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The baseline is wrong

How debt sustainability analyses used in the EU ignore climate change

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Executive Summary

The European Union has reformed its fiscal rules in late 2024, making debt sustainability analysis (DSAs) the central steering tool for European fiscal policy. DSAs will be used to project debt-to-GDP ratios and derive fiscal policy requirements.

In this paper, we show that DSAs currently largely ignore economic impacts resulting from climate damages, as well as from the climate policies needed to satisfy the emissions constraint set by European climate targets. Both will likely reduce economic growth and worsen fiscal indicators, according to relevant literature. We further discuss how the growth impact of climate policy depends on the mix of policy instruments. In the presence of market failures beyond the carbon externality and uncoordinated global climate action, a balanced policy approach including public investment will likely lead to better economic outcomes than an approach based purely on carbon pricing.

We show how DSAs can account for the impacts of climate damages and for policies in alignment with the current fiscal constraints (a new baseline). Illustrated by indicative simulations, we show that a more balanced climate policy approach could improve growth and possibly even fiscal indicators vis-à-vis this new baseline. We conclude that DSA methodology should be reformed to account for European climate targets and highlight some research gaps and modelling inconsistencies that need to be addressed to do so.

#CLIMATE POLICY[1]
#FISCAL RULES
#DEBT SUSTAINABILITY ANALYSIS

[1] Dezernat Zukunft and the Institute voor Publieke Economie are members of the European Macro Policy Network (*EMPN*) — a coalition of European economic think tanks and policy experts committed to reshaping macroeconomic policy for a more prosperous, sustainable, and sovereign Europe.

Table of Contents

1. Introduction

The European Union (EU) has just reformed its fiscal rules, making Debt Sustainability Analyses (DSAs) the key tool for European fiscal policy. Going forward, the fiscal rules will focus on the debt ratio. DSAs will be used to calculate fiscal policy requirements. Based on a projection of debt-to-GDP 14 to 17 years into the future, a public expenditure ceiling will be set for the coming four years (or seven years in the case an extension period is granted; European Commission 2023).

The EU has agreed on an emissions constraint which has been enshrined in law. The European climate law makes reaching the EU's climate goal of reducing EU net greenhouse gas emissions by at least 55% compared to 1990 by 2030 a legal obligation. By 2050, the EU committed itself to reaching net zero emissions. To meet these targets, the EU has implemented a broad range of climate policies including the so called Fit-for-55-package, a set of revisions to existing EU legislation, as well as new instruments with the aim of ensuring that EU policies are in line with the climate goals (see box below).

Carbon pricing plays a central role in Europe's climate policy mix. Already in 2005, the EU has implemented a cap-and-trade carbon pricing system, the EU Emissions Trading System (EU ETS). Total emissions are capped, the rights to emit can be traded. Currently, the ETS covers most of the energy sector, energy intensive industries, aviation (since 2012) and maritime transport (since 2024). In 2027, a second ETS will be introduced, the ETS2. It will cover buildings, road transport and smaller scale industrial and energy production plants. Despite the ETS, Europe is currently not on track to meet its 2030 climate target (CAT 2024; European Commission 2024a). In the absence of *additional* fiscal and/or regulatory instruments, prices in the ETS1 and ETS2 would have to increase sharply over the next years to reach Europe's 2030 target (Günther et al. 2024).

DSAs do not consider climate legislation and damages – "the baseline is wrong". The debt ratios predicted by the DSA method are sensitive to assumed future economic growth. Research on the impact of climate change shows that economic growth will likely be reduced, if the lead policy instrument is carbon pricing rather than a policy mix including public investment (and by public investment we also mean public support for private investment). In addition, climate change impacts are very likely to damage the economy due to, among others, reduced productivity or extreme weather events. The DSA framework accounts for neither.

Ignoring implications of climate policy misjudges fiscal risks and leads to biased DSAs. Current DSAs tend to underestimate debt-to-GDP ratios, as growth impacts of climate damages as well as reaching the EU's climate target in a way that is compatible with the EU's fiscal framework constraints – mainly via carbon pricing – are not accounted for. If DSAs would account for these effects in a baseline scenario, a more balanced policy mix including more public climate investments (which would lower carbon prices) may result in similar fiscal indicators vis-à-vis the baseline, as positive growth effects, at least partially, offset fiscal spending.

The paper is structured as follows. The following chapter briefly summarises how climate change may impact economic growth in Europe. In the annex, we provide a more detailed literature review. Chapter three discusses implications for DSAs. Chapter four presents results from own simulations, illustrating how DSA results may change if climate was fully accounted for, and discusses implications for fiscal policy. Chapter five concludes.

Relevant climate legislation

- **European Climate Law (Regulation (EU) 2021/1119):** Net Zero by 2050 the latest, at least 55 percent reduction compared to 1990 by 2030.
- **Effort Sharing Regulation (Regulation (EU) 2023/857):** Annual national emission limits, see also Commission Implementing Decision (EU) 2020/2126 and its partial update.
- **ETS and ETS2 (Directive 2003/87/EC, amended through Directive (EU) 2023/959):** Establishment of cap-and-trade systems including rules according to which the generated revenues must be used. Part of the 'Fit for 55' package.
- **Social Climate Fund (Regulation (EU) 2023/955):** Establishment of a fund for the support of vulnerable households and small businesses financed by ETS2 revenues.
- **Reporting requirements (Regulation (EU) 2018/1999):** Countries have to publish emission projections.

2. Climate change may pose a challenge to Europe's GDP growth

Research into the economic impacts of climate change roughly falls into three categories. First, literature that looks at the impacts climate change has on economic activity; for example, because temperature increases, land becomes less fertile, or because extreme weather events occur more frequently. Second, literature that investigates the impact climate policy targeted at reducing emissions has on economic activity. Third, literature that brings damage and mitigation effects together and investigates total impacts in integrated assessment models. The following sections provide a brief overview of relevant literature for Europe.

Climate damages

Climate change may lead to damages in several ways. Warmer temperatures can reduce labour productivity and change agricultural yields. Extreme weather events, such as droughts, heatwaves, floods and cyclones can lead to faster capital depreciation. Rising sea levels may have similar consequences. Furthermore, damages may indirectly impact economic growth through reduced capital accumulation (IPCC 2023).

Roughly forty years of climate research has produced a wide range of estimates on the direct impact of global climate change on economic activity. Tol (2024) conducts a meta-analysis of this expansive literature. Methods range from enumerating sectoral impacts, to modelling efforts to account for more dynamic impacts, to econometric efforts, to simply asking experts (or even non-experts) what impact they expect. Combining 69 studies that look at impacts of global average temperature change, Tol (2024) finds that 2.5/5.0 degrees of warming leads to a -1.4%/-4.2% change in income, with 95%-confidence intervals at 2,6% to -3,6% (2.5°C) and 5,3% to -7,3% (5.0°C). In terms of impact on economic growth, Tol (2024), drawing on the same data, finds that warming of 4.3°C changes global economic output by 0,8% to -5.3% (67% confidence interval) by 2100, with -1.6% being the central estimate. In other words, impact estimates are highly uncertain, with risks skewed to the downside. [2]

Some studies that infer impacts of climate change from observed weather changes find much higher potential impacts. Drawing on empirical analysis, Kalkuhl and Wenz (2020) find robust evidence that temperature affects productivity levels considerably. An increase in global mean surface temperature by about 3.5°C until 2100 would reduce global output by 7–14%, with even higher damages in tropical and poor regions. Kotz et al. (2024) find that the world economy is already committed to an income reduction of 11-29% until 2050 (independent of future emission reduction choices), compared to a scenario without climate change. These numbers exclude non-market damages and damages from extreme weather events or sea-level rise or tipping elements, so that total damages are likely to be even greater.

The expected damages from global warming vary significantly by country but may reduce Europe's output by 5% to 10% by 2050. We derive this figure from Kotz et al. (2024), which is also the basis for the damage modelling in the latest scenario update of the Network on Greening the Financial Sector (NGFS), a collaborative effort of central banks and

[2] Estimates in the literature reviewed by Tol (2024) only identify part of the damages that are to be expected. The literature typically identifies the impact of climate by comparing different regions that currently deal with different climates. Changes in weather that one can adopt to in the longer run, may cause damages in the short run that these studies would not identify. In some studies, the effect of long-run changes in climate on GDP is therefore enhanced by estimates of the effect of shorter-term changes (see for example Kalkuhl and Wenz, 2020). Similarly, larger natural disasters and sea level rises are ignored by many methods and require additional adjustments to estimates.

supervisors that includes the European Central Bank (ECB).

Climate policy

Europe has agreed on an emissions constraint which has been enshrined in law. The European climate law makes reaching the EU's climate goal of reducing EU net greenhouse gas emissions by at least 55% compared to 1990 by 2030 a legal obligation. By 2050, the EU committed itself to reaching net zero emissions. To meet these targets, the EU has implemented a broad range of climate policies including the so called Fit-for-55-package, a set of revisions to exisiting EU legislation, including carbon pricing, as well as new instruments with the aim of ensuring that EU policies are in line with the climate goals.

Climate policy consists of three main instrument types: carbon pricing, regulations and public financing. Carbon pricing schemes put a price on emissions and, hence, make polluting activities more expensive, creating incentives to reduce polluting activities and switch to cleaner alternatives. In the absence of market frictions or failures (beyond the carbon externality), carbon pricing is regarded as the most cost-efficient way to reduce emissions (Stiglitz et al. 2017). Income generated through carbon pricing can be used in various ways, but most proponents of carbon pricing argue in favour of paying it (at least partially) back to households as compensation. Regulations and standards ban certain polluting activities. Research shows that including some regulations can improve the effectiveness of climate policy, at little to no additional cost (Stiglitz 2019; Dimanchev & Knittel 2023). Lastly, public funding includes public investment in public mitigation infrastructures as well as financial support to households and companies targeted at lowering the cost of green investments. A broad literature exists that shows public investment support can increase the effectiveness of climate policy as well as economic growth effects in the presence of market frictions and failures beyond the carbon externality (Acemoglu et al. 2012; Stiglitz et al. 2017; Stern et al. 2021; Blanchard et al. 2023; Armitage et al. 2024).

Carbon pricing plays a central role in Europe's climate policy mix. The EU has implemented a cap-and-trade carbon pricing system, the EU Emissions Trading System (EU ETS) in 2005. Total emissions are capped, the rights to emit can be traded. Currently, the ETS covers most of the energy sector, energy intensive industries, aviation (since 2012) and maritime transport (since 2024). Since 2005, emissions from stationary installations covered by the ETS have fallen by 48% (European Environment Agency 2024).[3] In 2027, a second ETS will be introduced, the ETS2. It will cover buildings, road transport and smaller scale industrial and energy production plants. Despite the ETS, Europe is currently not on track to meet its 2030 climate target (CAT 2024; European Commission 2024a). In the absence of *additional* fiscal and/or regulatory instruments, prices in the ETS1 and ETS2 would have to increase sharply over the next years for Europe to reach it's 2030 target (Günther et al. 2024).

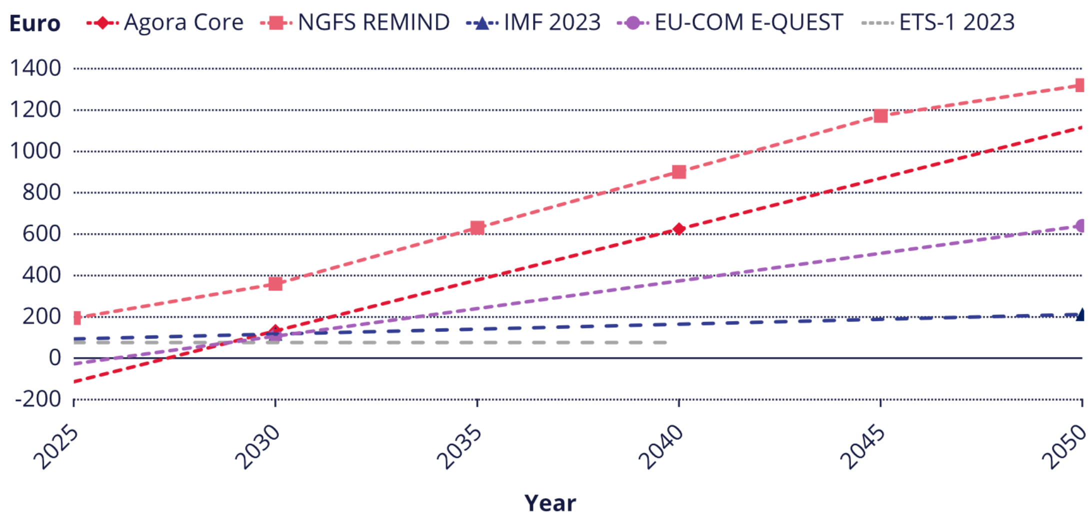
Existing literature suggests GDP losses of around 2% from policies that rely *primarily* on carbon pricing to deliver the EU's net zero target. The relevant literature is too extensive to provide a complete literature review here. Annex 1 summarises several papers relevant to the EU policy context, including modelling by the European Commission, OECD and NGFS (we use the NGFS modelling results to adjust DSA results in chapter 4). Estimates for the most relevant scenarios show GDP losses from around 1% to around 2% by the mid-2030s, treating carbon prices primarily as a cost shock

[3] Other instruments, including, among others, national renewables and efficiency subsidies, contributed to this decline, too.

to the economy (European Commission 2021; Varga et al. 2022; Château et al. 2023; NGFS 2023). These estimates depend on model assumptions, can vary significantly across member states, and are generally larger when the transition is imposed over a shorter period. Most models also assume ambitious global climate action, which is likely to result in overly optimistic economic impacts assessments for the EU. Finally, reviewed models yield very different predictions of the future level of carbon prices, ranging from around 200 to 900 in 2040, as the following figure shows

Carbon prices

In Euro, 2023 prices



The chart compares the carbon prices that different studies expect will be required to meet climate targets.

How to read the chart: The NGFS Remind model assumes a carbon price of about 200 euros in 2025, which increases to over 1000 euros by 2045.

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Figure 1: Carbon prices

Source: European Commission 2021; Varga et al. 2022; Château et al. 2023; NGFS 2023

Research shows that a policy mix minimises the negative impact of climate policy on growth. Many scholars investigate the impact of different policy mixes on growth and show that combining carbon pricing with public financing has the least negative impact. In most models this implies not or only partially compensating consumers for higher prices and instead recycling pricing revenues into clean subsidies. Varga et al. (2022) find that a scenario combining carbon pricing with clean energy subsidies results in a GDP decrease of 0.61% by 2050 compared to scenarios that redistribute revenue via lump-sum resulting in a negative GDP impact of 0.86%. Agora Energiewende (2024) reports that a policy mix with low carbon pricing and high investment support leads to a 0.5% GDP increase by 2040 over a high carbon pricing scenario, although it also raises the debt-to-GDP ratio by 7%. Other authors, such as Dafermos and Nikolaidi (2019; 2022), find that a climate investment agenda may even result in lower debt levels. Bistline et al. (2023) study the US Inflation Reduction Act (IRA) and conclude that the subsidies-approach would be preferable to carbon pricing, if there are strong learning-by-doing externalities. Additionally, there is a large body of literature showing that green subsidies not only stimulate economic growth but also improve mitigation effectiveness in the presence of other market failures beyond the carbon externality, incl. knowledge externalities, coordination failures, market entry barriers, liquidity bottlenecks, and uncertainty (Acemoglu et al. 2012; Stiglitz et al. 2017; Stiglitz & Stern 2021; Berkouwer & Dean 2022; Armitage et al. 2023; Blanchard et al. 2023).

Existing literature likely underestimates carbon pricing impacts. Future research should delve deeper into the impact of different policy mixes on the economy. Firstly, existing modelling focused on carbon pricing is unclear on how high carbon prices need to be to secure the EU's climate targets. Secondly, these modelling efforts largely neglect the literature on other market failures surrounding green investments, likely overestimating the level of fossil-to-green technology switches as a response to carbon pricing and underestimating negative impacts on the economy. If market failures beyond the carbon externality are not addressed, or if infrastructure necessary to use green alternatives is not built, high carbon prices will lead to significant demand destruction. Thirdly, existing literature largely assumes global climate action and harmonized policy mixes across major emitters, which, too, is likely to underestimate economic impacts in Europe. It follows that carbon pricing-led climate policy is likely to result in worse economic outcomes than indicated by the literature reviewed in annex 2.

Integrated impacts

With integrated assessment models (IAMs) modelling on physical impacts, climate policy and economic impacts can be combined to weigh up costs and benefits of climate action. Nordhaus (1991)has famously developed one of the first IAMs, the so-called DICE-model, arguing in 2018 that around 3°C of global warming by 2100 would be cost optimal on the basis of his latest model calibration (Nordhaus 2018). There is much criticism of this conclusion as well as the methodological underpinnings of the DICE-model and other IAMs. Among others, critics point out that IAMs insufficiently account for market failures, underestimate damages by ignoring tail risks and use inappropriate approaches to discounting (Stern 2008; Stiglitz & Stern 2021). If adjusted for these and other shortcomings, scholars show that staying under 2 degrees of global warming could be cost-optimal (Dietz & Stern 2015; Hänsel et al. 2020).

By 2050, Europe's cumulative GDP growth might be reduced by 6 percentage points as a result of climate damages and policy, according to NGFS modelling. NGFS (2024) assesses total impacts of different climate scenarios and finds that climate damages in a current policies scenario outweigh growth impacts of climate damages and policy in the global net zero scenario by a factor 1.8x until 2050. These figures are comparisons against a hypothetical baseline scenario in which climate change does not occur, and NGFS assumes globally coordinated climate action. As argued above, unilateral climate action may result in larger policy impacts for Europe.

The combined literature in this chapter suggests that its imperative to include climate change impacts comprehensively in Europe's debt sustainability analysis. This follows from potential economic damages resulting from climate change and its effects on debt sustainability. It also follows from the literature on how climate policy impacts growth, providing evidence that climate policy under fiscal constraints results in slower emission reduction and/or worse economic outcomes.

3. Consequences for debt sustainability analysis

The EU has just reformed its fiscal rules, making DSAs the key tool for European fiscal policy. As a result, fiscal policy will revolve around projections of the debt-to-GDP ratio 14 to 17 years into the future**.** The combined literature in the previous chapter suggests that its imperative to include climate change impacts in these projections. Both damages resulting from climate change and the impact of policy on growth may affect debt sustainability.

The DSA methodology is meant to take into account legislated policies. Key assumptions in the DSA are on the government's primary balance, growth, and the interest rate. As a general rule, spending and revenue will be taken into account when it is legislated or sufficiently certain. Thus, current climate policies will be included, while policies that have not been legislated yet, will not. The DSA methodology is also meant to take into account the effect of policies on growth, to the extent that they are legislated or sufficiently certain (see footnote 2 and Box 1 in European Commission 2023).

In practice, the impact of climate change on growth through damages and the emissions constraint appears to be not fully accounted for. Currently, the growth projections that enter the DSA are based on different methodologies for short-, medium-, and long-term growth. DSA assumptions on short-term growth (up to two years in the future) follow from the Commission's autumn forecast (European Commission 2023b). Medium-term growth is projected using the so-called Commonly Agreed Method (EUCAM) (Blondeau et al. 2021). Growth beyond t+10 is projected based on the latest Ageing Report by the EU-Commission. The Ageing Report projects GDP development fifty years into the future based on assumptions about population development and the corresponding labour supply, labour productivity, and unemployment (European Commission 2024b). None of these elements make *explicit* adjustments for climate change, although the 2024 Ageing Report does discuss potential interactions between ageing and climate change.

The methodologies for estimating medium- and long-term growth include statistical elements that are likely to pick up some but not all climate damages. For instance, the EUCAM uses a Kalman filtering method to estimate TFP changes. As climate damages scale approximately linearly with temperature changes under 2°C (Tol, 2024), it can be assumed that EUCAM picks up some future climate damages, but likely not all. There is some evidence that suggests damage functions might be non-linear as a consequence of tipping elements – which are not covered by Tol (2024) –, which may be reached with increasing likelihood as global warming exceeds 1.5°C (Armstrong McKay et al. 2022). Moreover, adaptation spending across the EU is likely to increase considerably in the coming years, as governments seek to prevent their citizens from acute physical impacts. This may shift supply capacities away from more productive investment in other infrastructure, thereby impeding growth.

Economic impacts that may result from policies aimed at reaching the EU's climate target are not sufficiently covered by DSAs. Forecasting growth, primarily on the basis of historic trends, underestimates the economic impacts of meeting the EU's climate targets for several reasons. Firstly, marginal abatement cost curves have been found to be convex and steeply increasing. The shorter the transition period is, the steeper is the marginal abatement cost curve (Hintermayer et al. 2020). Secondly, the European Union is not on track to meet its climate targets (CAT 2024; European

Commission 2024a). Climate policy needs to intensify, if the 2030 target of 55% emission reduction is to be met. Thirdly, reaching the EU's climate target under its newly reformed fiscal rules requires stringent fiscal adjustments in most member states (Darvas et al. 2024), impeding investment-led climate policy approaches. This will shift Europe's climate policy mix further towards carbon pricing and regulations, which is likely to result in higher economic damages, as discussed in chapter 2. These are currently not accounted for in DSAs – the baseline is wrong.

DSAs need to adequately incorporate climate change. Doing so will improve the outcomes of managing debt sustainability trade-offs and allow member states to implement climate policy mixes that effectively drive emission reduction while maximising growth effects.

4. DSA projections look worse when incorporating climate

Integrating climate impact estimates into policy analysis

Assessing the effect of climate in a DSA requires specific estimates. To produce a DSA that correctly deals with the impact of climate damages and policy on economic growth, the insights of the literature above must be applied to specific countries, taking into account currently legislated emissions targets over the relevant timeline. There have been few efforts to incorporate climate impacts into DSA frameworks as they are used in policy processes. An exception is Zenios (2022), who integrates IAMs into a stochastic DSA framework. Our focus differs from his, in that we are interested in the new EU DSA framework in particular and aim for an implementation based on current EU climate targets and policies.

Impact estimates should be transparent, well documented and have legitimacy with policy makers. These criteria are very hard to meet and there do not seem to be estimates that fit the bill perfectly. One of the more well-known and well documented efforts is the modelling done by central banks under the umbrella of the NGFS. Those estimates can be found at *https://www.ngfs.net*. NGFS model outputs have already been used for policy purposes: The European Central Bank (ECB) conducted an exploratory climate stress test in 2022, using scenarios based on NGFS model outputs (European Central Bank 2022). Subsequently, the ECB used the NGFS scenarios to stress test the Eurosystem's balance sheet (European Central Bank 2023).[4]

The NGFS scenarios consider different types of GDP losses in a manner that is both internally consistent and largely consistent with the findings of the literature. First, 'chronic' physical impacts on productivity from changes in temperature and weather are estimated following a specification from Kotz et al. (2024), in which climate change causes lower growth rates during the transition. Second, 'acute' physical impacts such as droughts and heatwaves are considered separately, following outputs from the CLIMADA model (Aznar-Siguan & Bresch 2019). Third, the impact of transition policies is modelled jointly with the chronic physical impacts through several IAMs with a macro-overlay (see annex 1). All three impacts depress economic growth during the transition and hence lower the level of GDP, but do not lead to lower growth after the transition is complete.

That said, estimating the GDP-impact of climate policy in the context of DSAs for European fiscal surveillance is a very specific use case. Clearly none of the NGFS scenarios has been designed with this use case in mind. There are several reasons for why the scenarios may significantly under- as well as overestimate the GDP impact of legislated climate goals. In the following, we try to account for this by using a scenario in which the factors leading to under- and overestimation roughly balance out. Given the qualitative judgement calls involved in doing so, we do not think that the magnitudes presented below are necessarily meaningful. Instead, what this paper can do, is illustrate a principle, which then needs to be operationalised with a tailormade model for DSAs (developed by the NGFS or others).

[4] NGFS estimates have been used outside of the Eurozone as well, for example in a pilot banking stress test by the US Federal Reserve Board (Federal Reserve Board, 2024).

A new baseline

We use growth impact estimates from the NGFS 'net zero' scenario to represent the expected impact of reaching legislated EU targets. In this scenario, European governments achieve net zero emissions by 2039 through a carbon tax that increases over time. Half of the resulting carbon revenues are used for debt reduction, while the other half are used for government investment to aid the green transition.

There are several reasons why this scenario may severely under- as well as overestimate the GDP impact. It assumes a globally coordinated mitigation effort including global carbon pricing.[5] Hence, from a European perspective, GDP impacts are likely overoptimistic. The same applies to trade effects, as only a small fraction of global emissions are currently subject to carbon pricing. Secondly, it assumes that carbon prices of several hundred Euros are possible without dedicated support to households. Instead, revenues from carbon pricing are partly used for growth enhancing public investment and for paying down government debt. Finally, economy-wide carbon prices start increasing continuously from 2020 onwards, surpassing 150 US-Dollars (base year 2010) in Europe by 2025. Yet, the ETS2 covering buildings and transport will only become fully operational in 2027, such significantly shortening the period during which the economy can adjust. On the other hand, the NGFS's net zero scenario is based on far more ambitious emission reductions than required under the European law with Europe achieving net zero by 2039 already. Such an ambitious timeline is likely required for global net zero by 2050 but it is not European law, the reference point for DSAs.

Thus, in sum, Europe will have a shorter timeline starting later than assumed by NGFS, is likely to feel worse trade effects, use a fiscal strategy which is less optimal for growth (spending money on compensating consumers) but, on the other hand, will have significantly more time to achieve its goals than assumed. Hence, as explained above, we do not think that the magnitude of effects presented here is robust. Instead, this paper should serve to illustrate the principle and motivate the development of a tailor-made effort to incorporate the growth effects of climate damages and climate targets in DSAs.

Future research should work towards consistency between the DSA's assumptions and those of the underlying models. In this paper, we leave the DSA's assumptions on the primary deficit and interest rates largely unchanged, with one important exception: we increase the primary balance in alignment with the growth of carbon pricing revenues assumed to be used for debt reduction in the NGFS scenario. This is necessary to ensure consistent implementation of NGFS results but is inconsistent with DSA assumptions and currently legislated policies.[6] Additionally, NiGEM, the macroeconomic model NGFS scenarios run through (see annex 1), also makes predictions on the increase in interest rates and inflation in different scenarios, which would have implications for the DSA. These effects are not considered here. The box below describes the macroeconomic outcomes of the NGFS 'net zero' scenario.

[5] Modelling does not assume a uniform carbon price, but prices differentiate across regions.

[6] ETS2 revenues are partially earmarked for the Social Climate Fund (the use of which requires additional national co-financing), and the ETS directive requires that all revenues be dedicated to climate and energy-related purposes (European Environment Agency 2024), i.e. would not be used to pay down debt.

Macroeconomic outcomes of the NGFS 'net zero' scenario – the example of Italy

We choose the example of Italy as it is a large member state whose GDP growth will be affected considerably by both climate damages and policies required to meet climate targets.

The NGFS 'net zero' scenario relies primarily on pricing to ensure that net zero is reached globally by 2050. However, modelling does not assume a globally uniform carbon price but differentiates regional climate measures that yield different implicit carbon prices across regions. In Europe, which reaches net zero by 2039 in the 'net zero' scenario, the carbon price in the IAM (REMIND model) grows from about 150 US dollars in 2025 to almost 500 US dollars by 2035 (base year 2010). The energy mix from the REMIND model is an input to NiGEM, the macro-overlay used to produce economic outcomes.

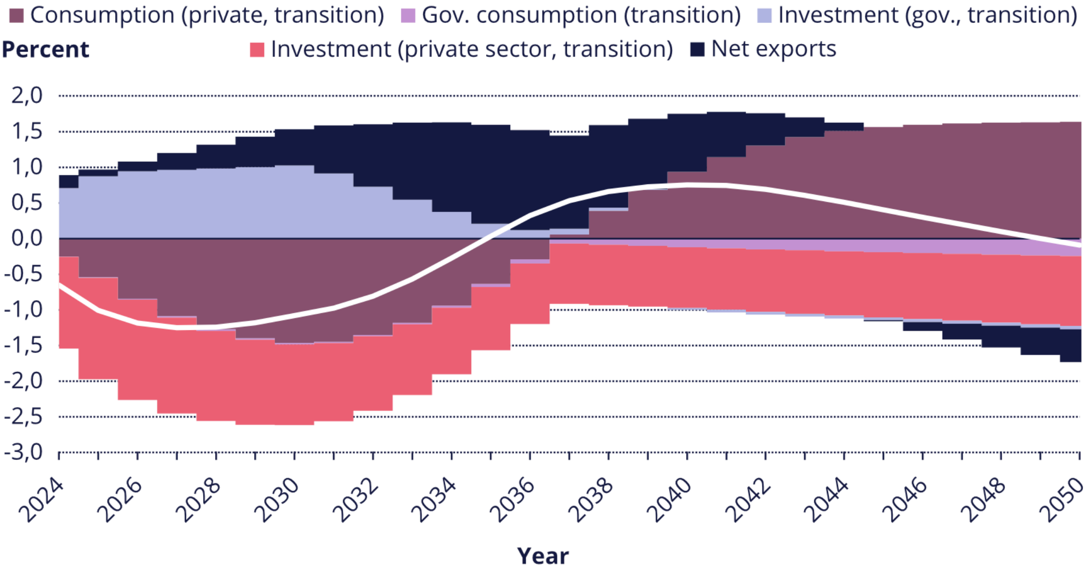
In NiGEM, carbon prices influence the economy through several channels. The cost of production increases, depressing consumption as inflation increases, and reducing firm investment as profits are squeezed. Overall productive capacity falls as some energy sources are no longer used. A changing energy mix also affects fossil fuel prices at the world level and leads to changes in trade patterns. There is not necessarily a loss in competitiveness, however, as it is assumed that the rest of the world also decarbonises rapidly.

Carbon revenues are recycled, with 50% used to pay down government debt and 50% to increased government investment (in the long run, a fiscal rule in NiGEM slowly reverses the budget balance towards a long-term target). The central bank raises interest rates in response to inflation, further reducing private investment.

In aggregate, the components of GDP then show the following pattern: in the short run, reduced private investment and consumption lead to a decline in GDP vis-à-vis the baseline, although their magnitude is partly undone by an increase in public investment and net exports. The former rises as a result of partial carbon revenue recycling via public investment, the latter as the net zero scenario assumes more coordinated global climate action vis-à-vis the baseline. By 2038, the pattern reverses however, and private consumption is now larger than in the baseline scenario. This is likely due to the large multiplier effect that government investment (which is increased using revenues from carbon pricing) has in the NiGEM model. Private investment remains depressed, a result that seems to be somewhat specific to the NGFS modelling setup, as other papers in the literature expect that the need to change production processes would increase total investment (Varga et al. 2022), or at least undo some of the reduction in investment that is due to reduced demand (Château et al. 2023). Figure 2 shows the pattern for Italy.

Change compared to baseline

In percent of baseline GDP



The line shows how GDP changes in the NGFS Net Zero scenario. That effect is decomposed in components of GDP.

How to read the chart: Government investment rises by up to 1 percentage point of GDP versus the baseline by 2030, and then decreases back to the baseline level by 2040.

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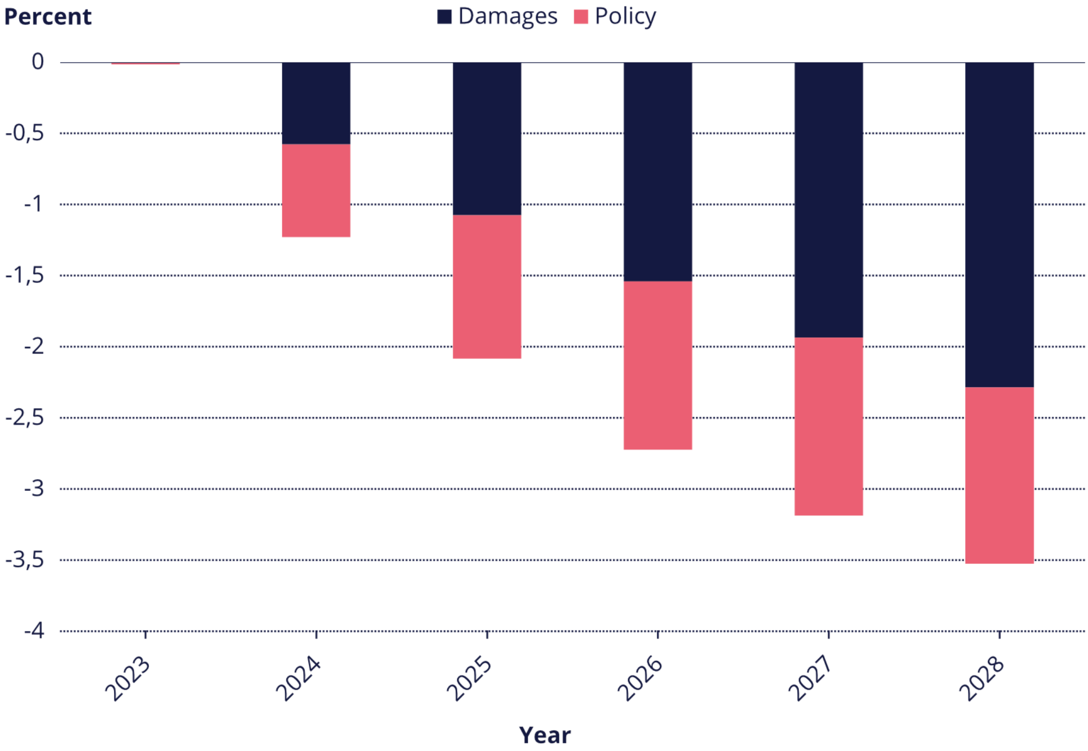
Figure 2: Change compared to baseline

Source: Varga et al. 2022, Château et al. 2023

Besides the impact of policy, Italy's growth is impeded by climate damages. The chart below puts both the negative impacts of climate damages and of climate policy together. For a more detailed description on how we computed the damages figure from publicly available NGFS outputs, see Annex 2.

Cumulative impact on GDP for Italy

In percent



The chart shows the GDP impact of climate change versus the baseline, separating the impact of damages and the impact of transition policies.

How to read the chart: In 2023, climate damages are still accounted for in the baseline, but by 2028 the baseline underestimates climate damages by more than 2 percentage points of GDP.

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Figure 3: Cumulative impact on GDP for Italy

Source: Author calculations based on NGFS

5. Putting it all together – DSA with revised growth assumptions

We follow the European Commission's DSA assumptions and adjust these for the impact of climate on growth. We perform two analyses: First, we adjust the Commission's growth projections to incorporate our preferred NGFS estimates of GDP effects, including climate damages and policy. We also adjust the primary balance for additional carbon pricing revenues used to pay down debt in the 'net zero' scenario but leave all other assumptions of the Commission's DSA analysis unchanged, assuming the gap in emission reduction between the 'net zero' and baseline scenario is closed *without* additional public spending. We then analyse what this means for the development of debt-to-GDP, as well as for the required fiscal adjustment. Second, we show indicatively how different climate policy mixes, i.e. higher shares of public spending, may change DSA outcomes.

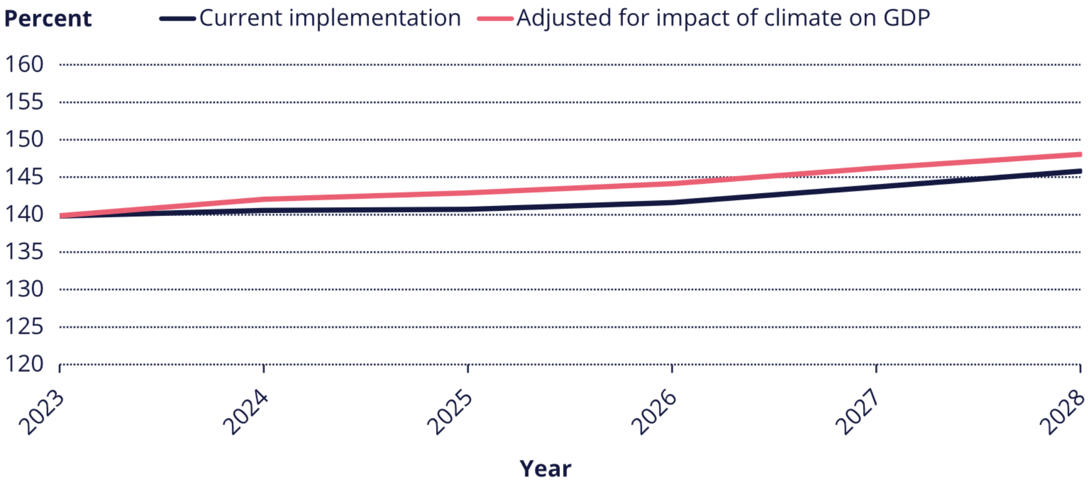
We focus our description of the results on the case of Italy. For Italy our NGFS estimates show a relatively large growth impact (see above). The following figures show how our adjustments affect debt-to-GDP projections of Italy.

Adjusting both growth and potential output for climate damage and policy impacts increases the projection of Italy's debt-to-GDP in 2028 from 146% to 148%. We focus on the year 2028 because this is the final year of the adjustment period under the new fiscal rules (unless the Member State applies for an extension period). This is a significant impact, that follows a simple arithmetic: reducing the denominator by a percent increases the debt ratio by about a percent. The majority of the impact results from damages. Additional carbon revenues in the 'net zero' scenario undo some of this through the primary balance. (In the longer run, these revenues go to zero as there are no emissions left to be taxed.)

To be compliant with the European fiscal rules, Italy would have to adjust its primary balance even more than the already required 0.5 percentage points per annum (as estimated by Darvas et al. 2024). This would create incentives to use an even higher share of carbon revenues for debt reduction instead of public support for private climate investments, which would lead to additional upward pressure on carbon prices, which in turn could dampen output even further.

Debt/GDP projections for Italy, following EC method

In percent



Projections based on the EU fiscal rules' methodology for deterministic DSAs.

How to read the chart: Italy's debt is expected to increase from 140% in 2023 to over 145% of GDP in 2028.

Dezernat Zukunft
Institut für Makrofinanzen

Figure 4: Debt/GDP projections for Italy, following EC method

Source: Author calculations

Next, we simulate changes to the climate policy mix and show how a more public investment driven policy mix might hypothetically impact debt-to-GDP. In the NGFS 'net zero' scenario emissions are mitigated through carbon pricing, while half of the carbon revenues are used for public investment. In the following, we show how growth and debt-to-GDP might change, if the same emission abatement is instead achieved through a policy mix including lower (but still increasing) carbon prices and increased public financing of climate investments. We assume that carbon prices increase only half as quickly as they do in the 'net zero' scenario and that, as a result, economic impacts are also cut approximately in half. We assume further that additional public investment of 1% of GDP is needed to make up for lower carbon prices. We derive this estimate from a recent study for Germany that investigates the relationship of additional public spending needs depending on carbon price scenarios (Heilmann et al. 2024).

A more public investment driven policy mix might increase or decrease debt-to-GDP vis-a-vis an adjusted baseline depending on multiplier assumptions. Figure 5 shows our debt-to-GDP projections for different multiplier assumptions. When using standard Commission assumptions, i.e. an investment multiplier of 0.75 with only a short-run impact, the debt-to-GDP projection for the year 2028 increases from 145% to 149% vis-a-vis the new baseline including full carbon pricing impacts (we exclude the impact of damages in this comparison). However, there is evidence that multipliers of decarbonisation investments can be considerably higher and follow more favourable timely patterns. Batini et al. (2021) show that green investment multipliers tend to be significantly larger than conventional estimates, with long-lasting positive effects on output and fiscal sustainability. The literature reviewed in chapter 2 also strongly suggests that targeted climate spending has positive growth effects vis-à-vis a carbon pricing-led policy baseline. We draw on these findings and simulate three alternative debt-to-GDP-paths, with a multiplier of 0.75, 1.5 and 3.0. In all three cases debt-to-GDP improves compared to the projection building on Commission assumptions. With a multiplier of 3, debt-to-GDP roughly equals the adjusted baseline projection.

The following section offers a brief discussion of our simulation results and highlights uncertainties and research gaps.

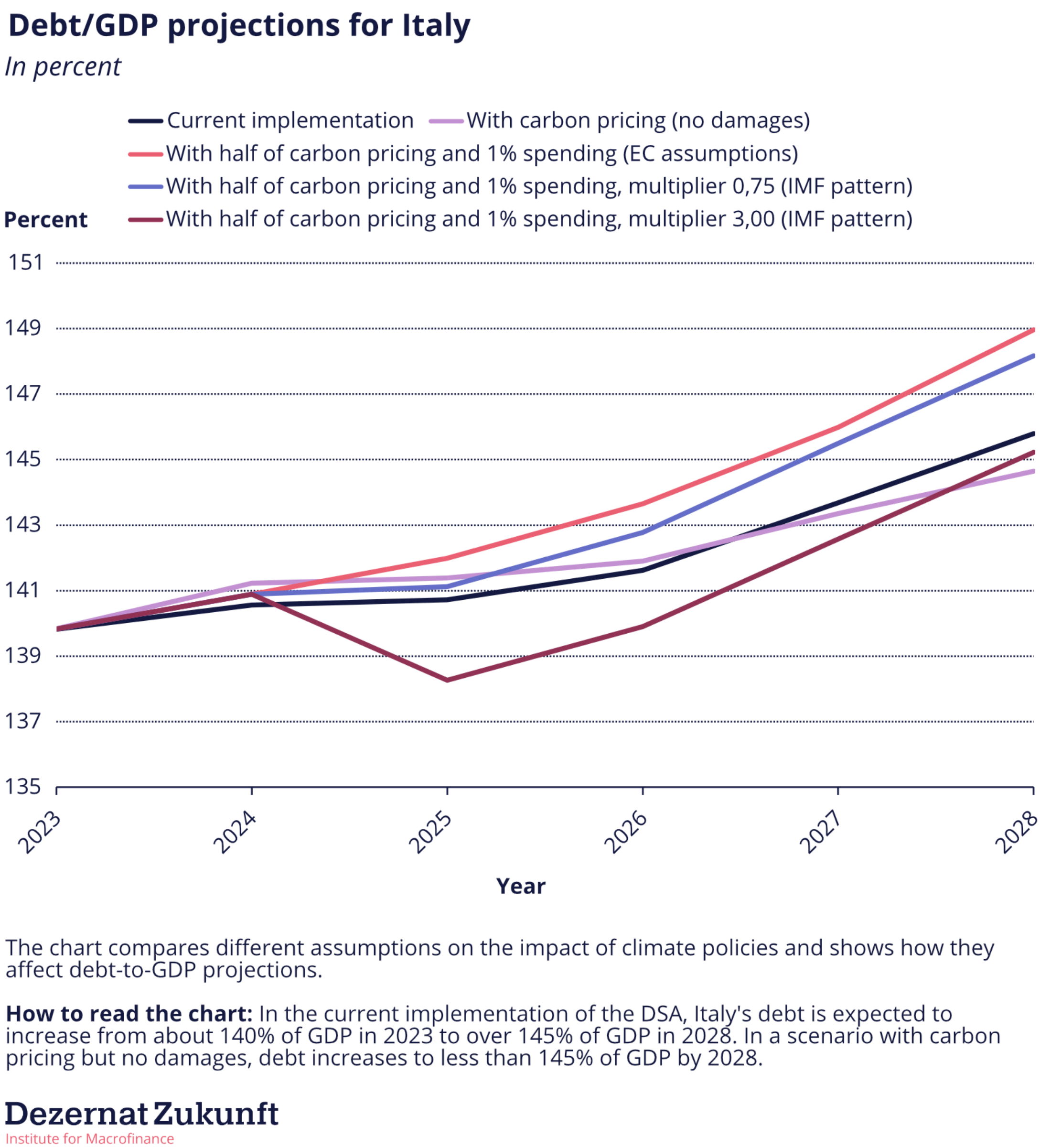


Figure 5: Debt/GDP projections for Italy

Source: Author calculations

6. Discussion of simulation results

DSA projections look worse when incorporating climate. This result is not new. The IMF finds that carbon pricing-driven climate policy aiming for net zero by mid-century (with only moderate spending-based instruments and without climate damages) will lead to an increase in debt-to-GDP by 10 to 15 percentage points by 2050 for a representative advanced economy (International Monetary Fund 2023). Our illustrative analysis for Italy, based on NGFS impact estimates, shows that compared to current DSA-implementation, including climate – physical and policy impacts – would increase debt-to-GDP by around 2% over four years. The increase is driven primarily by damages, as negative policy impacts are roughly offset by carbon revenue recycling via public investments and deficit reduction, as assumed by NGFS.

Our adjusted DSA most likely *underestimates* the effect of climate on debt-to-GDP projections in several ways. To start with, we have assumed, in line with NGFS 'net zero' scenario assumptions, that the world achieves net zero by 2050, using carbon pricing as their primary policy instrument. If the rest of the world mitigates slower, climate damages would be larger. If other industrialized nations, especially the US and China, continue to mitigate slower than Europe, which is to be expected given current trends, decline in trade and/or industrial reallocation may result, especially if trade protection mechanisms like the EU Carbon Boarder Adjustment Mechanism (CBAM) only provide partial protection.

Uncertainty around damages and policy impacts on output is tilted to the downside. In our review of the literature, we have encountered a wide range of estimates for damages with a skew to the downside. While NGFS estimates based on Kotz et al. (2024) are rather large compared to other estimates, there is evidence that suggests damages maybe even larger than assumed by NGFS (see chapter 2). Using NGFS estimates of damages in our DSA also required assumptions which would merit further research (see annex 2). Estimates of the impact of policy show some consensus on the order of magnitude, but this hides significant disagreement over the underlying mechanisms.

Models tend to take a generous view on carbon pricing. Implementing the emissions constraint with carbon pricing is an efficient policy choice in most IAMs. However, in practice, decarbonisation through carbon prices alone is likely to turn out more difficult and expensive than suggested by models, as several other market failures beyond the emission externality exist, which are not or only partially addressed in the reviewed models (see chapter 2 and annex 2). Without additional public spending that corrects these market failures, creating the preconditions for businesses and households to react to price signals, high carbon prices are likely to reduce emissions partially by demand destruction instead of technology switch, amplifying negative effects on output.

As a consequence, it's reasonable to assume public climate investment comes with relatively high multipliers vis-a-vis a carbon pricing only baseline. But only if public spending is targeted at low-carbon infrastructure investments that are a precondition for switching to low-carbon technologies as well as to correct market failures hindering private climate investment. Targeted this way, public spending can increase the effectiveness and efficiency of carbon pricing.

Accounting for climate in DSAs would likely give Member States more opportunities for implementing public climate spending. This result is central and rests on the assumption that DSA baseline modelling strictly accounts for the EU's emission constraint as specified by the EU's climate targets. Building on the arguments in the previous paragraphs, targeted public climate spending might partially or even fully refinance itself vis-a-vis an adjusted baseline that adequately incorporates the emission constraint in growth forecasts. More research is needed that explores the multiplier effects of climate spending vis-à-vis a pricing-led baseline.

Accounting for climate in DSAs requires going beyond current NGFS modelling. None of the NGFS scenarios has been designed with this use case in mind. For example, in the Net Zero scenario carbon revenues are used in equal measure to increase public investment and reduce debt levels. The latter is completely at odds with realities of European climate policy. According to the reformed ETS directive, revenues created through the ETS2 must be used for providing investment support in the buildings and transport sector and addressing distributional consequences through compensation measures. And there are more reasons that disqualify existing NGFS estimates as basis for DSA modelling (see chapter 3). Accounting for climate in DSAs would require a tailor-made model that matches European policy realities and can be integrated seamlessly into DSA modelling.

7. Conclusion

The baseline is wrong – DSAs should account for climate. The literature and our simulations show that climate damages and an emissions constraint are a challenge to GDP growth during the transition – especially when a fiscal constraint is also present. This in turn has fiscal implications, which the DSA methodology should consider but currently does not.

Growth assumptions in the DSA methodology should reflect underlying climate policy choices. The reviewed models and broader climate literature provide ample evidence that the climate policy mix impacts growth outcomes, especially in the presence of uncoordinated global climate policy and market failures beyond the carbon externality. Our simulations highlight the possibility that targeted public climate spending can improve growth and potentially even debt-to-GDP vis-a-vis a growth baseline that satisfy the emissions constraint primarily through carbon pricing. It follows that growth projections must be made endogenous to policy choices. The starting point is to adjust the DSA methodology for baseline growth projections and include the emissions constraint. Additionally, our analysis highlights the need to refine the use of fiscal multipliers and implement a more nuanced approach, as also shown by Heimberger (2024).

More nuanced and consistent modelling is needed. Our analysis emphasizes a more general point: Making fiscal policy dependent on complex modelling comes with huge down-side risks. This is particularly true for climate, which is associated with significant uncertainties. Yet, if fiscal policy is steered this way, modelling needs to reflect all material variables and should do so in transparent and consistent way. While NGFS was not designed as basis for DSAs, our analysis highlights the need to align model assumptions with policy constraints and reduce inconsistencies. In summary, the DSA methodology needs an urgent update to deal with climate and growth in a more nuanced and consistent manner. This will improve fiscal and decarbonization outcomes.

Annex I: Review of literature on macroeconomic implications of reaching the EU's climate target

In chapter 2 we summarised how climate policy aimed at reaching the EU's climate targets may impact economic growth. This annex provides further details on relevant literature. We focus our attention here on literature that investigates the impact of a carbon pricing-driven policy approach, as Europe's fiscal constraint impedes a more spending-driven policy mix. However, we highlight some literature that investigates the impact of policy mix variations alongside carbon pricing.

Modelling the effect of carbon prices is demanding. Carbon prices lead to higher costs for producers in the polluting sectors of the economy. For traded goods, this makes their products less attractive on world markets. If policies increase consumer prices, this will reduce demand. At the same time, producers and consumers will adjust their behaviour in reaction to carbon prices, which will to some extent mitigate the impact on GDP. Producers can change the energy mix in production, or innovate their production methods, or eventually compensate for pollution using carbon capture. Workers and capital can move towards non-polluting sectors. Consumers can substitute home-produced for imported goods, or change their consumption mix to include more non-polluting goods (increasing demand in those sectors). Shifting labour and capital from one sector to another may in the short run lead to frictions and reduce GDP (much like downturns in the business cycle) but may also lead to increased investment effort. Underway, wages and interest rates may respond to changes in supply and demand, adding general equilibrium effects to the picture.

Varga et al. (2022) extend QUEST, the macroeconomic model used by the European Commission, to study carbon pricing. The resulting model, E-QUEST, includes all of the aforementioned adjustment margins and is calibrated to represent the EU. The model is used to explore the macroeconomic implications of reaching net zero in 2050 using carbon pricing, following an exogenous emissions reduction path. The authors compare different recycling options for the carbon pricing revenue. GDP is reduced by 0,5% to 1% by the end of a 30-year adjustment period. The negative GDP impact is minimised if all revenues from carbon pricing are recycled into investment subsidies instead of compensating consumers for higher prices. The combined effect of carbon pricing and subsidies is assumed to lead to a temporary increase in investment which dampens the GDP impact of a drop in consumption.[7] The scenario is based on a moderate carbon tax after 10 years (around $100 USD per tonne of CO2) but a higher one after 30 years (around $600 per tonne of CO2).[8] The authors also study a scenario which primarily relies on regulation to meet climate goals, in which case the GDP impact approaches 2% by the end of the adjustment period.

E-QUEST has two practical shortfalls for our exercise: It does not include damages, and it is a regional model. Thus, we cannot use it to

[7] Because the model assumes perfectly credible carbon taxes and perfect foresight, it shows an increase in investment in the intermediate period. Because the model assumes habit formation in consumption, consumers who can borrow delay consumption losses until the end of the adjustment period. Jointly, these assumptions reduce the intermediate impact on GDP.

[8] The paper does not specify the base year for these carbon prices, but they can likely be interpreted as real prices with a base close to the year 2020.

study the impact of climate change and climate targets on the DSA of individual countries.

Chateau et al. (2023) estimate that the EU's 'Fit-for-55' package will cause GDP losses of slightly over 2% by 2035, using the OECD's ENV-Linkages model. Besides the ETS2, this includes existing EU policies and the Carbon Border Adjustment Mechanism (CBAM), as well as Member States' national policies as described in the National Energy and Climate Plans. This much larger loss than in E-QUEST is partly explained by a significantly higher carbon price: The model predicts a carbon price of €178 per tonne of CO_2 in 2030 (base year 2020), but the development for later years is not reported. GDP losses quickly accelerate after 2030, growing from 1% of GDP to over 2%. Impacts differ across countries and are larger for countries with a large industrial base. The authors also assume that carbon price revenues will be largely invested in the energy transition. Without such growth-enhancing measures, they expect that the negative effect of climate policies on GDP would be higher. Computable general equilibrium (CGE) models such as ENV-Linkages (Chateau et al. 2014) include many of the channels discussed above, but not all. Learning and technological development is more exogenous compared to other models such as E-QUEST. Being a CGE model, ENV-Linkages has an extensive sectoral structure, including a detailed modelling of capital vintages, but does not include any temporary reallocation frictions.

The European Commission's impact assessment of the ETS2 mechanism assumes lower carbon prices will suffice to meet climate goals. The focus of the impact assessment is on 2030. The impact assessment uses an analytical framework consisting of several models (European Commission 2021, Annex 4). The economic core of the framework is the GEM-E3 model used by the European Commission's Joint Research Centre (Capros et al. 2017). Gem-E3 is a computable general equilibrium (CGE) model with a focus on energy and the environment (see also Weitzel et al. 2019), similar in style to the ENV-Linkages model that we describe above.[9] The GDP impact of the scenario that extends carbon pricing according to the Commission's plans ranges from -0.7 to -0.3 percentage points in 2030. This is in order to achieve a 55 percent reduction of GHG emissions by 2030. Carbon prices are however expected to remain under €100 per ton of CO_2 in 2030 (base year 2015). The scenarios in the impact assessment do not rely entirely on carbon pricing, as they also change the ambition level of accompanying policies (European Commission 2020). Such accompanying measures may indeed help adhere to the climate constraint at lower carbon prices. However, those would require further legislation, as well as funding that may not be available under the fiscal constraint. Therefore, we do not use these impact estimates to adjust the DSA baseline in our simulations.

Agora Energiewende (2024) models different policy scenarios and finds a positive GDP impact of around 2% for the EU by 2040. The impact can be larger in the short run and varies significantly by Member State. Using the Oxford Economics GEM modelling suite, Agora Energiewende studies several policy scenarios and shows their impact on GDP and debt levels. A pricing-based scenario that meets emissions goals by 2050 requires carbon prices that rise to €600 per ton of CO_2 (in constant prices of 2010). The scenarios do not follow from legislated policies as would be required under fiscal rules but rather make assumptions on what policies will support carbon pricing. The required investment is assumed to take place and

[9] Other models used are Quest (a DSGE model discussed above) and E3ME (a Keynesian demand-driven model. The impact assessment considers different policy scenarios: REG (standards), CPRICE (no new standards but larger ETS), MIX; differences in impact on GDP are not large (p.77). JRC-GEM-E3 is the only model that examines the scope extension of ETS, which includes road transport and buildings (p.75).

the EU's fiscal rule is not modelled as a constraint. The report concludes that absent significant tax increases or budget cuts in areas other than climate, debt stocks will rise as a consequence of climate investments. Yet, according to Agora Energiewende, the growth resulting from climate investments will keep debt-to-GDP ratios close to their baseline for some countries. For the purpose of adjusting the DSA baseline for climate under the EU's fiscal constraint (as done in chapter 4), the modelling approach chosen by Agora Energiewende is not suitable.

The Network on Greening the Financial Sector (NGFS), a collaborative effort of central banks and supervisors that includes the European Central Bank, delivers estimates of GDP losses from policy for a range of different global reduction scenarios. NGFS (2023) combines a macro-econometric model with features of a dynamic stochastic general-equilibrium model (NiGEM) with three different IAMs. These models that inform NGFS also inform IPCC reports. Of the three IAMs used (GCAM, MESSAGE, REMIND), the REMIND model provides the most extensive modelling of channels through which the economy adjusts and is most comparable with the other papers discussed in this section. The analysis of different reduction scenarios by NGFS is particularly instructive. Shorter transitions lead to larger GDP-losses than more stretched out ones. Depending on the exact scenario, GDP losses in Europe from the impact of policy alone may reach up to 1.5% of GDP. Getting there requires EU-wide carbon prices that grow to over 450 US-Dollars by 2035 (base year 2010). In chapter 4, we use NFGS figures to adjust DSA projections for climate.

Other models show small GDP losses. For example, a recent IMF paper studies fiscal policy in a climate context using a DSGE model (International Monetary Fund 2023, chapter 1 and online annexes), but with less modelling detail on several adjustment channels compared to E-QUEST. The paper is not based on a net zero scenario but on an emissions reduction of 80 percent compared to 2023. A policy mix including carbon pricing reduces GDP in advanced economies by about 1.5% by 2050. Using carbon prices as the only policy instrument, the model predicts that carbon prices will rise close to \$300 per tonne of CO_2.[10] This paper is among few in its focus on the development of debt-to-GDP, showing significant increases for advanced economies in several scenarios. Another example is Hinterlang et al. (2023), who describe the Bundesbank's EMuSe model. EMuSe is a full-fledged DSGE model with sectoral detail. This makes the model similar to E-QUEST, but with less detail on learning and innovation. While not reporting overall GDP losses, they show about a 0.5% difference between orderly and disorderly scenarios (where scenarios are taken from the NGFS, including the trajectory of carbon prices).

[10] The paper does not specify the base year for these carbon prices, but they can likely be interpreted as real prices with a base close to the year 2023.

Annex II: Obtaining climate impacts for DSAs from NGFS scenario's

Translating NGFS scenario's into DSA inputs requires some data choices. We use the NGFS's Phase V output from NiGEM that uses REMIND-MAgPIE as an IAM.

The combined GDP impacts from climate policy and chronic damages (these are one combined figure in the NiGEM output, which also captures interactions between the two) is reported in % difference from a theoretical baseline scenario without climate change (the comparison is in 2015 euros).

We want to obtain GDP impacts as compared to current GDP measures, which already include some effect of climate change. For policies, there is no difference, as the NGFS's 'current policy' scenario by definition does not show any GDP impact from policy. But chronic damages should include damages that are already part of GDP today. To achieve consistency with DSA assumptions, we take the chronic damages for 2023 as our baseline and use deviations from that year as our series for chronic damages.

We do not include acute damages, available from Climate Analytics in the same output set (interactions that also include acute damages are not available). NGFS's Phase V results for chronic damages overlap with acute damages to some unknown extent. We prefer a more conservative approach that avoids any overlap. As a result, our figures may underestimate total climate damages. For chronic physical damages, the NGFS uses the 95th percentile of the impact distribution given by the damage function and reports only those outcomes. This is because many applications further interact damages with other modelling, as we do in our DSA. Ideally, one would show the resulting outcomes (debt-to-GDP in our case) for each scenario and average thereafter, which may well show a non-linear impact as damages get worse (and hence a higher average outcome than for the average damage input). When this is not possible, higher percentiles can be used to reflect the uncertainty inherent in the modelling of the macroeconomic effects. However, an upward bias to our results seems likely.Future research could delve deeper into the implications of different stochastic outcomes for the DSA. Climate could even be treated as a source of uncertainty in stochastic DSAs. Zenios (2022) shows how to integrate IAMs into a stochastic DSA framework.

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