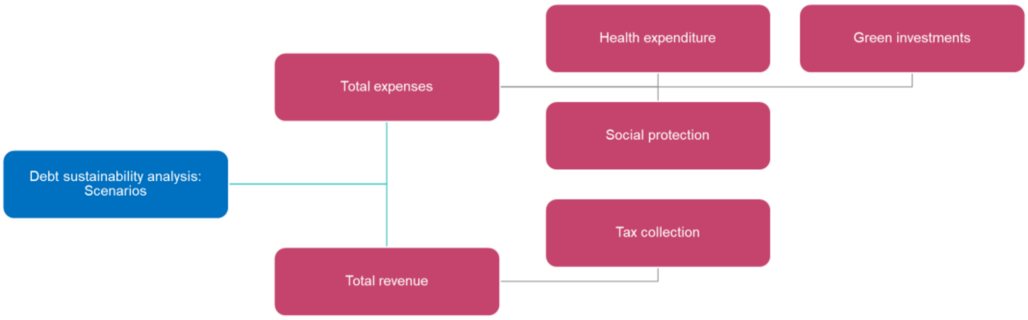


Source: Latvian FDC: 28122022_Final_Council_input_Makroekonomiskais_ietvars_un_zala_ietekme
Fiscal projections from - 28122022_Final_fiskalais_ietvars__green_inest_scen_2022
Revenue side calculations from - REV_simulating_tool_2002_08

The off-model debt sustainability scenarios produced by the IFI incorporate health and social protection expenditures[22] (broad tax collection on the revenue side) without substantially accounting for climate impact and action. These estimates minimally consider climate issues, whether related to climate change or climate action by incorporating elements from the Berenschot report on climate financing by 2040 (Berenschot, 2020). The debt sustainability calculations are based on several key assumptions: a gradual increase in tax and social security contributions (SSC) revenues aiming towards the EU average of 41.5% of GDP and a more modest target of 33% of GDP; the implicit interest rate on debt projected to stabilise at 3%; real GDP growth averaged at 2.9% annually, with the GDP deflator averaging 2.60%; the economically active population aged 15-64 is projected to reach 86% by 2041, while the unemployment rate is expected to be 6% by 2041; and total factor productivity growth is projected to be 2.1%. Additional assumptions include a depreciation rate of 0.05 and a capital elasticity rate of 0.7. These assumptions support the analysis and projections related to Latvia's fiscal sustainability under the new regulatory environment[23].

Figure 9: Latvian FDC Debt sustainability analysis

[22] The main assumptions are that social protection and health care funding reach 66% and 75% of the EU average.
[23] Assumptions derived from LDC's Assumption_Survey_Council.

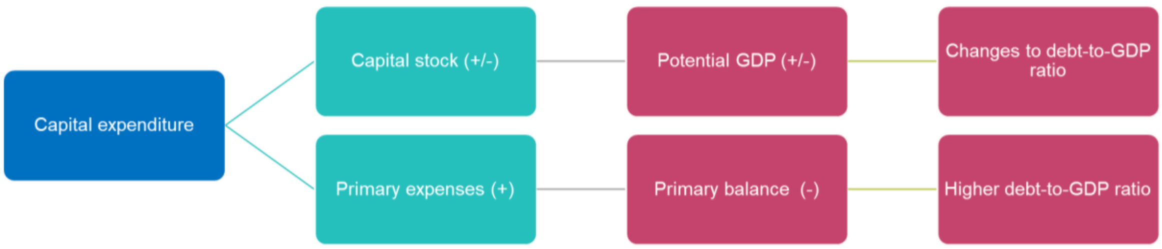


Source: Latvian FDC - 28122022_Final_modeling_debt_green_social_protection_att

The IFI incorporates elements of **transition costs** for reducing carbon losses to produce four renewed debt sustainability scenarios with three simplistic alternative green investment options from the Berenschot (2020) report: low, moderate and high unprofitable top margins (UTM) to attract investments in carbon-efficient technologies. UTM is used here as a proxy for subsidies/regulations/ taxes needed to allow for transition and compliance to the EU Green Deal. The FDC combines the fiscal outputs produced by the tool with these off-model calculations to produce an overall picture of Latvian debt and fiscal scenarios as illustrated in.

In its Country Reports for Latvia (European Commission, 2023a, 2024a) the European Commission suggests that the government has introduced measures to counter economic impacts, such as those from increased energy prices through investments in renewable energy sources. Additionally, the country's Recovery and Resilience Plan, supported by the EU's Recovery and Resilience Facility, aims to enhance energy efficiency and sustainable mobility, which could lead to a more resilient and diversified capital stock. These efforts, coupled with targeted policy incentives to promote innovation, are expected to contribute positively to Latvia's GDP in the long run. However, the precise net impact on the capital stock and potential GDP remains uncertain, as it depends on various factors including the effectiveness of the implementation of these measures and the broader global economic environment. The impact of these expenditures on the debt-to-GDP ratio has been illustrated through Figure 10.

Figure 10: Impact of transition costs of climate change and action on capital expenditure



Source: Cambridge Econometrics

During discussions with the Latvian FDC colleagues, physical risks were deemed low for Latvia. and that global warming is expected to improve the agricultural production and tourism in Latvia and lead to negligible costs linked to acute risks (i.e. extreme weather conditions). However, further review of the impacts of climate change on Latvia indicates that Latvia is increasingly experiencing the impacts of extreme weather events. While it may not face floods or droughts, it is witnessing an increase in heat, fluctuations in agricultural output, and changes in precipitation patterns (Feofilovs et al., 2024; Pfeifer et al., 2020)[24]. The World Bank's Climate Change Knowledge Portal indicates that extreme precipitation events might show different signs and larger magnitudes of change when compared to mean precipitation. In a warmer world, the potential of air to carry moisture increases exponentially, thus the potential for heavier precipitation also increases. Additionally, as global temperatures rise, the frequency and intensity of heat waves are expected to increase in Latvia, posing a risk to human health and agriculture. Moreover, Latvia has experienced substantial economic losses due to these weather and climate-related extremes. Between 1980 and 2022, such extremes caused economic losses estimated at EUR 650 billion in the EU Member States.

Specific instances of extreme weather events include a powerful storm that hit Latvia and Lithuania in 2024, causing one death and leaving some 200,000 households without electricity[25]. Additionally, a recent study (Matisons et al., 2020) has shown that the occurrence of 'blue' and 'frost' rings in the eastern Baltic provenances of Scots pine reveals the trees' sensitivity to frost.

Following the methodologies of the Swedish National Institute of Economic Research (Section 2.2.3.3), the IFI has determined that physical risks are not substantial enough to require specific considerations in their modelling approach.

During Deliverable 2B, the current model will be reviewed in-depth at the request of Latvian FDC colleagues. If deemed suitable, several improvements will be necessary. First, it is crucial to incorporate a more detailed breakdown of **transition costs**, reflecting the specific economic and policy conditions in Latvia. While **compliance costs** and the need to replace or repair existing capital stock to meet green transition requirements can lead to increased capital expenditure, the long-term benefits may offset these initial investments. Thus, the model should account for the potential long-term benefits of these investments, providing a balanced view of immediate costs and future gains. Moreover, integrating measures introduced by the Latvian government into the model can offer a more accurate representation of the country's fiscal and economic scenarios. The model should also consider targeted policy incentives designed to foster innovation and their potential effects on GDP growth.

This highlights the need for a comprehensive long-term model, with a significant climate dimension block. To address this, we propose to incorporate climate dimensions as described in the proposed framework with inputs capturing the impacts of transition and compliance costs on public finances. Transition and compliance costs (see Figure 11) can be calculated as the total of planned transition investments, subsidies, transfers, and ESR and RED compliance costs. Although public spending is expected to rise in the short- and medium-term due to transition and compliance costs, much of this spending could be financed through higher sectoral carbon prices and taxes rather than through the general budget (de Mooij & Gasper, 2023). While these costs could negatively impact the Latvian primary balance, the net impact of these revenues and costs need to be further explored in Deliverable 2B.

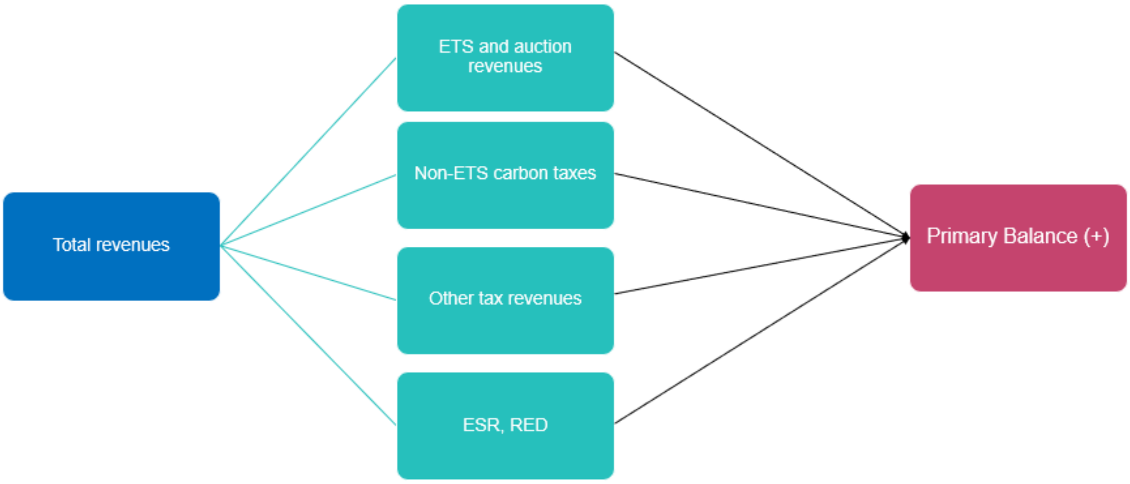
RED targets can stimulate investment in clean energy, fostering economic activity and innovation particularly in light of Latvia having 43.3% of its energy consumption being derived from

[24] World Bank's Climate Change Knowledge Portal: https://climateknowledgeportal.worldbank.org/country/latvia/extremes

[25] https://apnews.com/article/baltics-latvia-lithuania-storm-rain-damage-9ca30e2f41d75f26d5dd458f74dc88fb

renewables[26]. Collectively, these mechanisms can not only increase direct tax revenue but also promote sustainable investments and behavioural shifts that drive long-term economic growth and additional fiscal benefits for Latvia (International Energy Agency, 2024).

Figure 11: Revenue generation from transition and compliance



Source: Cambridge Econometrics

Figure 11 illustrates the changes to the relevant revenue blocks of the FDC's model, capturing the revenue impacts of transition and compliance. In the short term, total revenues could be negatively impacted due to increased investment needs to replace and update existing capital stock. However, total revenues could also be positively impacted through various environmental taxation and market mechanisms, notably the ETS, auction revenues, non-ETS carbon taxes, ESR, and RED targets. ESR targets for sectors outside the ETS could compel Latvia to implement additional taxes, contributing to overall revenue gains.

Going forward, this model will either be upgraded with climate change risks or replaced with a new model.

4.5. Slovenian Fiscal Council

For debt sustainability reports, the SFC uses an Excel run model based on European Commission Debt Sustainability method and extends the time horizon to 15 years beyond the current period. The SFC has indicated that, to date, the application of DSA and climate risk analysis has focused on specific supplementary assessment/components on the expenditure side (i.e. the cost of investment in climate action), but not on the revenue side e.g. concerning different taxes and tax bases etc. This approach thus also overlooks the potential erosion of the tax base due to climate action without further green fiscal policies. For example, Slovenia is dependent on road traffic tax and fossil fuel tax (excise tax, in addition to VAT) from all the transport transiting the country. The switch to electrical vehicles might reduce some components of the Government's revenues.

The IFI has indicated needing analytical capacity to assess fiscal and debt sustainability impacts of the following trends:

[26] Share of energy from renewable sources: [Eurostat]

1. Physical risks
2. Transition and compliance costs
3. Ageing – this is being achieved through another TSI which will finish soon. The IFI is getting technical support from the EC in modelling the impact of ageing which could potentially bolster the IFIs analytical capacities looking at the costs of ageing[27].

Following the meeting in May, the SFC colleagues have indicated the wish to find out more about the IMF CPAT tool. Since then, initial presentation by IMF was performed and the CPAT tool was given to SFC. The use of CPAT is currently limited to government institutions and is not to be provided to other parties. SFC finds that CPAT may be supplementary tool to define certain scenarios of climate-related risks, and that it is not primarily meant to be a tool to assess the fiscal costs of climate-related actions, especially in terms of government spending.

A review of the SFC's two reports: 'Slovenia's general government debt: characteristics, medium-term sustainability and long-term simulations' (Delakorda, 2021) and 'Assessment of budgetary documents for 2024 and 2025' (Slovenian Fiscal Council, 2023) illustrated the IFI's modelling capacities.

General Assessment of Government Fiscal Balance

The debt-to-GDP ratio (D) is determined by incorporating the primary budget balance (PB), interest rate, nominal economic growth, and stock-flow adjustments). This allows for the calculation of PB*—the primary budget balance needed to stabilise the initial debt level, given current debt and varying interest rate-growth differentials.

Medium-Term Analysis

In the previous years, The SFC carried out medium-term debt sustainability analysis using the IMF's template. The analysis constructs a baseline scenario borrowed from Slovenia's Draft Budgetary Plan and IMAD's forecasts. This included projections of fiscal aggregates, using historical elasticities for revenue and risk assessment related adjustment of expenditure growth based on past trends. The baseline scenario was tested against alternative scenarios to measure the debt's sensitivity to various shocks. The SFC uses GDP forecasts from the Institute of Macroeconomic Analysis and Development (IMAD), which are updated biannually and currently[28] cover up to t+2 years. The SFC used the IMF's DSA framework for market-access countries and involves three key modules: baseline projections producing a debt fan chart, a Gross Financing Needs (GFN) module to analyse financing risks, and stress tests to capture specific risks not fully addressed by the other tools. This framework assesses both solvency and medium-term rollover risks.

Since this year, Slovenia's Fiscal Council has adopted the European Commission's methodology for medium-term debt sustainability analysis, replacing the previously used IMF model. This approach includes a baseline scenario and alternative scenarios that account for shocks, extending the analysis period to align with the reformed EU economic governance framework.

[27] Slovenian Fiscal Council is currently involved in the TSI project "Developing a consistent system of economic models to improve fiscal supervision in Slovenia, granted by the EU-commission. The purpose of this project is to enable the Fiscal Council to develop a framework of demographic projection models and a macroeconomic model aiming at providing a consistent system of tools to improve fiscal supervision, assessment of fiscal sustainability, and policy analysis, mainly related to aging-related issues and the sustainability of social security systems.

[28] According to available information there is an ongoing discussion IMAD/MoF to extend the forecast horizon in order to align with the extended horizons within the new EU Economic Governance Framework. However, no final decision has been made yet.

The Council also assesses additional fiscal risks, including those related to demographics and climate finance.

Long-Term Analysis

Long-term fiscal projections incorporate assumptions about revenue, expenditure, and the debt-to-GDP ratio based on the medium-term budgetary documents. Expenditure projections consider long-term trends related to an ageing population, as outlined in the latest version of the EC's Ageing Report, while revenue projections focus on the impact of demographic changes on the labour force.

Climate Finance Gap Analysis

The Brložnik (2022) report assesses the gap between needed investments and available financial resources for Slovenia's climate transition from 2021 to 2030. The report outlines three investment scenarios based on different assumptions about revenue sources and the price of CO2 emissions. The Fiscal Council has used these scenarios to estimate the impact on GDP and the general government balance, employing a structural macroeconomic model which embodies a SVAR model, and which integrates fiscal policy responses to economic deviations. The structural macroeconomic model consists of traditional demand side with some elements of supply side. The model's behavioural equations include components of government revenue and expenditure. It does not include production function but does incorporate some equations resembling sectoral (value-added and employment) functions. There is no publicly available information on the model structure and on standardised model simulations. SFC uses the model internally as a check of official macroeconomic and fiscal forecasts as well as for basic policy simulations[29].

4.6. Spain AIReF

The AIReF's model, which is designed to assess long-term debt sustainability in Spain, is illustrated in Figure 12. This system is composed of three principal components:

1. Potential GDP
2. Primary balance
3. Interest rates

The model allows for the projection of variables that determine the evolution of Spanish public debt as well as the debt-to-GDP ratio. And projections on debt evolution, primary balances etc are forecast over a t+15 year period. Presently, the equations do not factor in climate change/action nor its downstream impacts.

We propose extending this model to include the climate change and action-related expenditure identified in Section **Error! Reference source not found.** to the debt sustainability equations. T his would involve identifying variables of the existing model impacted by these assumptions. The public policy intervention related to climate change and action leads to variations in revenues

[29] Note: In using this model for any further purposes, it is important to bear in mind its deficiencies. E.g., it is essential to pre-define the source of a shock to GDP as GDP itself is not defined by the behavioural equation but rather via an identity (production and the corresponding spending side). Also, tax components are not very detailed, consisting of indirect taxes, CIT, PIT, social contributions and (remaining) "other taxes".

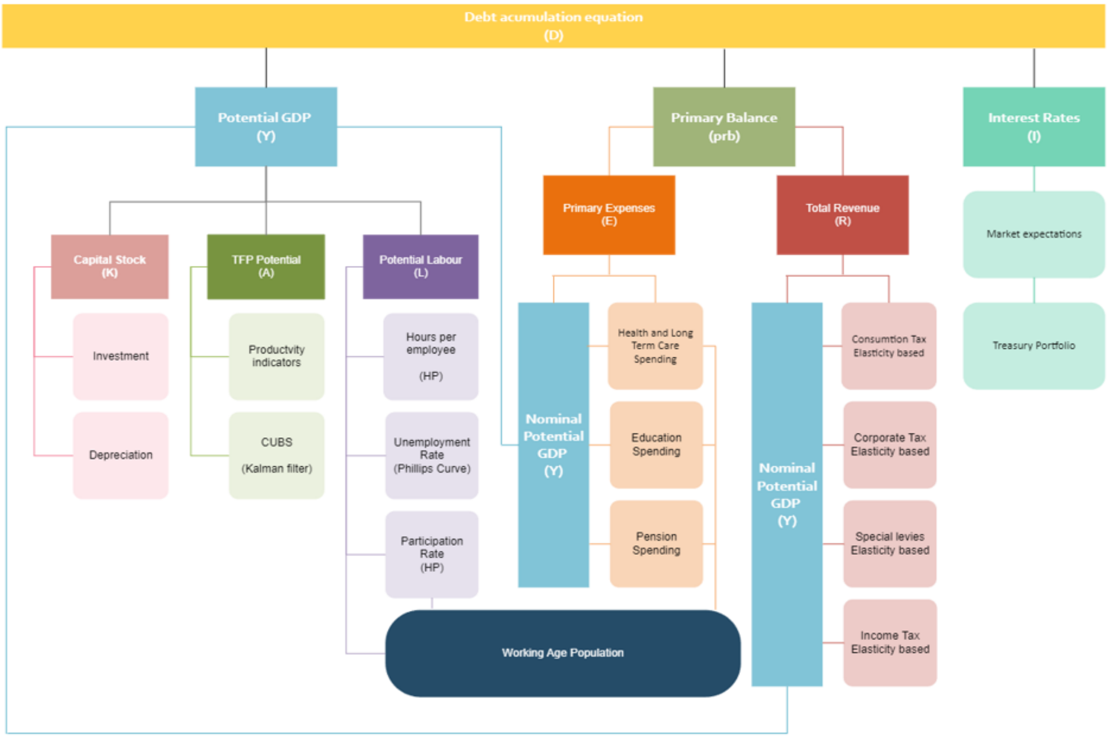
and expenditures, resulting in distinct macroeconomic and borrowing cost scenarios which are broken down by into the three blocks.

The channels of impact are now explained in detail:

Physical risks, due to climate change, can negatively impact multiple components of the debt accumulation equation. Specifically, they affect:

1. Potential GDP through damage to the capital stock, whether acute or chronic, caused by climate shocks.
2. Primary balance through the costs of restoring damaged infrastructure, which are classified as primary expenses.

Figure 12:AIReF framework for long-term debt sustainability



Source: AIReF

Figure 13 illustrates the direction by which physical risk potentially impacts different components of the DSA equation. This will required the disaggregation of capital stock and primary expenses in more detail to be able to account for physical risks.

Figure 13: Impact of physical risks

Source: Cambridge Econometrics

Transition and compliance costs impact primary expenses through the need to invest in and switch to new technologies. In addition, transition risks could potentially impact capital stock either through investment (replacing technology to be more energy efficient/compliant) or depreciation from a reduction in repairs/maintenance. The rationale behind capital depreciation is that reduced cash flows to carbon-intensive technology can have valuation effects on existing assets because the value of an asset is the discounted sum of expected cash flow, lower income than expected will result in its depreciation. This depreciation would stem from a transition or shift in investments from high-carbon to low-carbon technologies leading to depreciation of those that are either no longer viable or profitable. The benefits accrued from these costs would be realised in the long run with increases in long-term GDP and lower debt-to-GDP ratio through improved returns to investments through investments in capital stock and primary expenses respectively.

Figure 14 illustrates the impact of transition and compliance costs on different variables of AIReF's debt accumulation equation. Transition and compliance costs can have both negative and positive impacts in the short- and medium-term. For instance, if there are increased investments in low-carbon technology, subsequently leading to an increase in capital stock at a pace faster than capital depreciation, this could lead to a growth in GDP and a lower debt-to-GDP ratio. However, the impacts would be negative if investments and capital stock changes are at a slower pace than capital depreciation.

In addition, Green Transition would require the adoption of new technology, which in the short-term would cause a reduction in labour productivity due to the lack of skills but would improve productivity with re-skilling and up-skilling of the labour force in the medium- and long-term.

Figure 14: Impact of transition and compliance costs

Source: Cambridge Econometrics

These costs can also indirectly impact other components such as total revenue through different taxes levied as well as labour productivity under increasingly uncertain climatic conditions. For instance, climate change can worsen working conditions in regions experiencing high temperatures. Studies have found that both labour supply and productivity are projected to decrease under future climate change scenarios, especially in tropical regions. For example, under a scenario of 3.0°C warming, global total labour in low-exposure sectors could be reduced by 18 percentage points, with even higher reductions for outdoor work in full sunlight (Dasgupta et al., 2021).

4.7. Meetings

We propose the following regular meetings during the implementation phase:

1. Individual IFI meetings: twice per month, focusing on operational and technical matters
    a. These will discuss IFI-specific matters and be more technically focused e.g. covering data issues (variable definitions, units and API considerations).
    b. Progress updates will look to review the IFI-specific workplan and risks on an ongoing basis and agree any next steps or actions to continue advancing with the work.
    c. We suggest fixing a regular time for these calls with the option to reschedule relatively easily as needed, given the likely smaller group for these calls.
    d. During periods of greater intensity and/or IFI availability, there is the option for more frequent or longer meetings to make more rapid progress, which we will review with the IFIs as needed.

2. Cross-IFI meetings: Once every other month, focusing on peer/IFI learning and knowledge exchange
    a. These meetings will bring the IFIs and project team together to discuss broader lessons learned and share ongoing experience of the development process.
    b. The next meeting will take place on 5th February 2025, when the research team will present the lessons learned from in-depth review of the current models.

In all cases, we will book a full set of meetings early on in the project, to ensure as much notice as possible. We will prepare an agenda in advance of each meeting and note actions following the meeting (in many cases, leading to changes being reflected in live documents and notes).

5. Next Steps

Subject to clarifications and any further approval, the next steps are to begin work on the next phase of the project: implementation (Deliverable 2B).

As in the previous chapter, the first task in implementation is to clarify the IFI-specific workplans and timetable, with key actions as follows in each case:

- Formalisation of workplan
- Development of the basic model
- Data collection
- Upgraded analytical tools (climate considerations)
- Pilot simulations
- Prepare technical manuals

Subject to agreement on Deliverable 2A, the implementation phase will then commence in earnest. DGECFIN has expressed interest in contributing to the training and their involvement could give a valuable insight. Finally, it is important to follow the inception report regarding the planned join meetings within the whole team.

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